TESIS DOCTORAL

ESCUELA INTERNACIONAL DE DOCTORADO

Programa de Doctorado en Ciencias del Deporte

Las nuevas tecnologías como herramienta para la promoción de la salud en escolares de Educación Secundaria Obligatoria de la CARM: efectos de las aplicaciones tecnológicas deportivas sobre la salud física y psicológica de los adolescentes

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(1) Si la Tesis está dirigida por más de un Director tienen que constar y firmar ambos.

RESUMEN

El sobrepeso y la obesidad infantil se han visto incrementados en las últimas décadas, siendo causa de numerosas enfermedades crónicas. España se encuentra entre los países con mayor prevalencia de la Unión Europea, y uno de los principales motivos es el aumento de las actividades sedentarias y la falta de actividad física en esta población. Además, los malos hábitos nutricionales, así como la falta de importancia otorgada al mantenimiento de un adecuado peso corporal son factores que contribuyen a un desarrollo inadecuado de los adolescentes. Por su parte, el rápido desarrollo de las nuevas tecnologías también podría ser una de las causas que ha favorecido los cambios en los hábitos de vida de los jóvenes hacia un estilo de vida más sedentario debido al incremento en la utilización de las redes sociales y el tiempo de pantalla.

Esto fue especialmente relevante durante el confinamiento producido por la pandemia de COVID-19 en la que se imposibilitó la práctica de cualquier actividad física y el uso de las nuevas tecnologías aumentó exponencialmente. Las consecuencias de la inactividad física fueron especialmente negativas en la población adolescente donde empeoró la composición corporal y el estado psicológico, y aumentó el uso problemático y adictivo de las nuevas tecnologías. Por tanto, tras la COVID-19 era necesario conocer el estado en que se encontraba la población adolescente en cuanto a la adquisición de hábitos saludables se refiere, ya que la pandemia produjo cambios significativos en los comportamientos que son más determinantes para lograr un estilo de vida activo y un desarrollo saludable.

A partir de esa información y para tratar de revertir las consecuencias negativas de la COVID-19, eran necesarios programas que fomentasen la actividad física promovidos desde el ámbito escolar. Sin embargo, la efectividad de estos había mostrado ser reducida en investigaciones previas debido a que en España únicamente se dispone de dos horas de educación física semanales, siendo este tiempo insuficiente para lograr cambios significativos. Por tanto, si se pretendían conseguir cambios notables en el nivel de actividad física, debía hacerse uso del tiempo extraescolar, siendo las tecnologías de la información y la comunicación (TIC) una herramienta útil para ello. Esto se debe a que los estudios previos habían

mostrado que el uso de las TIC podía ser beneficioso para aumentar los niveles de actividad física y la motivación por la práctica deportiva en los adolescentes. En este sentido, debía valorarse la influencia que podría tener el uso de diferentes aplicaciones móviles en horario extraescolar promocionadas desde la materia de educación física sobre el nivel de actividad física de la población adolescente, y los cambios que podrían producirse en la composición corporal, el nivel de adherencia a la dieta mediterránea, la condición física, la satisfacción con la vida y la satisfacción de las necesidades psicológicas básicas.

Por estos motivos, los objetivos generales de la presente tesis doctoral fueron: 1) analizar las diferencias en las variables cineantropométricas, la composición corporal, la condición física y el uso de las nuevas tecnologías de la población adolescente según el nivel de actividad física practicado, el nivel de adherencia a la dieta mediterránea, el estado de peso y el estado psicológico de los adolescentes; y 2) determinar la influencia de una intervención con aplicaciones móviles en horario extraescolar promocionada desde la asignatura de educación física en el incremento del nivel de actividad física practicado, y su efecto sobre las variables cineantropométricas, la composición corporal, el estado psicológico y la condición física de los adolescentes.

Para dar respuesta a estos objetivos se diseñó un estudio dividido en dos fases. En la primera fase se planteó un diseño transversal para dar respuesta al primer objetivo que incluyó un total de a 791 adolescentes de los centros de Educación Secundaria Obligatoria de la CARM (404 chicos and 387 chicas; edad media: 14.39 ± 1.26 años) a los que se realizó pruebas físicas (handgrip, CMJ, sit-and-reach, 20-m shuttle run test y 20 m sprint), se administraron cuestionarios relacionados con el nivel de práctica deportiva (PAQ-A), la satisfacción de las necesidades psicológicas básicas (BPNS), la satisfacción con la vida (SWLS), la adherencia a la dieta mediterránea (KIDMED), y las experiencias relacionadas con el uso de internet y el móvil (CERI y CERM); y se realizó una valoración antropométrica compuesta por cinco perímetros (brazo relajado, cintura, caderas, muslo y pierna), tres pliegues (tríceps, muslo y pierna) y tres medidas básicas (masa corporal, talla y talla sentado). En la segunda fase, se planteó un diseño longitudinal para dar respuesta al segundo objetivo en el que se llevó a cabo una intervención de diez semanas de duración con cuatro grupos experimentales y un grupo control (400 adolescentes; 210 chicos y 190 chicas; edad media: 13.96±1.21

años). Cada uno de los grupos experimentales utilizó en horario extraescolar una de las aplicaciones tecnológicas móviles (Strava, Pacer, MapMyWalk o Pokémon Go) que fueron elegidas por incluir un elevado número de técnicas para el cambio de comportamiento. La intervención tuvo una duración de 10 semanas, en las que los adolescentes utilizaron las aplicaciones móviles para caminar o correr tres veces por semana, un mínimo de 60 minutos cada día. La distancia a recorrer fue incrementada semanalmente siguiendo una progresión de la carga, comenzando por 4,5 km por sesión en la primera semana, y finalizando con 8 km por sesión en la décima semana. En la semana previa (pre-test) y posterior (post-test) a la intervención, así como a las 10 semanas de finalizar la misma, se llevaron a cabo las mediciones antropométricas, de condición física (handgrip, CMJ, sit-and-reach, 20-m shuttle run test, 20 m sprint, curl-up y push-up) y se cumplimentaron los cuestionarios (actividad física y adherencia a la dieta mediterránea).

Respecto a la primera fase, los resultados obtenidos mostraron que los adolescentes activos presentaban menor grasa corporal ($p<0.001$), mayor masa muscular ($p<0.001$), mejor adherencia a la dieta mediterránea (AMD) ($p<0.001$), mayor fuerza ($p<0.001$), velocidad ($p<0.001$) y capacidad cardiorrespiratoria ($p<0.001$) que los adolescentes sedentarios. Además, en el mismo grupo de peso, los adolescentes más activos presentaban mayor masa muscular ($p<0.001$-0.034), rendimiento físico ($p<0.001$-0.041) y AMD ($p<0.001$-0.002), confirmando el paradigma "fat but fit". Respecto a la importancia de la AMD, no se hallaron diferencias significativas en las variables cineantropométricas ($p>0.05$) y de condición física ($p>0.05$) en adolescentes con diferente nivel de AMD, por lo que el paradigma "fat but healthy diet" no pudo ser confirmado. En cuanto a la relevancia de las necesidades psicológicas básicas para el desarrollo adolescente, los resultados mostraron que los adolescentes en los percentiles más altos de satisfacción mostraron mayor actividad física practicada ($p<0.001$), AMD ($p<0.001$), mejores variables cineantropométricas ($p<0.001$-0.015) y condición física ($p<0.001$). Además, la satisfacción de las tres necesidades psicológicas básicas de forma conjunta mostró los mayores beneficios ($p<0.001$-0.020), pero cuando esta no se producía, la competencia mostró ser la variable más relevante ($p<0.001$-0.039). En cuanto al uso de las nuevas tecnologías, se observó que el uso problemático de internet y el móvil afectó negativamente a la actividad física practicada ($p=0.013$), a la AMD ($p<0.001$-0.001) y al estado psicológico ($p<0.001$-0.028) de las chicas, así como a la AMD (p=0.047), la condición física (p=0.001-0.019) y el estado psicológico (p=0.001-0.010) de los chicos. En concreto, el uso problemático del teléfono móvil produce los efectos más negativos sobre la población adolescente ($p<0.001$-0023). Cabe destacar también, que la actividad física parece ser el comportamiento saludable más determinante puesto que es capaz de compensar las diferencias halladas entre chicos y chicas en la composición corporal ($p<0.001$) y las variables psicológicas ($p<0.001$-0.045), a diferencia de la AMD ($p>0.05$) y el estado de peso ($p>0.05$) que no mostraron diferencias significativas.

En cuanto a la segunda fase, los resultados mostraron que las aplicaciones móviles utilizadas en horario extraescolar eran eficaces para mejorar la actividad física practicada (p=0.039), la composición corporal ($p<0.001$-0.034) y la condición física de los adolescente (p=0.034-0.043), pero no para aumentar la AMD (p=0.477). Además, la aplicación móvil utilizada parece ser un aspecto relevante a tener en cuenta, ya que los cambios producidos en la masa corporal (p=0.043), la fuerza de prensión manual (p=0.009) y curl-up ($p<0.001$-0.013) fueron significativamente diferentes según las aplicaciones utilizadas. En concreto, el uso de Pokémon Go mostró aumentos significativos de la actividad física (p=0.038) de los adolescentes inactivos, permitiendo disminuir la masa grasa ($p<0.001$-0.036) y aumentar la masa muscular ($p<0.001$-0.008), independientemente de si se utilizó la forma de juego continua o intermitente, y sin importar el nivel de actividad física previo.

De los estudios que componen la presente tesis doctoral se ha podido concluir que el nivel de actividad física de la población adolescente es la variable más relevante a tener en cuenta en las diferencias halladas en las variables cineantropométricas, en la composición corporal, la condición física y en el uso de las nuevas tecnologías, mientras que la AMD, el estado de peso y el estado psicológico, a pesar de ser relevantes, parecen ejercer un papel secundario. No obstante, es de vital importancia considerar todas las variables puesto que pueden influir desde una visión global en el desarrollo saludable de los adolescentes. Además, la intervención de diez semanas de duración con aplicaciones móviles promovida desde la materia de educación física y utilizada en horario extraescolar permitió aumentar el nivel de actividad física realizado por la población adolescente, produciendo cambios significativos en las variables cineantropométricas, de composición corporal y de condición física.

PALABRAS CLAVE

Actividad física; adolescentes; aplicación móvil; aptitud física; cambio de comportamiento; composición corporal; condición física; dieta mediterránea; diferencias de género; educación básica; fisiología del ejercicio; forma de juego continua; forma de juego intermitente; jóvenes; masa grasa; medición antropométrica; necesidades psicológicas básicas; nuevas tecnologías; patrón dietético; peso corporal; satisfacción con la vida; videojuegos.

ABSTRACT

Childhood overweight and obesity have increased in recent decades and are the cause of numerous chronic diseases. Spain is among the countries with the highest prevalence in the European Union, and one of the main reasons is the increase in sedentary activities and the lack of physical activity in this population. In addition, poor nutritional habits, as well as the lack of importance given to maintaining an adequate body weight, are factors that contribute to the inadequate development of adolescents. For its part, the rapid development of new technologies could also be one of the causes that has favored changes in the lifestyle habits of young people towards a more sedentary lifestyle due to the increased use of social networks and screen time.

This was especially relevant during the confinement produced by the COVID-19 pandemic in which the practice of any physical activity was made impossible, and the use of new technologies increased exponentially. The consequences of physical inactivity were especially negative in the adolescent population where body composition and psychological state worsened, and problematic and addictive use of new technologies increased. Therefore, after COVID-19, it was necessary to know the state of the adolescent population in terms of the acquisition of healthy habits, since the pandemic produced significant changes in the behaviors that are most decisive in achieving an active lifestyle and healthy development.

Based on this information and in order to try to reverse the negative consequences of COVID-19, programs to encourage physical activity promoted in schools were necessary. However, the effectiveness of these programs had been shown to be reduced in previous research due to the fact that in Spain there are only two hours of physical education per week, which is insufficient time to achieve significant changes. Therefore, if significant changes in the level of physical activity were to be achieved, use should be made of out-of-school time, with information and communication technologies (ICT) being a useful tool for this purpose. This is because previous studies had shown that the use of ICTs could be beneficial in

increasing physical activity levels and motivation to practice sports in adolescents. In this sense, the influence that the use of different mobile applications in out-of-school hours promoted from the subject of physical education could have on the level of physical activity of the adolescent population, and the changes that could occur in body composition, the level of adherence to the Mediterranean diet, fitness, life satisfaction and satisfaction of basic psychological needs should be assessed.

For these reasons, the general aims of the present doctoral thesis were: 1) to analyze the differences in kinanthropometric variables, body composition, fitness, and the use of new technologies in the adolescent population according to the level of physical activity practiced, the level of adherence to the Mediterranean diet, weight status and psychological state of the adolescents.; and 2) to determine the influence of an intervention with mobile applications in out-of-school hours promoted from the physical education subject on the increase in the level of physical activity practiced, ant its effect on kinanthropometric variables, body composition, psychological state, and fitness of adolescents.

In order to respond to these aims, a two-phase study was designed. In the first phase, a cross-sectional design was proposed to respond to the first aim, which included a total of 791 adolescents from the centers of Compulsory Secondary Education of the CARM (404 boys and 387 females; mean age: 14.39 ± 1. 26 years) who underwent physical tests (handgrip, CMJ, sit-and-reach, 20-m shuttle run test and 20-m sprint), questionnaires related to the level of sports practice (PAQ-A), satisfaction of basic psychological needs (BPNS), life satisfaction (SWLS), adherence to the Mediterranean diet (KIDMED), and experiences related to the use of internet and mobile (CERI and CERM); and an anthropometric assessment was carried out consisting of five perimeters (relaxed arm, waist, hips, thigh and leg), three folds (triceps, thigh and calf) and three basic measurements (body mass, height and sitting height). In the second phase, a longitudinal design was proposed to respond to the second aim in which a ten-week intervention was carried out with four experimental groups and a control group (400 adolescents; 210 boys and 190 females; mean age: 13.96±1.21 years). Each of the experimental groups used one of the mobile applications (Strava, Pacer, MapMyWalk or Pokémon Go) during out-of-school hours, which were chosen for including a high number of behavior change techniques. The intervention lasted for 10 weeks, during which the adolescents used the mobile apps to walk or run three times a week, a minimum of 60 minutes each day. The distance to be run was increased weekly following a progression of load, starting with 4.5 km per session in the first week, and ending with 8 km per session in the tenth week. In the week before (pre-test) and after (post-test) the intervention, as well as 10 weeks after the end of the intervention, anthropometric and fitness measurements were taken (handgrip, CMJ, sit-and-reach, 20-m shuttle run test, 20-m sprint, curl-up and push-up) and questionnaires were completed (physical activity and adherence to the Mediterranean diet).

Regarding the first phase, the results obtained showed that active adolescents had lower body fat ($p<0.001$), greater muscle mass ($p<0.001$), better AMD ($p<0.001$), greater strength ($p<0.001$), speed ($p<0.001$) and cardiorespiratory capacity ($p<0.001$) than sedentary adolescents. Furthermore, in the same weight group, more active adolescents presented greater muscle mass ($p<0.001$-0.034), physical performance ($p<0.001$-0.041) and AMD ($p<0.001$-0.002), confirming the "fat but fit" paradigm. Regarding the importance of AMD, no significant differences were found in kinanthropometric ($p>0.05$) and fitness ($p>0.05$) variables in adolescents with different level of AMD, so the "fat but healthy diet" paradigm could not be confirmed. Regarding the relevance of basic psychological needs for adolescent development, the results showed that adolescents in the highest percentiles of satisfaction showed higher practiced physical activity ($p<0.001$), AMD ($p<0.001$), better kinanthropometric variables ($p<0.001$-0.015) and fitness ($p<0.001$). In addition, the satisfaction of the three basic psychological needs jointly showed the greatest benefits ($p<0.001$-0.020), but when this did not occur, competence was shown to be the most relevant variable ($p<0.001$-0.039). Regarding the use of new technologies, it was observed that the problematic use of internet and mobile negatively affected the physical activity practiced ($p=0.013$), AMD ($p<0.001$-0.001) and psychological state ($p<0.001$-0.028) of females, as well as AMD ($p=0.047$), fitness ($p=0.001$-0.019) and psychological state ($p=0.001$-0.010) of males. In particular, problematic use of the mobile phone produces the most negative effects on the adolescent population ($p<0.001$-0023). It should also be noted that physical activity seems to be the most determinant healthy behavior since it is able to compensate for the differences found between males and females in body composition ($p<0.001$) and psychological variables ($p<0.001$-0.045), unlike AMD ($p>0.05$) and weight status ($p>0.05$) which did not show significant differences.

Regarding the second phase, the results showed that the mobile applications used after school hours were effective in improving the physical activity practiced (p=0.039), body composition (p<0.001-0.034) and adolescent fitness (p=0.034-0.043), but not in increasing AMD (p=0.477). Furthermore, the mobile application used seems to be a relevant aspect to consider, since the changes produced in body mass (p=0.043), manual grip strength (p=0.009) and curl-up (p<0.001-0.013) were significantly different according to the applications used. Specifically, the use of Pokémon Go showed significant increases in physical activity (p=0.038) of inactive adolescents, allowing to decrease fat mass (p<0.001-0.036) and increase muscle mass (p<0.001-0.008), regardless of whether continuous or intermittent gameplay was used, and regardless of previous physical activity level.

From the studies that comprise the present doctoral thesis, it has been possible to conclude that the level of physical activity of the adolescent population is the most relevant variable to consider in the differences found in the kinanthropometric variables, in body composition, fitness and in the use of new technologies, while AMD, weight status and psychological status, despite being relevant, seem to play a secondary role. Nevertheless, it is vitally important to consider all the variables since they can have a global influence on the healthy development of adolescents. In addition, the ten-week intervention with mobile applications promoted by the physical education subject and used outside school hours increased the level of physical activity performed by the adolescent population, producing significant changes in kinanthropometric variables, body composition and fitness.

KEYWORDS

Adolescents; anthropometric measurement; basic education; basic psychological needs; behaviour change; body composition; body weight; continuous gameplay; dietary pattern; exercise physiology; fat mass; gender differences; intermittent gameplay; life satisfaction; Mediterranean diet; mobile application; new technologies; physical activity; physical condition; physical fitness; videogames; youth.

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"La única diferencia entre el éxito y el fracaso es la capacidad de actuar". Alexander Graham Bell (1847-1922).

ÍNDICE GENERAL

SIGLAS Y ABREVIATURAS

η2, effect size (tamaño del efecto)

A, autonomy (autonomía)

AF, active females (chicas activas)

AM, active males (chicos activos)

AMD, adherence to Mediterranean diet (adherencia a la dieta mediterránea)

ANOVA, analysis of variance (análisis de la varianza)

APHV, age at peak height velocity (edad del pico de velocidad de crecimiento)

App, application (aplicación)

BF, body fat (grasa corporal)

BMI, body mass index (índice de masa corporal)

BPNS, basic psychological needs scale (escala de satisfacción de las necesidades psicológicas básicas)

C, competence (competencia)

CERI, cuestionario de experiencias relacionadas con internet

CERM, cuestionario de experiencias relacionadas con el teléfono móvil

CG, control group (grupo control)

CI, confidence interval (intervalo de confianza)

CMJ, countermovement jump (salto con contramovimiento)

CV, coefficient of variation (coeficiente de variación)

Diff, differences (diferencias)

EG, experimental group (grupo experimental)

ES, effect size

F, females (chicas)

GH, growth hormone (hormona del crecimiento)

I, internet related experiences (experiencias relacionadas con internet)

ICC, intraclass correlation coefficients (coeficientes de correlación intraclase)

ISAK, International Society for the Advancement in Kinanthropometry (Sociedad Internacional para el Avance de la Cineantropometría)

KIDMED, Mediterranean diet quality index for children and adolescents (Índice de calidad de la dieta mediterránea para niños y adolescentes)

M, males (chicos)

MANOVA, multivariate analysis of variance (análisis multivariante de varianza)

N, no (no)

NA, not aplicable (no aplicable)

NI, need to improve (necesita mejorar)

NP, no problems (sin problemas)

NSCA, National Strength and Conditioning Association (Asociación Nacional de Fuerza y Acondicionamiento)

NWF, normal weight females (chicas normopeso)

NWM, normal weight males (chicos normopeso)

OA, optimal adherence (adherencia óptima)

ODF, optimal adherence females (chicas con adherencia óptima)

ODM, optimal adherence males (chicos con adherencia óptima)

OP, occasional problems (problemas ocasionales)

OWF, overweight females (chicas con sobrepeso)

OWM, overweight males (chicos con sobrepeso)

p, signficance value (valor de significación)

PA, por adherence (adherencia pobre)

PAQ-A, Physical Activity Questionnaire for Adolescents (Cuestionario de actividad física para adolescentes)

PDF, poor adherence females (chicas con pobre adherencia)

PDM, poor adherence males (chicos con pobre adherencia)

PU, problematic use (uso problemático)

PY, partial yes (parcialmente si)

R, relatedness (relación social)

RoB, risk of bias (riesgo de sesgo)

SD, Standard deviation (desviación estándar)

SF, sedentary females (chicas sedentarias)

SM, sedentary males (chicos sedentarios)

SMD, standardized mean differences (diferencia de medias estandarizada)

Sum, summatory (sumatorio)

SUP, sit ups

SWLS, satisfaction with life scale (escala de satisfacción con la vida)

TEM, technical error of measurements (error técnico de medida)

TIC, tecnologías de la información y la comunicación

VO2 max, maximal oxygen consumption (consumo de oxígeno máximo)

WHtR, waist to height ratio (ratio cintura/talla)

X, mean (media)

Y, yes (sí)

ÍNDICE DE FIGURAS, DE TABLAS Y DE ANEXOS

ÍNDICE DE FIGURAS

CAPÍTULO II. JUSTIFICACIÓN

CAPÍTULO V. MÉTODOS, RESULTADOS Y DISCUSIÓN

ÍNDICE DE TABLAS

CAPÍTULO II. JUSTIFICACIÓN

ESTUDIO 1

ESTUDIO 2

CAPÍTULO V. MÉTODOS, RESULTADOS Y DISCUSIÓN

ESTUDIO 1

ESTUDIO 2

ÍNDICE DE ANEXOS

I – INTRODUCCIÓN

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La práctica de actividad física durante la adolescencia es fundamental debido a que se encuentra relacionada con la prevención y tratamiento de numerosas enfermedades crónicas (Anderson & Durstine, 2019; Salam et al., 2020). Esto adquiere especial relevancia debido al constante aumento de la obesidad y el sobrepeso en los jóvenes (Ezzati et al., 2017), siendo España uno de los principales países afectados de la Unión Europea (Candel et al., 2020; López-Gil et al., 2020). Además, la práctica de actividad física es determinante porque se encuentra relacionada con numerosos comportamientos saludables de los adolescentes, destacando especialmente la adherencia a la dieta mediterránea (García-Hermoso et al., 2020), el mantenimiento de una adecuada composición corporal (Agata & Monyeki, 2018), la mejora de la condición física (Bravo-Sánchez et al., 2021) o el mantenimiento de un estado psicológico adecuado (Beltrán et al., 2015; Solís et al., 2019).

La adherencia a la dieta mediterránea es esencial para el establecimiento de un estilo de vida saludable en la población adolescente (Malheiros et al., 2021). Esto se debe al rol que desempeña este patrón nutricional en la prevención de enfermedades crónicas tales como la obesidad o la hipertensión (Aydin & Yilmaz, 2021), así como a la facilitación de un nivel glucémico adecuado (Domínguez-Riscart et al., 2022) o a su efecto antiinflamatorio y antioxidante (Augimeri et al., 2022). La relación existente entre la adherencia a la dieta mediterránea y la práctica de actividad física ha sido constatada en investigaciones previas, siendo los adolescentes que practican mayor actividad física los que presentan una mejor adherencia a este patrón nutricional (García-Hermoso et al., 2020; Moral-García et al., 2019), siendo ambos comportamientos relevantes en la adquisición de un estilo de vida saludable.

En cuanto a la composición corporal, se ha observado una relación positiva con la práctica de actividad física, siendo los adolescentes que más practican los que presentan menor masa grasa, menor índice de masa grasa y una mayor masa muscular (Mateo-Orcajada, González-Gálvez, et al., 2022). Del mismo modo, la práctica de actividad física se relaciona con una mejor condición física, destacando una mayor capacidad cardiorrespiratoria, mayor flexibilidad isquiosural y de la zona lumbar, así como una mayor fuerza y resistencia de la musculatura abdominal y del tren superior (Mateo-Orcajada, González-Gálvez, et al., 2022). Estos beneficios obtenidos con la práctica de actividad física en la composición corporal y la condición física de los adolescentes son determinantes por la influencia que ejercen sobre la salud en esta y posteriores etapas de la vida (Kolb et al., 2021).

Respecto al estado psicológico, las investigaciones previas han mostrado que la práctica de actividad física regular favorece la satisfacción de las necesidades psicológicas básicas y aporta una mayor satisfacción con la vida en la población adolescente (Beltrán et al., 2015; Feng et al., 2022; Rubio et al., 2019; Solís et al., 2019). Esto adquiere especial importancia debido a que en los últimos años se ha producido un creciente aumento de las afectaciones mentales, entre las que destacan la depresión, la ansiedad o el estrés (Shorey et al., 2022). Por tanto, la actividad física ejerce un rol preventivo en la aparición de desórdenes mentales ya que favorece la síntesis de hormonas como la serotonina y lleva a cabo una función catalizadora anti-estrés, siendo este fundamental para el desarrollo de la población adolescente (Alghadir et al., 2016; Hale et al., 2021; Tajik et al., 2017).

Estos son algunos de los motivos por los que la Organización Mundial de la Salud (OMS) recomienda a los adolescentes realizar una práctica de actividad física regular de sesenta minutos de actividad física por día, incluyendo tres días por semana de actividades físicas de intensidad vigorosa, combinando el trabajo cardiorrespiratorio y de fuerza resistencia (Chaput et al., 2020). Sin embargo, investigaciones recientes muestran que durante la pandemia de COVID-19 se produjo una disminución drástica de los niveles de actividad física de los adolescentes (Farooq et al., 2020), no habiéndose recuperado los niveles pre-pandemia actualmente (Tapia-Serrano et al., 2022) y habiendo disminuido entre un 15% y un 20% la práctica de actividad físico-deportiva entre los jóvenes (Conger et al., 2022; Pechtl et al., 2022).

Esta disminución en la práctica deportiva se debió principalmente a la imposibilidad de realizar actividades físicas al aire libre (Elnaggar et al., 2022; Yomoda & Kurita, 2021), así como el incremento del tiempo en actividades sedentarias (Pechtl et al., 2022) y el uso excesivo de las nuevas tecnologías por parte de la población adolescente (Alaca, 2020; Kamran et al., 2018). En definitiva, se produjo un cambio en los hábitos de vida de los adolescentes que, además de afectar al ámbito físico, repercutió negativamente en la pérdida de relación social y contacto con los iguales, así como en la salud mental y el estado anímico (Mondragón et al., 2020; Vallejo-Slocker et al., 2020). Ante esta situación, la presente tesis doctoral se hace necesaria para conocer el efecto real de la pandemia de COVID-19 sobre la adquisición de hábitos de vida saludables de la población adolescente como la práctica de actividad física y la adherencia a la dieta mediterránea, así como para analizar los posibles cambios producidos en la composición corporal, la condición física y el estado psicológico.

Además, la presente tesis doctoral trata de aprovechar un elemento percibido hasta el momento como negativo para la población adolescente, como son las nuevas tecnologías, para la obtención de beneficios físicos y psicológicos. Esto se debe a que, tras la pandemia de COVID-19, el uso de estos dispositivos se convirtió en habitual entre la población adolescente, incrementando el porcentaje de jóvenes que disponían de un teléfono móvil y que lo tenían totalmente integrado en su día a día (Del Rosario et al., 2015; Vaterlaus et al., 2021).

Además, se optó por la tecnología móvil debido a que los proyectos previos que la habían utilizado para promocionar la salud en la población adolescente mostraron resultados prometedores. Un claro ejemplo de ello sería el proyecto PEGASO Fit for Future (PEGASO F4F), siendo una de las intervenciones más relevantes al realizarse en tres países europeos, incluido España (Caon et al., 2018; Puigdomenech et al., 2019). En este proyecto se diseñó un ecosistema móvil a través del cual se facilitaba a los adolescentes la adopción de hábitos de vida saludables. El programa presentó una gran aceptación por parte de los adolescentes, destacando la viabilidad del mismo, una mayor motivación, el incremento de la actividad física realizada, la disminución de los comportamientos sedentarios y la mejora de la composición corporal (Caon et al., 2018; Puigdomenech et al., 2019). Así, se consiguió que los adolescentes estuviesen interesados en dar un uso alternativo a la tecnología para mejorar su estilo de vida, siendo el uso del teléfono móvil el que reportó valoraciones más positivas en la implementación del programa en comparación con el uso de otros dispositivos portátiles (Caon et al., 2018; Puigdomenech et al., 2019). No obstante, uno de los inconvenientes de este estudio piloto fue que se realizó con una aplicación móvil diseñada exclusivamente para este proyecto, lo que dificultó su seguimiento y evaluación en otros países.

Posteriormente, se han realizado otras intervenciones atractivas para los adolescentes basadas en videojuegos activos que han mostrado resultados favorables en el seguimiento de un estilo de vida activo y en la mejora de la salud física y mental. Sin embargo, los efectos han sido moderados en término de eficacia, no se ha considerado su efecto a largo plazo y tienen limitaciones metodológicas considerables, lo que dificulta la extrapolación de los resultados (Badawy & Kuhns, 2017; Dute et al., 2016; Ramírez-Granizo et al., 2020; Zurita-Ortega et al., 2018).

Por tanto, la presente tesis doctoral surgió con el objetivo de testar la eficacia de diferentes aplicaciones móviles para aumentar la actividad física y generar cambios en la composición corporal, la condición física o el estado psicológico de los adolescentes. Para ello, se seleccionaron aplicaciones móviles disponibles actualmente en el mercado, en IOS y en Android, ya que facilitaría su uso por parte de los adolescentes que participasen en el proyecto. Además, se seleccionaron las aplicaciones móviles atendiendo al número de técnicas de cambio de comportamiento que incluían, tratando que fuesen las más óptimas para lograr modificaciones en los comportamientos saludables (Bondaronek et al., 2018). Así, se pretendía dar un uso alternativo a una herramienta tan valiosa como el teléfono móvil, siempre que se hiciera un uso adecuado del mismo, ya que las investigaciones previas habían mostrado su potencial, pero presentaban baja calidad metodológica en sus evidencias y los datos eran heterogéneos (McMullan et al., 2020).

Así, en la parte experimental de la tesis se utilizaron las aplicaciones móviles de seguimiento de pasos seleccionadas esperando extraer conclusiones sobre la utilidad de estas para la promoción de hábitos de vida saludables en el ámbito escolar, así como las mejoras que esto podía provocar en la condición física, la salud psicológica y la composición corporal de los adolescentes. Esto era esencial en una situación post pandemia COVID-19 en la que la disminución de la actividad física y la falta de relación social habían afectado en gran medida a la salud física y mental de los adolescentes. Así, se pretendió seguir la línea de las investigaciones previas realizadas con aplicaciones móviles en adolescentes, pero en una situación social totalmente distinta y utilizando el centro educativo como fuente de promoción para el seguimiento del programa. Además, se esperaba poder fomentar estrategias para aumentar la práctica deportiva que perdurasen en el tiempo, así como determinar si las aplicaciones móviles seleccionadas habían sido útiles, solventando los problemas metodológicos y los reducidos tamaños muestrales de investigaciones previas.

II – JUSTIFICACIÓN

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La justificación de la presente tesis doctoral se encuentra compuesta por dos artículos de revisión publicados en revistas con revisión por pares. Las referencias de los mencionados artículos se encuentran a continuación:

Artículo 1

Mateo-Orcajada, A., González-Gálvez, N., Abenza-Cano, L. & Vaquero-Cristóbal, R. (2022). Differences in physical fitness and body composition between active and sedentary adolescents: A systematic review and meta-analysis. *Journal of Youth and Adolescence, 51*(2), 177-192.

Impact Factor: 4.9

Quartile: Q1

Category: Psychology, Developmental

Journal position: 9

Number of journals in the category: 76

Artículo 2

Mateo-Orcajada, A., Vaquero-Cristóbal, R. & Abenza-Cano, L. (2023). Mobile application interventions to increase physical activity and their effect on kinanthropometrics, body composition, and fitness variables in adolescent aged 12-16 years old: An umbrella review. *Child: Care, Health, and Development, online ahead of print.*

Impact Factor: 1.9

Quartile: Q3

Category: Pediatrics

Journal position: 74

Number of journals in the category: 130

IIa – ESTUDIO 1: Differences in Physical Fitness and Body Composition Between Active and Sedentary Adolescents: A Systematic Review and Meta-Analysis

ESTUDIO 1 - DIFFERENCES IN PHYSICAL FITNESS AND BODY COMPOSITION BETWEEN ACTIVE AND SEDENTARY ADOLESCENTS: A SYSTEMATIC REVIEW AND META-ANALYSIS

2.1. Abstract

Previous research analyzing the differences in physical fitness and body composition between active and sedentary adolescents aged 12–16 has not provided conclusive results. For this reason, a systematic review with meta-analysis was conducted to provide an overview of the results obtained to date. The objectives of this systematic review and meta-analysis were to investigate the differences in the physical fitness and body composition of adolescents who engaged in daily physical activity and those who were inactive. A search in PubMed, EBSCO, and Web of Sciences databases was performed. A total of 13,884 articles were reviewed and 11 were included in the meta-analysis . In the physical fitness performance, significantly higher values in cardiorespiratory fitness, hamstring and lower back flexibility, sit-ups and upper limb resistance were found in active compared to the inactive participants. In body composition, the inactive group showed significantly higher values in variables related to body fat, mainly in body fat percentage, fat mass and fat mass index compared to the active group. The results revealed that maintaining an active lifestyle through physical activity is a determining factor in improving the physical fitness and body composition of adolescents aged 12–16 years. The study design of the systematic review was previously registered in PROSPERO with code CRD42021241975.

2.2. Introduction

The benefits of physical activity for different population groups have been reported in numerous studies that point out its importance for improving physical fitness and maintaining fat mass at optimal levels (Amatriain-Fernández et al., 2020). However, the research conducted so far in adolescents aged 12–16 years does not provide conclusive results when comparing the physical fitness and body composition of active and sedentary adolescents, since the differences between the two groups are small and studies use different methodologies that make comparison difficult. Due to this lack of information and the limitations found in the scientific literature, it is difficult to draw conclusions on the importance of daily physical activity for the prevention of overweight, obesity and associated pathologies in this population. To address these shortcomings, the present investigation consists of a systematic review with a meta-analysis of the scientific literature existing to date, comparing the physical capacities (upper body strength, lower body strength, cardiorespiratory capacity) and body composition (fat mass, fat-free mass, weight) of active and sedentary adolescents aged 12–16 years, with the aim at investigating the existing differences in these parameters.

2.2.1. Lifestyle and Health Risks

Sedentary lifestyles are positively associated with the risk of chronic diseases during adolescence and later stages, so that adolescents who do not engage in physical activity have a greater risk of developing cardiovascular diseases (Rendo-Urteaga et al. 2015; Zheng et al. 2020), metabolic syndrome (Renninger et al., 2020), and otorhinolaryngological diseases (Pazdro-Zastawny et al., 2020). Despite the large body of scientific evidence on the relationship between physical exercise and health, the number of hours spent by adolescents for the practice of sports is low (Fernández et al., 2017). This is evidenced by studies of large populations of adolescents, which found that only a small percentage met the minimum recommendations for moderate and vigorous physical activity, while a high percentage of adolescents exhibited sedentary behaviors for much of the day (Ferrari et al., 2020). The importance of these results is due to the fact that lack of physical activity and sedentary behaviors during adolescence are related to levels of sports practice and sedentary behaviors during adulthood (Li et al., 2016), which would increase the likelihood of diseases related to body fat accumulation, such as diabetes or cardiovascular diseases (Cristi-Montero et al., 2019). Therefore, it seems essential to increase sports practice during adolescence to prevent the onset of adiposity-related diseases such as diabetes mellitus and cardiovascular risk factors during adulthood (Cristi-Montero et al., 2019).

2.2.2. Influence of Physical Activity on Physical Fitness and Body Composition

Studies conducted in different populations have shown that greater physical activity is related to greater cardiorespiratory fitness (Lagestad & Mehus, 2018), greater strength production or better flexibility (Lee et al., 2021), with active subjects showing better physical fitness (Thomas et al., 2020) and greater satisfaction with life (Pacífico et al., 2019). Therefore, increased physical activity, especially at vigorous intensity, is essential for the improvement and maintenance of physical fitness (Beltran-Valls et al., 2020). Increased physical activity also is essential to produce changes in body composition, mainly decreases in body mass (Drenowatz et al., 2016), in factors associated with fat as percentage of fat mass, waist and hip circumference, or the sum of skinfolds (Kristiansen et al., 2018), as well as increases in muscle mass (Morelli et al., 2020). All of the above-mentioned changes in fat accumulation are related to obesity, overweight or cardiovascular risk (Ramírez-Vélez et al., 2017); they reveal physical activity to be a protective factor against these pathologies (Kallio et al., 2021).

Despite the importance of physical activity on health, and its relationship with physical fitness and body composition, previous research on the differences between active and inactive adolescents are very scarce and the evidence provided is not very clear. The instruments used, sample size, geographical location, ethnicity, or sex of the participants are very heterogeneous between studies (Cho & Kim, 2017; Khatun et al., 2016). Moreover, few studies analyze the differences between active and sedentary adolescents, as most of these include in their analyses the practice of sports activities, which have different demands and involve a totally different development of physical fit- ness and body composition. For the above reasons, the aims of this systematic review and meta-analysis were to investigate the differences in the physical fitness and body composition of adolescents who engaged in daily physical activity and those who were inactive.

2.2.3. Current Study

Based on previous research conducted in other population groups and the studies mentioned in the introduction, it was hypothesized that physically active adolescents would show higher physical fitness values (upper body strength, lower body strength, flexibility, cardiorespiratory endurance) (Hypothesis 1) and better body composition (lower fat mass, higher fat-free mass, lower body skinfolds, waist circumference) (Hypothesis 2). These hypotheses would indicate that physical activity produces significant changes in physical fitness and body composition during adolescence, which would be relevant for the associated benefits later in life. These hypotheses were addressed through statistical analysis of the individual results obtained in each of the articles included in the meta-analysis to establish whether the effect of each variable was sufficient to be considered significant.

2.3. Methods

The search strategy and inclusion criteria for the present systematic review were previously recorded with the international prospective registry of systematic review PROSPERO (code: CRD42021241975). This systematic review and meta-analysis followed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement (Liberati et al., 2009).

2.3.1. Search Strategy

The search for these studies concluded on February 1, 2021, and included articles from PubMed, EBSCO, and Web of Science databases. The search strategy was created for Web of Science and adapted to the PubMed, and EBSCO databases. The reference lists of the articles included in the study were hand-searched for relevant additional studies. Studies that examined the relationship between the levels of physical activity practiced with physical fitness, body composition and kinanthropometric variables were included in the meta-analysis.

The inclusion criteria were: (a) cross-sectional and observational studies; (b) adolescents aged 12–16 years old; (c) results divided by active and inactive group, considering active those subjects who performed physical activity more than twice a week, and inactive those who did not practice physical activity during the week (Cho & Kim, 2017); (d) written in English; (e) outcome measurements based on physical fitness, body composition, kinanthropometric variables, or these variables combined. The exclusion criteria were: (a) studies in which the active population practiced a specific sport; (b) studies conducted in adolescents with pathologies, mental or physical disorders; (c) studies whose results are divided into groups of obese and over- weight subjects; and (d) improper article type (letter, meeting abstract, communication).

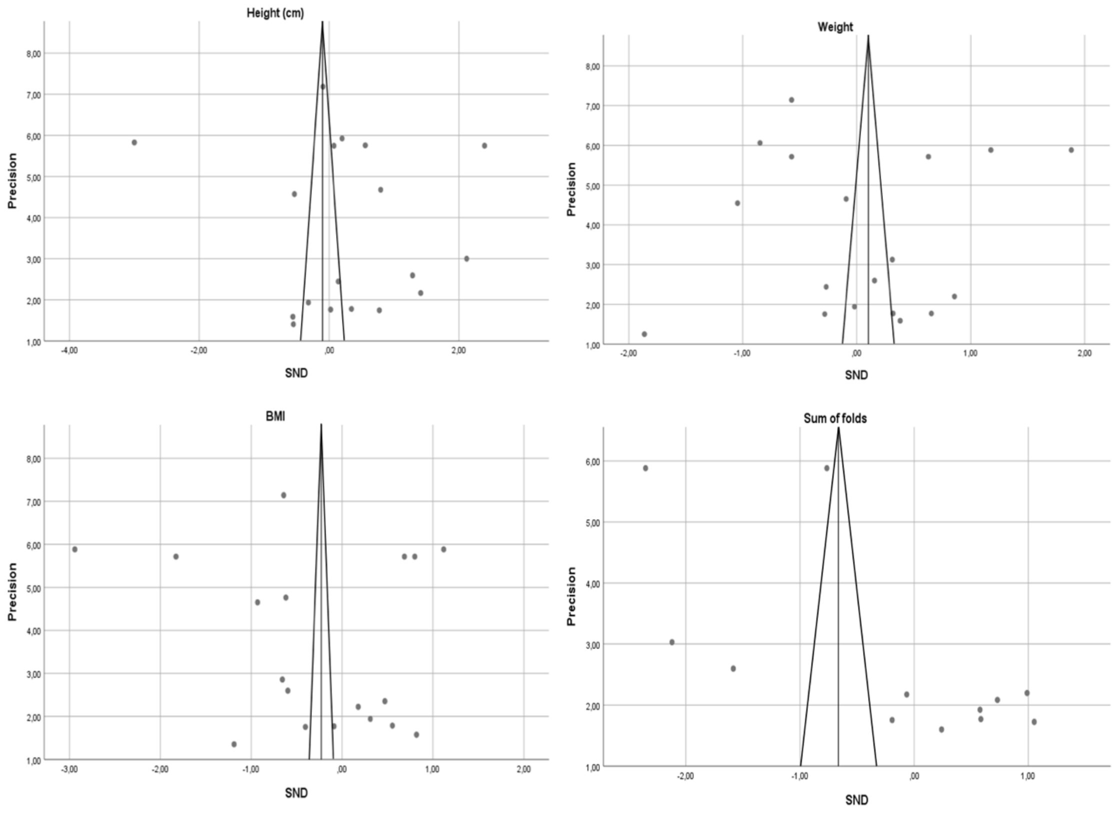
2.3.2. Data extraction and risk of bias

The search was independently carried out by two reviewers (A. M.-O. and R. V.-C.), who examined the titles and abstracts of the articles, after reviewing the full texts to determine the articles to be included in the meta-analysis. A third reviewer (L. A.-C.) was consulted to resolve any disagreements regarding the inclusion of certain articles. To determine the inter-rater reliability of the reviewers, Cohen's Kappa (McHugh, 2012) was calculated, showing a strong level of agreement (Kappa = 0.899).

2.3.3. Quality assessment and risk of bias

To assess the quality of the studies included, the Strengthening Reporting of Observational Studies in Epidemiology (STROBE) statement was used (Von Elm et al., 2008). Two reviewers (R.V-C and A. M.-O) were responsible for the quality assessment of the studies. A third reviewer was consulted to resolve any disagreements (L. A-C.). Egger's (Egger et al., 1997) bias statistics and Rosenthal's (Rosenthal, 1979) fail-safe N were used to assess the risk of bias, and funnel plots were created (Figure 1). When a meta-analysis is based on a small number of studies, the capacity of Egger's test to detect bias is limited (Sterne et al., 2011). Therefore, this test must be performed when there are at least ten studies included in the meta-analysis (Egger et al., 1997).

Figure 1. Funnel Plot.



This is the risk of bias for the variable's height, weight, body mass index, and fold sum of the articles included in the systematic review and meta-analysis. This graph represents with each point the articles that analyze the variables mentioned, as well as the effect measured for that variable in each article. The dispersion in the variables analyzed is high, so there may be publication bias in the articles included.

2.4. Statistical Analysis

The statistical analysis and meta-analysis were performed using the Comprehensive Meta-Analysis program (version 3, Englewood, Bergen County, NJ, USA). The meta-analysis was done for continuous data by using the mean and standard deviation of each variable and according to the level of physical activity (active or inactive). This information was directly extracted from the studies. The analysis was performed when at least three groups were included for the same variable. When a study included more than one group separated by sex or country, all groups were included in the analyses. For studies that did not include the necessary data, the standard deviation (SD) was calculated and imputed when possible, using standard errors and confidence intervals. The Dersimonian–Laird (Cohen) pooling method was used, and heterogeneity was assessed using the Cochrane Q test (chi2), Higgins I2, and significance (p) to determine the appropriateness of the application of a fixed or random-effect model for the pooled analysis (Ioannidis, 2008). A meta- analysis with a random-effects model was performed to infer the pooled estimated standardized mean difference (SMD) (Higgins & Thompson, 2004; Knapp & Hartung, 2003). Dersimonian–Laird (Cohen) was interpreted using Cohen's (Cohen, 1988) as small (0 to 0.2), medium (0.3 to 0.7), and large (> 0.8). The significant differences were determined at a level of $p < 0.05$.

2.5. Results

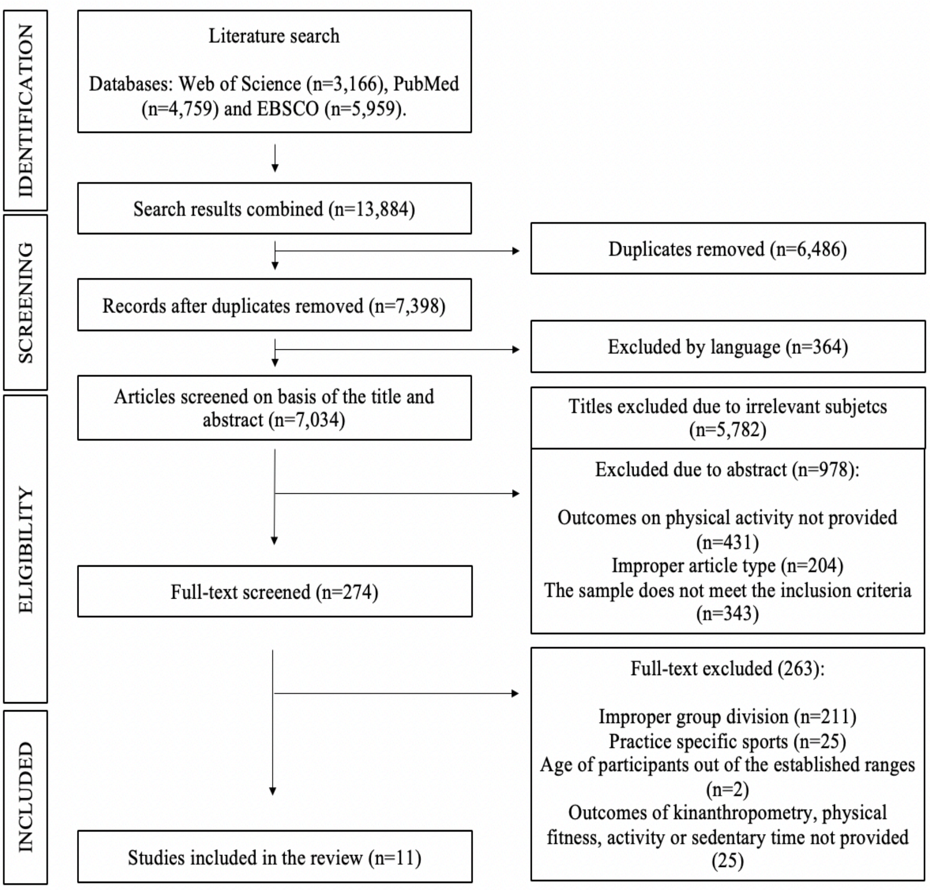
2.5.1. Data Search and Characteristics of the Studies

A total of 13,884 articles were reviewed, of which 11 were included in the meta-analysis (Figure 2).

The characteristics of the studies that were included in the meta-analysis are shown in Table 1. The quality of the selected studies, assessed with the STROBE scale, are listed in Table 2. All studies followed a cross-sectional design (STROBE scale range 14-21), involving a total of 5 938 subjects (3 167 active; 2 771 inactive). The mean sample size was 539.82 ± 801.74 (range 31-2 799). Seven studies were carried out with males and females (63.64%) (Agata and Monyeki 2018; Duncan et al. 2014; Gea-García et al. 2020; Huang and Malina 2002; Khatun et al. 2016; Pacífico et al. 2019; Sivrikaya et al. 2019), two only with females (18.18%) (Cho & Kim, 2017; De Milander, 2011), and two only with males (18.18%) (Güvenç et al., 2011; Mukhopadhyay et al., 2005).

To measure the physical activity level of adolescents, two studies used the international physical activity questionnaire (one study used the short version and one study used the children's version) (Agata & Monyeki, 2018; Gea-García et al., 2020), two studies used surveys or interviews (Cho & Kim, 2017; Khatun et al., 2016), one study used the Activity Gram questionnaire (De Milander, 2011), one study used the Al-Hazzaa and Al-Ahmadi questionnaire (Duncan et al., 2014), one study used heart rate recording to establish physical activity (Güvenç et al., 2011), one study used the Bouchard activity record (Huang and Malina 2002), one study used the physical activity questionnaire for adolescents (Pacífico et al., 2019), one study designed an ad-hoc questionnaire (Mukhopadhyay et al., 2005), and lastly, one study did not specify how to measure the level of physical activity (Sivrikaya et al., 2019).

Figure 2. PRISMA diagram of study selection.



This diagram has four distinct phases. Identification: the articles found in the databases that included the search keywords were collected; screening: repeated articles and those that were not written in English were excluded; eligibility: the abstracts were reviewed and, after this first filter, the complete articles; included: the articles that met all the inclusion criteria were selected.

Table 1. Results obtained for physical activity variables, physical fitness and body composition from the studies included in the systematic review and meta-analysis.

Author	Sex (n)	Physical activity level	Age (X±SD)	Physical Activity Measure	Physical Condition Assessed	Kinanthropometric Measurements and Body Composition
(Agata & Monyeki, 2018)	M (90)	Active (83)	14.90 ± 0.80	International Physical Activity Questionnaire Short Form Version (IPAQ-SF)	Lower body explosive strength, upper limb resistance, abdominal strength and endurance, cardiovascular fitness, hamstring, and lower back flexibility	Height, body mass, sum of two skinfolds (triceps, and subscapular), BMI, and body fat percentage (Slaughter et al., 1988) equation)
		Inactive (7)				
	F (148)	Active (125)				
		Inactive (23)				
(Cho & Kim, 2017)	F (31)	Active (16)	12.30 ± 1.20	Survey/Interview	Handgrip strength, abdominal strength and endurance, and hamstring and lower back flexibility	Height, body mass, BMI, fat mass, and fat-free mass (method: body composition analyzer Inbody 720)
		Inactive (15)	12.70 ± 0.90			
(De Milander, 2011)	F (94)	Active (48)	12 to 13	Activity Gram	Cardiovascular fitness, upper limb resistance, abdominal strength and endurance, hamstring, and lower back flexibility	Height, body mass, BMI, and body fat percentage (anthropometry)
		Inactive (46)				

(Duncan et al., 2014)	M (797)	Active (426)	16.50 ± 1.00	Al-Hazzaa & Al-Ahmadi (2003) questionnaire	-	Height, body mass, BMI, waist girth, and WHtR.
		Inactive (371)	16.60 ± 0.98			
	F (851)	Active (168)	16.40 ± 0.93			
		Inactive (683)	16.50 ± 0.95			
	M (585)	Active (483)	15.20 ± 0.98			
		Inactive (102)	15.20 ± 0.88			
	F (566)	Active (374)	15.20 ± 0.94			
		Inactive (192)	15.20 ± 0.95			
(Gea-García et al., 2020)	M (164) F (161)	Active (151)	12.39 ± 1.03	Physical Activity Questionnaire for Children (PAQ-C)	Cardiovascular fitness, speed and agility, handgrip strength, lower body explosive strength, hamstring and lower back flexibility, and abdominal strength and endurance	Height, body mass, arm span, BMI, and body fat percentage (method: bioelectrical impedance)
		Inactive (172)				
(Güvenç et al., 2011)	M (147)	Active (73)	13.00 ± 1.50	HR monitoring	Cardiovascular fitness and aerobic endurance	Height, body mass, sum of eight skinfolds (biceps, triceps, subscapular, chest, iliac crest, abdominal, thigh, and calf), body fat percentage (Slaughter et al., 1988) equation), and fat-free mass (body mass*body fat percentage)
		Inactive (74)	12.90 ± 1.40			

(Huang & Malina, 2002)	M (68)	Active (34) Inactive (34)	13.60 ± 0.80	Activity record (Bouchard et al. 1983)	Cardiovascular fitness, abdominal strength and endurance, and hamstring and lower back flexibility	Sum of four skinfolds (triceps, subscapular, iliac crest, and calf)
	F (72)	Active (36) Inactive (36)	13.60 ± 0.90			
(Khatun et al., 2016)	M (522)	Active (282) Inactive (240)	13.44 ± 2.20	Survey/Interview	-	Height, body mass, BMI, sum of five skinfolds (biceps, triceps, subscapular, iliac crest, and calf), body fat percentage ((Slaughter et al., 1988) equation), fat mass, fat-free mass, fat mass index, and fat-free mass index (VanItallie et al., 1990)
	F (546)	Active (304) Inactive (242)	13.29 ± 2.13			
Mukhopadhyay et al. (2005)	M (528)	Active (313)	13.40 ± 2.00	Ad-hoc questionnaire	-	Height, body mass, BMI, fat mass, fat mass index, ten skinfolds (subscapular, iliac crest, midaxillary, chest, abdominal, triceps, biceps, forearm, thigh, and calf), and body fat percentage ((Slaughter et al., 1988) equation).
		Inactive (215)	13.20 ± 2.10			

(Pacífico et al., 2019)	M (90)	Active (36)	16.35 ± 0.65	Physical Activity Questionnaire for Adolescents	Cardiovascular fitness, abdominal strength and endurance, hamstring and lower back flexibility, upper limb resistance	BMI
		Inactive (54)				
	F (145)	Active (47)	16.19 ± 0.67			
		Inactive (98)				
Sivrikaya et al. (2019)	M (191)	Active (104)	12 to 14	-	-	Height, body mass, BMI, and sum of five skinfolds (subscapular, triceps, biceps, iliac crest, and abdominal)
		Inactive (87)				
	F (144)	Active (64)				
		Inactive (80)				

X: mean; SD: standard deviation; M: males; F: females; BMI: body mass index; WHtR: waist to height ratio

Table 2. Analysis of the quality of the articles included in the systematic review according to the STROBE scale.

Study	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	100%	Total
(Agata & Monyeki, 2018)	1	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	81.82	18
(Cho & Kim, 2017)	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	0	0	1	0	1	0	0	63.64	14
(De Milander, 2011)	1	1	1	0	1	0	1	1	0	0	1	1	1	0	1	0	1	1	1	1	1	0	68.18	15
(Duncan et al., 2014)	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	95.45	21
(Gea-García et al., 2020)	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	86.36	19
(Güvenç et al., 2011)	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	1	0	1	81.82	18
(Huang & Malina, 2002)	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	0	1	1	0	1	0	0	68.18	15
(Khatun et al., 2016)	1	1	1	0	1	0	1	1	0	0	1	1	1	1	1	0	1	1	1	1	0	0	68.18	15
(Mukhopadhyay et al., 2005)	1	1	0	0	1	0	1	1	0	0	1	1	1	1	1	1	1	1	0	1	0	0	63.64	14
(Pacífico et al., 2019)	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	0	1	1	1	0	1	81.82	18
(Sivrikaya et al., 2019)	1	1	1	0	0	1	1	1	0	1	1	1	1	0	1	0	1	1	1	1	0	0	68.18	15
Mean of total scores:																							75.23	16.55

Within the table: *1: criterion met; 0: criterion not met;* ***In the table header***: *1: title and abstract; 2: context/rationale; 3: objectives; 4: study design; 5: context; 6: participants; 7: variables; 8: data sources/measures; 9: biases; 10: sample size; 11: quantitative variables; 12: statistical methods; 13: participants included in each phase of the results; 14: descriptive data; 15: outcome variable data; 16: main results; 17: other analyses; 18: key results discussed in the discussion; 19: limitations; 20: interpretation; 21: generability; 22: funding.*

2.5.2. Physical Fitness Test Results

Seven of the 11 articles finally included in the meta-analysis utilized physical fitness tests, using a total of 12 different tests, although eight variables were not included in the meta-analysis because they were not analyzed in three studies or more.

To assess the strength and endurance of the abdominal and hip-flexor muscles, sit-ups and curl-ups were the most common tests used in the research studies included in the meta-analysis, and were found in a total of four articles (36.36%) (Agata and Monyeki 2018; Cho and Kim 2017; Gea-García et al. 2020; Huang and Malina 2002) and two articles (18.18%) (De Milander, 2011; Pacífico et al., 2019), respectively. Considering the sit-ups, two of the four articles (50.00%) found statistically significant differences when comparing active and inactive subjects (Agata & Monyeki, 2018; Gea-García et al., 2020), while for the curl-ups, one of the two studies (50.0%) showed significant differences (Pacífico et al., 2019). It should be noted that Pacífico et al. (2019) found significant differences in the curl-up, but did not indicate the duration of the test or the criterion considered for ending it.

To assess hamstring and lower back flexibility, the sit-and-reach test was used in five studies (45.45%), with significant differences found in one of them (20.0%) (Huang and Malina 2002). The trunk flexion test was used in two studies, of which only one showed significant differences (Cho & Kim, 2017).

Cardiovascular fitness and aerobic endurance were measured in six studies using the 20-m shuttle run test, Wingate anaerobic test, progressive aerobic cardiovascular endurance run test (PACER test), and the one mile run, with significant differences found in five of the tests (Agata and Monyeki 2018; De Milander 2011; Güvenç et al. 2011; Huang and Malina 2002; Pacífico et al. 2019). Upper limb resistance was analyzed in three studies (27.27%), using the push-up test in two of them (66.67%), with one of them showing significant differences (50.0%) (De Milander, 2011), while the unique study which evaluated this parameter with the bent arm hang test (33.3%) did not find significant differences (Agata & Monyeki, 2018).

Table 3 shows the results of the meta-analysis of the comparison of the active and inactive subjects' groups (SMD standardized mean difference; 95% CI: 95% confidence interval; z test for overall effect; p significance). A positive SMD value indicates that the results of the active group were higher than those of the inactive group. The results of the meta-analysis showed that the active subjects showed significantly higher values in cardiovascular fitness and aerobic endurance (SMD = 2.22; $p < 0.001$), hamstring and lower back flexibility (SMD = 1.13; $p = 0.025$), abdominal strength and endurance (SMD = 0.50; $p < 0.001$) and upper limb resistance (SMD = 0.50; $p < 0.001$), as compared to the inactive subjects. Figure 3 represents the forest plots of the physical fitness tests that were statistically significant between active and inactive subjects. Forest plots of cardiovascular fitness and aerobic endurance, hamstring, and lower back flexibility, abdominal strength and endurance, and upper limb resistance were included.

2.5.3. Body Composition Results

A total of 12 body composition and kinanthropometric variables were analyzed in the 11 studies included in the meta-analysis. Ten body composition and anthropometric variables were analyzed in three studies or more and were therefore included in the meta-analysis.

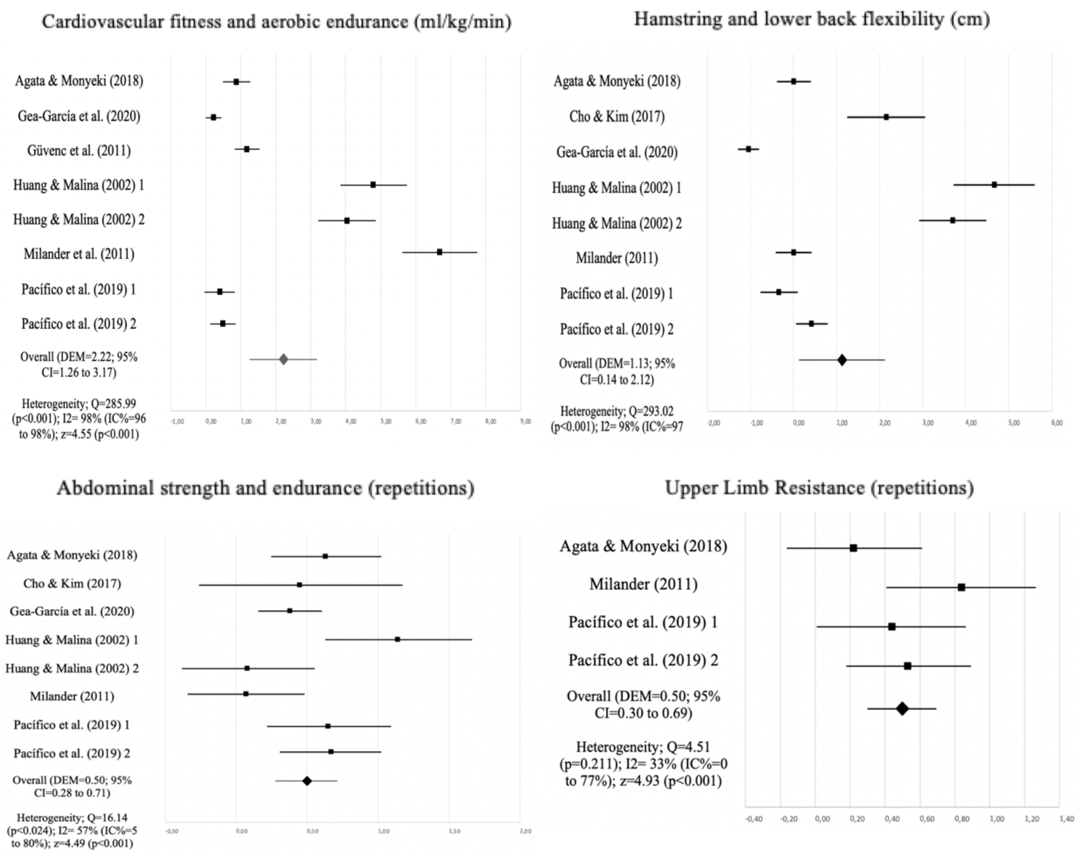
Of the eleven studies included in the meta-analysis, nine analyzed adolescent height and body mass (81.82%). For height, only three studies (27.27%) found significant differences between groups (Duncan et al., 2014; Güvenç et al., 2011; Khatun et al., 2016), while for body mass, the differences were significant in four of the nine studies (44.44%) (Cho & Kim, 2017; Duncan et al., 2014; Gea-García et al., 2020; Khatun et al., 2016). Body mass index was calculated in eight studies (72.73%) and differences were significant between active and inactive adolescents in five of them (62.50%) (Cho & Kim, 2017; Duncan et al., 2014; Gea-García et al., 2020; Khatun et al., 2016; Mukhopadhyay et al., 2005). Five articles measured the sum of skinfolds (45.45%), and six measured the percentage of fat mass of the participants (54.55%).

Table 3. Statistical differences and effect size in physical fitness and body composition variables between active and inactive subjects.

	Number of studies	Number of active and inactive groups compared	Active vs Inactive			
			SMD	95% CI	z	p
Height (cm)	9	18	0.10	-0.05 to 0.25	1.30	0.195
Body mass (kg)	9	18	0.02	-0.09 to 0.13	0.31	0.757
BMI (kg/m^2)	8	18	-0.07	-0.20 to 0.06	1.07	0.284
Sum of skinfolds (mm)	5	12	-0.03	-0.26 to 0.19	0.29	0.770
% BF	6	7	-0.39	-0.53 to -0.26	5.75	<0.001
Fat mass (kg)	3	4	-0.42	-0.77 to -0.07	2.38	0.017
Fat-free mass (kg)	3	4	0.04	-0.60 to 0.69	0.14	0.891
Fat mass index	2	3	-0.30	-0.40 to -0.20	5.93	<0.001
Waist circumference (cm)	1	4	-0.04	-0.13 to 0.04	1.00	0.319
WHtR (%)	1	4	-0.06	-0.22 to 0.09	0.84	0.403
Cardiovascular fitness and endurance (ml/kg/min)	6	8	2.22	1.26 to 3.17	4.55	<0.001
Hamstring and lower back flexibility (cm)	6	8	1.13	0.14 to 2.12	2.24	0.025
Abdominal strength and endurance (repetitions)	6	8	0.50	0.28 to 0.71	4.49	<0.001
Upper limb resistance (repetitions)	3	4	0.50	0.30 to 0.69	4.93	<0.001

SMD: standardized mean difference; CI: confidence interval; p: significance value; BMI: body mass index; % BF: body fat percentage; WHtR: waist to height ratio; VO2 max.: maximal oxygen consumption; and SUP: sit-ups.

Figure 3. Forest plots for active and inactive subjects for physical fitness tests.

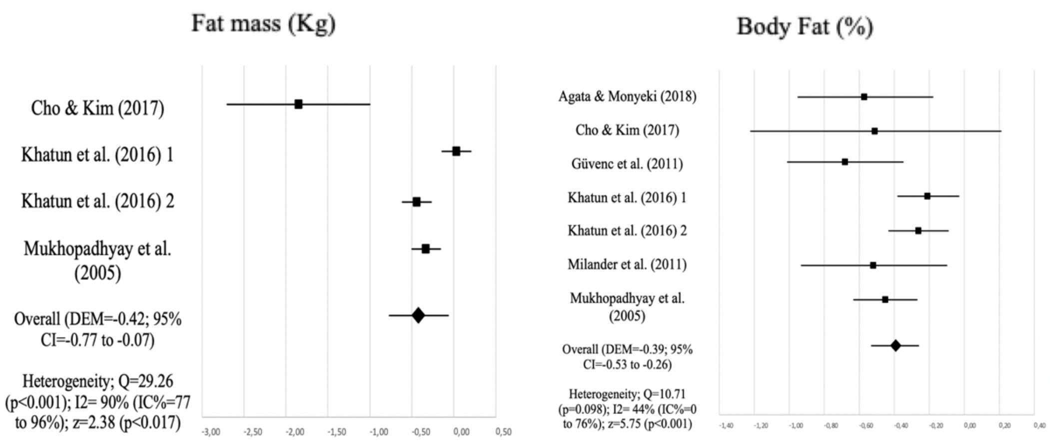


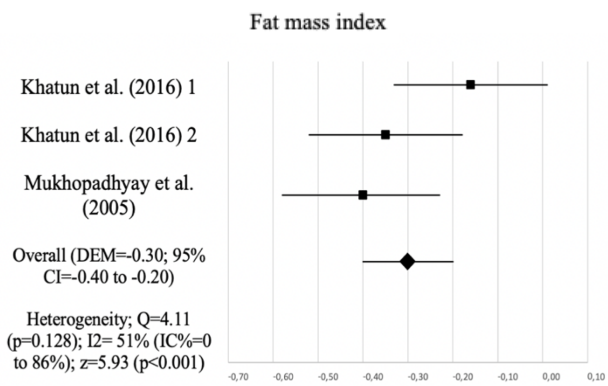
Each square represents the mean value for the variable studied in each article, and the horizontal bars the standard deviation for that variable in that study. The diamond at the bottom of each graph represents the mean value and standard deviation for all items.

Regarding the sum of skinfolds, differences between active and inactive subjects were significant in four of the five studies that included this variable (80.00%) (Agata & Monyeki, 2018; Güvenç et al., 2011; Khatun et al., 2016; Sivrikaya et al., 2019), while five of six studies (83.33%) showed significant differences in the percentage of fat (Agata & Monyeki, 2018; Cho & Kim, 2017; Güvenç et al., 2011; Khatun et al., 2016; Mukhopadhyay et al., 2005). Fat mass and fat-free mass were included in three studies (27.27%), with all three (100.00%) showing differences in fat mass (Cho & Kim, 2017; Khatun et al., 2016; Mukhopadhyay et al., 2005), while two (66.67%) in fat-free mass (Güvenç et al., 2011; Khatun et al., 2016). Two studies calculated the fat mass index (18.18%), and both found significant differences between adolescents in the active and inactive groups (Khatun et al., 2016; Mukhopadhyay et al., 2005). Waist girth and waist to height ratio were analyzed in one research (Duncan et al., 2014), but differences were not significant between active and inactive adolescents on these variables.

The results of the differences between active and sedentary subjects are shown in Table 3, including standardized mean differences (SMD), 95% confidence interval (95% CI), overall size effect (z), and significance (p). A positive SMD value indicates a higher value for active subjects than inactive subjects. The meta-analysis showed significant differences between subjects in the active and inactive groups in the variables body fat percentage (SMD = −0.39; $p < 0.001$), fat mass (SMD = −0.42; $p = 0.017$), and fat mass index (SMD = −0.30; $p < 0.001$), with the inactive subjects obtaining higher values in all variables. Body mass, body mass index, sum of skinfolds, fat-free mass, waist circumference, and waist-to-height ratio did not show significant differences between the groups. The forest plots of the variables that were significant, body fat percentage, fat mass index, and fat mass (kg), are shown in Figure 4. Egger´s test did no evidence publication of bias according to height (SE = −0.101; 95% CI = −0.404; 0.259; $p = 0.691$), body mass (SE = 0.103; 95% CI = −0.185; 0.277; $p = 0.684$) or body mass index (SE = −0.229; 95% CI = −0.394; 0.151; $p = 0.360$), although it reported light evidence of publication of bias according to sum of skinfolds (SE = −0.664; 95% CI =–0.932; 0.108; $p = 0.018$).

Figure 4. Forest plots for active and inactive subjects for body composition variables.





Each square represents the mean value for the variable studied in each article, and the horizontal bars the standard deviation for that variable in that study. The diamond at the bottom of each graph represents the mean value and standard deviation for all items.

2.6. Discussion

Research has revealed a lack of consensus on the influence exerted by physical activity on body composition and physical fitness in adolescents aged 12–16 years. In an attempt to address this situation, the present systematic review with meta-analysis was carried out, including the scientific literature published to date in which the differences in body composition and physical fitness between active and sedentary adolescents had been analyzed. The results showed that active adolescents who engaged in regular physical activity had better body com- position (lower percentage of fat, lower fat mass, and lower fat mass index) and better physical fitness (better cardiovascular endurance, better hamstring, and lower back flexibility, greater abdominal strength, and endurance and greater upper limb strength) than sedentary adolescents.

These results have made it possible to respond to the first objective set at the beginning of the research, which was to investigate the existing differences in the physical fitness of adolescents according to whether or not they practiced physical activity. An important result of the present meta-analysis was that the group of active adolescents showed significantly higher values of cardiorespiratory fitness, finding significant differences in this variable in five of the studies that included it, in favor of the active subjects (Agata and Monyeki 2018; De Milander 2011; Güvenç et al. 2011; Huang and Malina 2002; Pacífico et al. 2019). Previous research has found that the type of sport practiced or type of training performed can affect the development of cardiorespiratory fitness from childhood to adulthood (Rakovac et al., 2018), adolescence being a key stage for the development of cardiorespiratory capacity and having a great impact on the later stages of life of the subjects (Lazic et al., 2019). In this sense, one of the cardiovascular adaptations produced by the practice of systematic exercise is the development of the atria and ventricles of the heart (Castanheira et al., 2017), which would explain the differences found in the present investigation.

Of note is the great heterogeneity of the tests used to estimate cardiorespiratory fitness among the studies included in the present meta-analysis, which included four different tests with the 20-m shuttle run test (Agata & Monyeki, 2018; Gea-García et al., 2020), one mile run (De Milander 2011; Huang and Malina 2002), wingate anaerobic test (Güvenç et al., 2011) and PACER test (Pacífico et al., 2019). All four tests have been previously validated in adolescents (Batista et al., 2017), but only in one of these studies (Gea-García et al., 2020) it was indicated that the equation of Léger et al. (1988) had been used to calculate cardiorespiratory fitness. These aspects should be considered in future research.

Another result of the present meta-analysis is that the active group showed significantly greater hamstring and lower back flexibility than the inactive group; when analyzing the results of the different articles individually, it was found that there were differences in this variable in two of the six studies (Cho and Kim 2017; Huang and Malina 2002). Previous research has shown that the hamstring and lower back flexibility of adolescents is mainly influenced by the type of sports practiced. For example, the practice of sports in which the technical movements involve hamstring muscle extensibility can induce a traction stimulus that increases hamstring and lower back extensibility. Furthermore, specific stretching programs are included in the training of these sport modalities to achieve the range of motion which allows performing these specific movements with a good technique (Vaquero-Cristóbal, Molina-Castillo, et al., 2020). However, the studies included in the meta-analysis did not indicate the type of physical activity performed by the active subjects, that makes it difficult to establish whether the reason for the differences between active and inactive subjects, or between the studies that found significant differences in this capacity and those that did not, is due to the fact that the active participants practiced a certain type of sports. Therefore, the results should be taken with caution, especially considering that the sample sizes of four studies were less than fifty subjects per group (Cho and Kim 2017; De Milander 2011; Huang and Malina 2002; Pacífico et al. 2019), and that in one of the studies, a group of two hundred and eight active subjects was compared with a group of thirty sedentary subjects (Agata & Monyeki, 2018).

Another variable where the meta-analysis showed that active subjects had significantly higher values than inactive subjects was the strength and endurance of the abdominal and hip-flexor muscles. To assess this capacity, the sit-up test was used in four studies, where subjects had to perform a full sit-up and remain seated, of which two studies showed differences between groups (Agata & Monyeki, 2018; Gea-García et al., 2020); while the curl-up test was used in two studies, where subjects had to separate the upper back from the floor, of which one study showed differences between groups (Pacífico et al., 2019). The rectus abdominis and obliques are the main muscles involved during sit-ups and curl-ups (Escamilla et al., 2006). Previous studies have shown that the systematic practice of physical activity and sports is associated to an increase in the resistance of the abdominal muscles (Wang et al., 2018), suggesting that adolescents who engage in moderate to vigorous physical activity on a daily basis develop abdominal muscles to a greater extent than those who are sedentary.

The discrepancies in the protocol followed when performing the sit-up and curl-up tests lead to consider them as different tests. During the sit-up an individual almost completely sits up, while in the curl-up, there is an angle of about 30º. This could be one of the reasons for the differences found between the studies, but the following aspects should also be considered. While some of the studies included in the systematic review with meta-analysis used protocols of 30" duration (Agata & Monyeki, 2018; Cho & Kim, 2017; Gea-García et al., 2020), others opted for 60" (Huang and Malina 2002). There was also no homogeneity in foot support and knee flexion degrees, varying between keeping the feet in contact with the ground with the knees at 140º, and keeping the feet in the air with knee and hip flexion at 90º (Cho and Kim 2017; Gea-García et al. 2020; Huang and Malina 2002); or in the execution of each repetition, with some articles requesting that both knees be touched simultaneously with the elbows (Cho & Kim, 2017) and in others to touch the opposite knee alternately with the elbow (Huang and Malina 2002). The muscle activation is different depending on the trunk elevation performed, with greater or lesser pelvic and thoracic involvement (Cordo et al., 2003), which could be the reason for the differences found. Therefore, future research is needed to standardize the way of performing this test in order to corroborate the results of the present meta-analysis.

Another finding of the present study was that the active group showed significantly greater upper limb resistance than the inactive group. This variable was analyzed in three studies, and the differences between the active and inactive groups were significant in one of the two studies that used the push-ups test (De Milander, 2011), while in the research in which this variable was evaluated by means of the bent arm hang test, no significant differences were found (Agata & Monyeki, 2018). The discrepancies between the results of these studies could be due to the fact that the push-ups test is a push test that mainly involves the pectoral muscles, although differences are found depending on the placement of the hands, wrists and elbows (Kim et al., 2016), with greater activation during push-ups performed with the narrow base hand position, with the 50% and 100% palmar widths as compared with the 150% palmar width (Kyung-Hwan, 2017), while the bent arm hang test is a traction test that mainly activates the muscles of the shoulder girdle and is commonly used with climbers (Baláš et al., 2012). The different types of contraction produced in both tests could be the origin of the differences found. The push up is a dynamic exercise and the bent arm hang is an isometric exercise, and therefore they have different physiological demands and require different mechanisms for improvement (Warnock et al., 2019). In addition, it should be taken into account that the bent arm hang test and its modifications have methodological limitations. They appear to be a reliable measure of relative isometric strength, but not of absolute strength or muscular endurance (Clemons, 2014); it is a difficult and unreliable test in children (Sekeljic et al., 2015); and depend on the weight of the subject (Artero et al., 2010). Previous studies have proposed its modification or substitution with tests such as a two-handed bicep curl, so that the results are more valid (Bubanj et al., 2017). The results obtained with respect to the physical fitness of the active and inactive subjects allow to affirm the first hypothesis put forward at the beginning of the research, since the active subjects presented greater cardiorespiratory fitness, flexibility of the hamstrings and lower back, number of abdominals and strength of the upper limb.

The results also allowed to answer the second objective of the research, which was to analyze the existing differences in body composition and kinanthropometry variables of adolescents according to whether or not they practiced physical activity. The main result was that the active group showed significantly lower body fat percentage, fat mass and fat mass index than the inactive group. The latter variable calculates fat mass as a function of height, providing greater accuracy to body composition (Fedewa et al., 2020). After analyzing the results of the included articles individually, it was observed that 83.33% of the studies that estimated body fat percentage (Agata & Monyeki, 2018; Cho & Kim, 2017; Güvenç et al., 2011; Khatun et al., 2016; Mukhopadhyay et al., 2005) and 100% of those that estimated body fat mass (Cho & Kim, 2017; Khatun et al., 2016; Mukhopadhyay et al., 2005) or fat mass index (Khatun et al., 2016; Mukhopadhyay et al., 2005), found significant differences between active and inactive individuals. This could be due to the fact that the practice of moderate to vigorous intensity physical exercise produces body changes related to long-term fat loss (Espinoza-Salinas et al., 2020), while sedentary behaviors are related to fat accumulation, especially in the abdominal area (Golubic et al., 2015).

One aspect to consider when analyzing variables related to body fat is the method and formulas used for its estimation, as previous research has shown significant differences according to these (Vaquero-Cristóbal, Albaladejo-Saura, et al., 2020). In the present meta-analysis, some heterogeneity was found, as two articles analyzed these variables with bioelectrical impedance (Cho & Kim, 2017; Gea-García et al., 2020), while seven articles analyzed the percentage of fat through kinanthropometry, based on the measurement of skinfolds, muscle perimeters, and waist and hip circumferences mainly (Agata and Monyeki 2018; De Milander 2011; Güvenç et al. 2011; Huang and Malina 2002; Khatun et al. 2016; Mukhopadhyay et al. 2005; Sivrikaya et al. 2019), with four of the studies (Agata & Monyeki, 2018; Güvenç et al., 2011; Khatun et al., 2016; Mukhopadhyay et al., 2005), using the formula by Slaughter et al. (1988) which is the most commonly used formula for the assessment of adolescents (Alvero-Cruz et al., 2010).

In the present meta-analysis, no significant differences were found in fat-free mass between active and inactive subjects, and this could be due to the small number of studies that included this parameter. In fact, only three studies included it, with two of them finding differences in fat-free mass (Güvenç et al., 2011; Khatun et al., 2016). A second reason could be that this variable was estimated with bioelectrical impedance, and this method has been shown to have limitations in its validity with adolescents because the preconditions must be rigorously controlled for the measurements to be valid and reliable (Brewer et al., 2019), and the research does not indicate that these aspects have been taken into consideration. A third reason is that this component does not represent muscle mass, despite the fact that on many occasions this association is incorrectly made, since it represents mass that does not correspond to fat mass but does not correspond in its entirety to muscle mass (Jensen et al., 2019). Therefore, future research is needed to analyze the differences in muscle mass between active and inactive adolescents, as an independent parameter.

An expected result of the present investigation is that no significant differences in height were found between the active and inactive groups. Height is strongly dependent on genetics, and the influence of environmental variables is very limited (Jelenkovic et al., 2020), which could explain the results of the present investigation. However, it was surprising that there were no significant differences in body mass and body mass index. This could be because, although both parameters are frequently used to assess body composition, it is not possible to distinguish between changes in fat and muscle masses by only using these parameters (Herrero & Cabañas, 2009). The lack of changes in body mass and body mass index, which associates body mass to height, may be a consequence of the exercise-induced decrease in fat mass being compensated by an increase in muscle mass (Vaquero-Cristóbal et al., 2016). In addition, other studies have shown that fat mass and muscle mass are also influenced by factors such as energy intake (González Jiménez, 2013).

No differences were found in the sum of skinfolds between the active and inactive group, despite the fact that skinfolds are the basis of fat mass estimation using kinanthropometry (Vaquero-Cristóbal, Albaladejo-Saura, et al., 2020). Also, the analysis of the individual results in these articles showed that the differences between active and inactive subjects were significant in four of the five studies which included skinfolds (Agata & Monyeki, 2018; Güvenç et al., 2011; Khatun et al., 2016; Sivrikaya et al., 2019). The absence of significant results in this variable between the active and inactive group could be due to the heterogeneity in the number of skinfolds included in the sum, ranging from two to eight and including different skinfolds (Agata and Monyeki 2018; Güvenç et al. 2011; Huang and Malina 2002; Khatun et al. 2016; Sivrikaya et al. 2019), the protocol followed to perform the measurements (Agata and Monyeki 2018; Güvenç et al. 2011; Huang and Malina 2002; Khatun et al. 2016; Sivrikaya et al. 2019), or the plicometers used (Güvenç et al. 2011; Huang and Malina 2002; Sivrikaya et al. 2019). Therefore, it is necessary to contrast the results of the present meta-analysis in future studies in which all of these aspects are standardized.

Anthropometric indices, such as waist girths and waist to height ratio, are commonly used to assess assessing obesity during childhood and adolescence because of their simplicity, low cost, and strong correlation with the body fat percentage (Herrero & Cabañas, 2009). The present meta-analysis found that there were no significant differences between the active and inactive groups in waist girth and waist to height ratio. Only one study of those included in the meta-analysis analyzed these variables (Duncan et al., 2014), and although the sample was large (2 799) and included adolescent boys and girls, the results were limited to the geographical areas in which the research was conducted (Great Britain and Saudi Arabia). This last aspect is relevant, because the interaction of genetic and environmental factors seems to influence certain elements of body composition, as is the case of waist girth (Arya et al., 2018). In addition, it would be necessary to know other aspects such as television viewing hours or parental lifestyle habits, as they are positively associated with adolescent waist girth (Bruce et al., 2021); or the body composition of adolescents when they were still children, as previous research has shown that the waist-to-height ratio of girls was higher than expected during adolescence, the higher the body mass index was during childhood (Biro et al., 2010). The results obtained in the present systematic review regarding the differences in body composition between active and inactive subjects confirm the second hypothesis. However, of all the variables included, only the percentage of body fat, fat mass and fat mass index showed statistically significant differences, so it is necessary to continue to investigate the reasons why certain parameters of adolescent body composition are modified by the practice of physical activity.

The results obtained in the systematic review and meta- analysis reaffirm the importance of physical activity for the adolescent population. Although the number of physical fitness and body composition variables included in the meta-analysis was not very large, the results provided significant differences in physical fitness and body composition variables between physically active and inactive adolescents. This work provides a solid starting point to encourage the promotion of physical activity by sports and educational organizations, with the aim at increasing the level of physical activity among adolescents and reducing the risk of suffering any type of chronic disease that may appear during adolescence or adulthood. Although future research is needed to analyze more variables on which modifications can occur with the practice of physical activity, this study was necessary to obtain conclusions supported by statistical values with which to make professionals working with adolescents aware of the importance of physical activity in their development.

During the systematic review and meta-analysis, some limitations were observed in the available scientific literature. Firstly, the protocols used to assess physical fitness tests, body composition and anthropometric variables were different. Secondly, the sample sizes used in some of the articles were small, which makes their comparison, and the final interpretation of the meta-analysis results difficult. And thirdly, the samples used in the investigations included a disparate number of boys and girls, and some of them even included participants of only one sex, which makes it difficult to draw conclusions for adolescents as a whole.

With respect to the strengths of the present review, it should be noted that it was carried out in accordance with the PRISMA and STROBE declarations, that the number of studies included at the beginning of the review was very high, that it included meta-analyses that provided statistically relevant data on the effects found in the articles reviewed, and provides an overview of the scientific articles published to date that address the influence of physical activity on physical fitness and body composition in adolescents. Although these strengths make the article strong, some limitations should be noted. Firstly, research in a language other than English was not included, nor were unpublished articles or scientific productions other than articles (abstracts of meetings, conferences, etc.). Secondly, the selection of studies that divided their sample between active and inactive adolescents left out numerous articles that compared adolescents who practiced specific sports with those who did not. Thirdly, this review includes only cross-sectional studies, while interventions and longitudinal studies could provide other relevant data. And, fourthly, some of the studies used included samples from different countries, which implies the comparison of adolescents with different ethnicities, social classes and customs that were not considered, which could influence the results obtained.

2.7. Conclusion

Research conducted to date on the differences between active and sedentary adolescents aged 12–16 years did not provide consistent results that would allow conclusions to be drawn. For this reason, this systematic review with meta- analysis was needed to establish the differences between adolescents in both groups. The results obtained show that being an active adolescent is associated with better physical fitness, as shown by the statistically higher values in cardiovascular fitness and aerobic endurance, hamstring, and lower back flexibility, abdominal strength and endurance, and upper limb resistance, as compared to inactive adolescents. A relationship was also found between being active during adolescence and better body composition in all parameters related to fat mass, with inactive adolescents showing significantly higher values in all the variables related to fat mass. However, no differences were found in the other anthropometric and derived parameters, perhaps due to the different sample sizes, and the instruments and methodologies used in the studies. The results obtained allow to affirm that physical activity is necessary to achieve changes in the physical fitness and body composition of adolescents from 12–16 years of age, this being relevant to emphasize the promotion of youth sports in all educational and sports centers. The fact that adolescents develop in the best physical and psychological conditions is fundamental for them to become healthy adults with full autonomy to develop their duties during adulthood. Therefore, it is necessary to emphasize that all organizations and professionals working with adolescents give daily physical activity the importance that this research reflects.

IIb – ESTUDIO 2: Mobile application interventions to increase physical activity and their effect on kinanthropometrics, body composition, and fitness variables in adolescent aged 12-16 years old: An umbrella review

ESTUDIO 2 – MOBILE APPLICATION INTERVENTIONS TO INCREASE PHYSICAL ACTIVITY AND THEIR EFFECT ON KINANTHROPOMETRICS, BODY COMPOSITION, AND FITNESS VARIABLES IN ADOLESCENT AGED 12-16 YEARS OLD: AN UMBRELLA REVIEW

2.1. Abstract

Background: The aims of the present umbrella review were (a) to summarize the available evidence on the effectiveness of mobile applications aimed at increasing physical activity; (b) to analyse the effect of an increase in physical activity on kinanthropometric variables, body composition and physical fitness of adolescents aged 12–16 years old; and (c) to determine the strengths and limitations of the interventions carried out with adolescents aged 12–16 years old through the use of mobile applications, to provide recommendations for future research. Methods: The most relevant inclusion criteria were (a) adolescents aged 12–16 years old; (b) interventions carried out only with mobile apps; (c) pre-post measurements; (d) participants without illnesses or injuries; and (e) interventions lasting more than 8 weeks. The databases used to identify the systematic reviews were the Web of Science, Google Scholar, PubMed, and Scopus. Two reviewers independently used the AMSTAR-2 scale to measure the methodological quality of the included reviews and also carried out an analysis of external validity, with a third reviewer participating in the cases in which consensus was not reached. Results: A total of 12 systematic reviews were included (these included a total of 273 articles that used electronic devices, of which 22 studies exclusively used mobile applications with adolescents aged 12–16). Regarding physical activity and its effect on body composition, kinanthropometric variables and physical fitness, no significant differences were found for any of the variables analysed, and the results were not sufficiently consistent to determine the influence of these interventions. Conclusions: It is important to highlight that the scientific research conducted so far showed that mobile applications were not effective in increasing physical activity and changing the kinanthropometric variables, body composition or physical fitness of adolescents. Thus, future research with stronger methodological rigor and larger samples is needed to provide stronger evidence.

2.2. Introduction

Adolescence is a crucial stage for the creation of healthy lifestyle habits that can be maintained during adulthood (Badawy & Kuhns, 2017; Hayba et al., 2021; Li et al., 2017). Physical activity, kinanthropometric variables, body composition and physical fitness have been commonly studied in recent decades, not only due to their importance in the health of adolescents (Mateo-Orcajada, González-Gálvez, et al., 2022) but also to their close relationship with each other. Kinanthropometry, understood as the study of human size, shape, proportion, composition, maturation and gross function (Esparza-Ros et al., 2019), together with body composition, is modified by the practice of physical activity. Some of the important modifications include the decrease in fat mass and the increase in muscle mass in adolescents who are more physically active (Gralla et al., 2019; Mateo-Orcajada, González-Gálvez, et al., 2022). This is because physical activity during adolescence leads to greater energy expenditure and contributes towards the regulation of appetite and caloric intake, favoring a negative energy balance that influences the decrease in fat mass and waist circumference, as well as the increase in fat-free mass (Blundell, 2011).

With respect to physical fitness, previous research has shown that physical activity is also a determinant factor for its improvement, as active adolescents have higher values of cardiorespiratory fitness, hamstring and lower back flexibility, sit-ups and upper limb resistance, than inactive adolescents (Mateo-Orcajada, González-Gálvez, et al., 2022). This is because regular physical activity benefits muscular strength (Cronholm et al., 2020; Rosengren et al., 2021) and cardiorespiratory capacity (Chacón-Borrego, 2022), which may positively influence the results of fitness tests.

In addition, modifications in physical activity, kinanthropometric variables, body composition or physical fitness are related to numerous diseases and metabolic changes that affect the levels of plasma ferritin, which is essential in the process and function of various organs. Its depletion can lead to coronary heart disease or neurodegenerative disorders, in addition to an alteration in iron storage and supply (Shattnawi et al., 2018); decreased mental health (Rodriguez-Ayllon et al., 2019; Zhang & Chen, 2019), which is currently an important factor in the adolescent population, given the increases in anxiety, depression and suicide rates (Uddin et al., 2019); insulin resistance, which is a key trigger for impaired glucose metabolism, type-2 diabetes and cardiovascular disease in children and adolescents (Maffeis & Morandi, 2018); or changes in enzyme concentrations, such as the aspartate aminotransferase to alanine aminotransferase ratio, which indicates liver function and is related to cardiovascular abnormalities in this population (Elizondo-Montemayor et al., 2018; López-Gil et al., 2021), among other aspects affecting the health of adolescents.

Therefore, the practice of physical activity has been shown to be fundamental for the maintenance of adequate physical fitness and body composition, understood as a fat mass value between 10% and 25% in boys and between 17% and 32% in girls, with higher or lower values being unhealthy and associated with cardio- vascular disease (Lohman & Going, 2006). This is especially relevant, as an adequate body composition, adequate levels of body fat and high physical fitness during adolescence have a high probability of being maintained during adulthood, thereby facilitating the prevention of numerous diseases, and decreasing the cost of public health care (Eisenmann et al., 2005). However, physical inactivity in the adolescent population is increasing every year, making it difficult to achieve an adequate level of physical activity, defined by the World Health Organization (WHO) as the performance of 60 or more minutes of daily physical activity of moderate to vigorous intensity (DiPietro et al., 2020), which would be beneficial for the body composition and physical fitness in this population (Guthold et al., 2020).

In light of this situation, mobile technologies have been playing a relevant role in recent years (Statista, 2019), trying to improve the health status of the population, as shown by both the increase and improvement of applications developed for mobile devices (Li et al., 2017; Li et al., 2020; Zhang et al., 2013). Mobile applications cover many areas of life, with health being one of the most important, thanks to the development of applications for improving the quality of life (Plaza et al., 2011), human posture (Moreira et al., 2020), increased physical activity (Kim & Seo, 2020; Laranjo et al., 2021; Yerrakalva et al., 2019), medication adherence (González de León et al., 2021; Peng et al., 2020) or sleep (Elavsky et al., 2018), of middle-aged adults and older adults, becoming a useful tool for health promotion in these populations.

The adolescent population has also benefited from the increased number of health-related mobile applications (Fedele et al., 2017; Radovic & Badawy, 2020), especially those used to follow the evolution of certain diseases or to facilitate their treatment, by means of daily reminders for the intake of medications. They have become especially important in diseases related to diabetes (Dinath & Mearns, 2019; Holtz et al., 2019; Trawley et al., 2016), mental illness (Gipson et al., 2017; O'Dea et al., 2020), oral hygiene (Scheerman et al., 2020), eating disorders (Darcy & Lock, 2017) or weight control in adolescents with complex health needs (Rivera et al., 2018; Rodgers et al., 2018). In addition, mobile applications aimed at increasing the physical activity of adolescents (Direito et al., 2015a; Suleiman-Martos et al., 2021) have become relevant, but despite the many research studies carried out in recent years, the results obtained on the efficacy of mobile applications are inconclusive, as some interventions showed significant differences in physical activity of adolescents (Chen et al., 2017; Garde et al., 2015; Seah & Koh, 2021), whereas other studies showed little or no significant differences (Cowdery et al., 2015; Direito et al., 2015b, 2015b; Suleiman-Martos et al., 2021), with the effects on kinanthropometric variables, body composition, and physical fitness being very small.

Due to the lack of consensus among the different mobile interventions for increasing physical activity, and the effects produced on kinanthropometric variables, body composition and physical fitness of adolescents, numerous systematic reviews have been carried out on this topic in recent years (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022). The main aim of these systematic reviews has been to evaluate increases in the level of physical activity or daily steps of adolescents, by means of mobile applications, and to analyse the effect of this improvement on their kinanthropometric variables, body composition and physical fitness. However, the results of these systematic reviews are very disparate, and a more in-depth analysis is needed. Thus, the aims of the present umbrella review were (a) to summarize the available evidence on the effectiveness of mobile applications aimed at increasing physical activity; (b) to analyse the effect of increased physical activity on kinanthropometric variables, body composition and physical fitness of adolescents aged 12–16 years old; and (c) to determine the strengths and limitations present in the interventions carried out in the adolescent population aged 12–16 years old through the use of mobile applications, in order to provide recommendations for future research.

2.3. Methods

The present umbrella review of systematic reviews and meta-analyses was carried out according to Smith et al. 2011). Before starting, the protocol was registered in PROSPERO (code: CRD42022310373), and the guidelines from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were taken into account (Moher et al., 2009).

2.3.1. Identification of reviews and search strategy

The Web of Science, SCOPUS, PubMed and Google Scholar databases were used to search for systematic reviews. The search terms used to find systematic reviews based on mobile interventions for improving physical activity and body composition in adolescents were 'mobile phone', 'mobile application', 'body composition', 'adolescents', 'physical fitness', 'physical activity', 'anthropometric outcomes', 'intervention', 'systematic review' and 'meta-analysis' and all their possible synonyms and truncations. The detailed search strategy used is shown in Supplementary Table 1. In addition, the bibliographic references of the systematic reviews found by the search were reviewed to identify possible undetected studies. Thus, all studies that included a population, study design, intervention protocol and results in line with the search terms were included.

2.3.2. Eligibility criteria

Systematic reviews of randomized and non-randomized controlled trials were included if they met the following inclusion criteria: (a) the study population consists of adolescents between 12 and 16 years of age or a mean age in between; (b) interventions targeting only physical activity measured objectively (accelerometers or similar devices) or subjectively (previously validated questionnaires); (c) the intervention exclusively used mobile applications (stand-alone intervention using apps); (d) the studies included in the review performed a minimum of two data collections during the intervention (baseline and post-intervention); (e) the systematic review included studies that analysed the effects of the mobile applications by comparing pre and post values or by comparing the intervention group with the control group; and (f) the control group did not use any other alternative application nor did they start a simultaneous physical activity programme; they continued with their normal physical activity and were measured at the same time points as the intervention group. The search was limited to systematic reviews in English and Spanish, and all reviews available until 25 February 2023, were included. Systematic reviews with at least one of the following exclusion criteria were excluded: (a) systematic reviews conducted in unhealthy adolescents (with some type of disease or injury); (b) studies that did not base their intervention on the use of mobile applications; (c) multicomponent interventions that included mobile applications together with another technique to change behaviour (web-based, text messages); (d) interventions lasting less than 2 months (8 weeks) were excluded because this is the minimum time necessary, according to previous scientific literature, for interventions in children and adolescents to be effective (van de Kop et al., 2019); (e) systematic reviews with study populations younger than 12 years old or older than 16 years old, except in cases in which the results appeared separately and information could be extracted for adolescents; (f) systematic reviews whose main outcome was not physical activity, although a secondary outcome could be healthy behaviours; (g) studies that exclusively analysed treatments for obesity or pediatric weight control; and (h) studies that were not systematic reviews or systematic reviews with meta-analysis.

The inclusion of adolescents aged 12–16 years was due to the considerable physical and psychological changes that occur at this stage as a result of puberty (Beunen et al., 2006), as well as the changes in their peer group (Jindal-Snape et al., 2020), academic demands (Evans et al., 2018), social behaviours (Jindal-Snape et al., 2020) or mental health (Evans et al., 2018), with the decrease in the adolescents' practice of physical activity during this stage being one of the most noteworthy aspects (Remmers et al., 2020; Ridley & Dollman, 2019), together with a decrease in the practice of extracurricular physical activity as adolescents become older (De Meester et al., 2014).

Supplementary Table 1. Database search strategy.

Database	Search strategy	Number of records
Web of Science	"mobile phone" or "smartphone" or "earphone" or "m-health" or "e-health" or "mobile applications" or "cell phone" or "mobile device" or "mobile apps" or "health" (Topic) and "skinfolds" or "physical condition" or "physical activity" or "physical fitness" or "body composition" or "anthropometric outcomes" or "body weight" or "kinanthropometrics variables" or "fat mass" or "muscle mass" (Topic) and "adolescents" or "teenagers" or "youth" or "young adults" (Topic) and "intervention" or "longitudinal" (Topic) and "systematic review" or "meta-analysis".	1021
Google Scholar	(mobile phone OR mobile apps) AND (skin folds OR physical condition OR physical activity OR physical fitness OR body composition OR anthropometric outcomes OR body weight) AND (adolescents OR youth OR teens) AND (systematic review) AND (intervention).	7380
PubMed	("mobile phone" or "smartphone" or "earphone" or "m-health" or "e-health" or "mobile applications" or "cell phone" or "mobile device" or "mobile apps" or "health") and ("skinfolds" or "physical condition" or "physical activity" or "physical fitness" or "body composition" or "anthropometric outcomes" or "body weight" or "kinanthropometrics variables" or "fat mass" or "muscle mass") and ("adolescents" or "teenagers" or "youth" or "young adults") and ("intervention" or "longitudinal") and ("systematic review" or "meta-analysis").	877

SCOPUS	(TITLE-ABS-KEY ("mobile phone" OR "smartphone" OR "earphone" OR "m-health" OR "e-health" OR "mobile applications" OR "cell phone" OR "mobile device" OR "mobile apps" OR "health") AND TITLE-ABS-KEY ("skinfolds" OR "physical condition" OR "physical activity" OR "physical fitness" OR "body composition" OR "anthropometric outcomes" OR "body weight" OR "kinanthropometrics variables" OR "fat mass" OR "muscle mass") AND TITLE-ABS-KEY ("adolescents" OR "teenagers" OR "youth" OR "young adults" adults") AND TITLE-ABS-KEY ("intervention" OR "longitudinal") AND TITLE-ABS-KEY ("systematic review" OR "meta-analysis")) AND (LIMIT-TO (DOCTYPE, "re") OR LIMIT-TO (DOCTYPE, "article")) AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Spanish"))	1356

2.3.3. Article selection

After eliminating duplicate articles, two reviewers independently (A. M.-O. and R. V.-C.) screened the titles and abstracts according to the inclusion and exclusion criteria. In the second phase, the reviewers analysed the full texts and selected the final articles that would form part of the present study, with a Cronbach's alpha for the level of agreement of 0.98 between the two reviewers. In the articles for which an agreement was not reached between the two reviewers, a third reviewer (L. A.-C.) determined the eligibility of the article for being part of the review.

2.3.4. Data extraction

The data extraction was carried out by two reviewers (A. M.-O. and R. V.-C.) following the instructions indicated in the PRISMA statement (Moher et al., 2009). The data included in each systematic review were as follows: authors and year of publication, aim, databases analysed, eligibility criteria, number of studies included, number of participants and characteristics and inclusion or not of a meta-analysis (Table 1). In addition, Table 2 shows the selected research designs, type of intervention, duration of intervention, findings on physical activity and secondary outcomes (effect on kinanthropometric variables, body composition and physical fitness) and authors' conclusions. If there was disagreement between the data extracted by the two reviewers, a third reviewer (L. A.-C.) oversaw the data extraction, resolved the conflicts, and obtained an agreement (the information on each systematic review is included in Table 2).

2.3.5. Quality assessment

To analyse the quality of the systematic reviews included in the study, the AMSTAR-2 tool (Shea et al., 2017) was used (Table 3), which has a moderate validity for analysing the quality of systematic reviews (average kappa value 0.51) (Lorenz et al. 2019). This instrument is composed of 16 items: research question and

Table 1. Information about the authors, aim, and methodology issues in each systematic review included in the present study.

Authors and Publication Year	Aim	Analyzed databases	Eligibility criteria	Number of studies included	Number of participants and characteristics	Meta-analysis
Badawy & Kuhns (2017)	To evaluate efficacy of text messaging and mobile phone app interventions to improve adherence to preventive behavior among adolescents	Medline; Embase; CENTRAL; CINAHL; PsycINFO; Web of Science; Center for Review and Dissemination; INSPEC; Proquest dissertations; Scopus; ClinicalTrails.gov; WHO Clinical Trials; Controlled-Trialls.org; IEEE Explore; Google Scholar	Inclusion criteria: original research; controlled trails, quasi experimental studies, or pilot pre-post studies; at least one primary or secondary outcome related to adherence to preventive behavior; studies focused on parents rather than on adolescents, disease monitoring without intervention, or use of other forms of technology were excluded	19 (four studies used. Two of these were carried out in adolescents. One of these use mobile apps to improve physical activity and physical fitness in adolescents)	A total of 51 male and female participants (18 in the control group and 33 in the app intervention group) participated in the included study. The mean age was 15.55-year-old in the control groups and 15.75 years old in the intervention groups.	No
Böhm et al. (2019)	To evaluate the effects of mobile health (mHealth) and wearable activity trackers on PA-related outcomes	CENTRAL; PubMed; Scopus; SPORTDiscus; Web of Science	Inclusion criteria: published in peer reviewed journals in English; from 2012 to 2018; focused on children and/or adolescents; included healthy participants; examined the use of at least 1 mHealth tool or wearable; measured at least 1 PA-related variable as the outcome	7 (four studies used apps with children and adolescents. Of these, one used apps with adolescents)	A total of 51 male and female participants (33 intervention group and 18 control group) participated in the two included studies. The mean age was 15.7 years.	No

Covolo et al. (2017)	To find scientific evidence on the efficacy of apps in promoting health lifestyles	PubMed; Embase; Google Scholar	Inclusion criteria: randomized controlled trial design; written in English; full text available; key terms found in the paper; articles with original data; intervention with mobile apps, alone or associated with other technologies. Exclusion criteria: studies considering only a Personal Digital Assistant; studies carried out to evaluate the use of apps in diseases.	40 (only one study exclusively used apps with adolescents)	A total of 51 participants (33 intervention group and 18 control group) were included between the ages of 14 and 17 years old (mean age: 15.7).	No
Goodyear et al. (2021)	To update the evidence-based online physical activity interventions for young people and analyze the outcomes associated with online interventions across physical, cognitive, and social domains.	MEDLINE; PubMed; EBSCO and EMBASE	Inclusion criteria: children and young people aged 5-18 years old; use of an online-based medium to deliver an intervention related to physical activity; outcomes related to changes in physical activity, and in physical, cognitive, social, and affective domains; and quantitative, qualitative, and mixed methods studies.	26 (two studies used smartphone or mobile apps in adolescents)	281 male and female participants were included (172 intervention group and 109 control group). Mean age: 13.7 years old.	No
He et al. (2021)	To determine the effectiveness of smartphone-based interventions for improving PA in children and adolescents	PubMed; Web of Science; OVID; Scopus; and the China National Knowledge Infrastructure	Inclusion criteria: children and adolescents aged 6-18 years old; smartphone as the intervention tool, which used either an app or SMS text messaging or both to promote physical activity; control groups included participants not using smartphone technology; outcomes related to physical activity, including daily steps or any intensities of physical activity; the study design was randomized controlled trials.	9 (four studies based exclusively on smartphone apps, but only one used apps more than 8 weeks in duration)	A total of 51 male and female participants (33 intervention group and 18 control group) were included between the ages of 14 and 17 years old (mean age: 15.67).	Yes

Lee et al. (2021)	To systematically examine the effects of Pokémon Go play compared to non-players on individuals' PA, and psychological and social outcomes in cross-sectional, longitudinal, and experimental studies	PubMed; SPORTDiscus; PsychINFO; Web of Science; Science Direct; and Scopus	Inclusion criteria: quantitative research published in English; examined the relationships between or impact of Pokémon Go on PA, psychological, and/or social outcomes; and included participants who played or were exposed to Pokémon Go.	36 (three studies were conducted in adolescents, but only one were longitudinal and assessed physical activity level)	190 male and female participants (103 control group and 87 experimental group) with a mean age of 13.32 years old.	No
Mazeas et al., (2022)	The aim of this systematic review and meta-analysis is to evaluate the effectiveness of gamified interventions and their health care potential by testing the generalizability and sustainability of their influence of physical activity and sedentary behavior.	PubMed, Embase, Scopus, Web of Science, Cochrane Central Register of Controlled Trials	Inclusion criteria: studies were included when they used gamified interventions in daily life with an active or inactive control group and when they assessed a physical activity or sedentary behavior outcome.	16 (only one study used mobile apps in adolescents over 12 years of age)	51 male and female participants (33 intervention group and 18 control group) with a mean age of 15.7 years old	Yes

Pakarinen et al. (2016)	To describe and explore health game interventions that enhance the physical activity self-efficacy of children and to evaluate the effectiveness of these interventions	Medline; CINAHL; PsychINFO; EMBASE; and Cochrane Library	Inclusion criteria: participants had to be aged 18 years old or younger; the intervention needed to be a video game intervention, which incorporated a component that aimed to enhance physical activity self-efficacy; studies had to contain intervention and control group;	5 (one study used apps in adolescents)	A total of 51 male and female participants (18 in the control group and 33 in experimental group) with a mean age of 15.7 years.	No
Rose et al. (2017)	To summarize evidence on the effectiveness of digital interventions to improve diet quality and increase physical activity of adolescents, to discover effective intervention components and to assess the cost-effectiveness of these interventions.	MEDLINE; PsychINFO; CINAHL; PubMed; Embase; ERIC; NHS EED; and CENTRAL.	Inclusion criteria: intervention with and without control group; participants fall within the specified age range of 10-19 years old; digital interventions; studies that measure a diet or PA outcome at two or more time points, and where one measurement is a baseline measure; any setting; and any population of adolescents.	27 (only one study used mobile phone applications in adolescents)	51 male and female participants (18 in the control group and 33 in the experimental group) aged 14-17 years old.	No
Schoeppe et al. (2016)	To address the gaps in the literature by summarizing evidence for the efficacy of interventions that use apps to improve diet, physical activity, and sedentary behaviour	Scopus; CINAHL; SportDiscus; PsychINFO; and Web of Science	Inclusion criteria: use an app in an intervention to influence at least one of the following lifestyle behaviours: dietary intake, physical activity, or sedentary behaviour; children and/or adults; focused on behaviour change for disease prevention; and reported data regarding efficacy for behaviour change	27 (five studies targeted children or adolescents, but only one with an intervention of 8 weeks that measured physical activity)	51 male and female adolescents (18 control group and 33 intervention group) with a mean age of 15.7 years old	No

Shin et al. (2019)	To systematically review mobile phone interventions among adolescents; to statistically analyze intervention effects; and provide evidence that interventions were optimized to promote physical health and fitness	Medline; Embase; Cochrane Library; Cumulative Index to Nursing and Allied Health Literature; KoreaMed; and Research Information Sharing Service.	Inclusion criteria: adolescents with no health conditions, aged between 10 and 19 years old, or a mean age within this range; interventions included using mobile phones to improve health and fitness (physical activity, dietary intake, and sedentary behaviour); outcomes were fitness, body weight, and behavior changes; the studies were randomized controlled trials and non-randomized controlled trials that explored the effectiveness of mobile phone interventions.	11 (two studies included health applications on individuals' smartphone alone)	81 male and female adolescents (48 experimental and 33 control group). Mean age: 14.51.	Yes
Xu et al. (2022)	To investigate gamification apps in mHealth for improving PA levels.	PubMed; Scopus, Web of Science; Embase; CINAHL; IEEE Xplore.	Inclusion criteria: original empirical research, including qualitative and quantitative research. Peer-reviewed papers. Full text available in English. Clearly specify gamification or the use of at least one game element. Gamification is delivered through digital devices. The purpose of gamification is to promote PA. The papers describe at least one outcome regarding exercise or PA participation, which could be subjective self-report or objective indicator measurement.	50 (four studies used apps and of these, two were carried out in adolescents, but only one had a duration of 8 weeks or more)	51 male and female adolescents (33 intervention group and 18 control group) with a mean age of 15.7 (range 14 to 17 years old).	No

Table 2. Information about the designs, findings, and conclusion of each systematic review included in the present study.

Authors	Designs	Interventions	Duration	Findings	Authors' Conclusions
Badawy & Kuhns (2017)	RCT	Both immersive and non-immersive apps were used.	8 weeks	The study that used mobile applications in the intervention showed no significant differences in the physical activity level, nor in the time required to complete a mile walking or running. At 2 month follow-up, no significant differences were found in the time needed to complete 1-mile walk or run using an immersive app d=0.24 (IC: -0.43 to 0.9) or nonimmersive app d=-0.14 (IC: -0.81 to 0.54), compared to control group.	Despite the promising feasibility and acceptability data of mobile phone apps in improving preventive behavior among adolescents, the evidence for actual behavior change is modest, with most studies of relatively low to moderate quality.
Böhm et al. (2019)	RCT	Both immersive and non-immersive apps were used.	8 weeks	The study showed that after eight weeks, no significant increases for self-reported PA and PA self-efficacy were recorded. No statistically differences on physical fitness. The average daily time spent in MVPA decreased in the immersive app and control group, but the non-immersive app increased the MVPA.	No clear recommendations can be derived. In the field of mHealth, mobile games as apps were widely accepted. Future research should focus on developing age-appropriate games to increase PA among children and adolescents. There is a great lack of studies that seems to exist, especially in the European area. Future studies should aim to strengthen the evidence with a strong methodological quality design, an appropriate sample size, follow-up beyond post-intervention and the use of objective and valid measuring instruments.
Covolo et al. (2017)	RCT	Both immersive and non-immersive apps.	8 weeks	Fitness improved in both groups (immersive and non-immersive apps), but no significant differences as compared to controls. No changes in self-reported physical activities ($p > 0.05$).	The negative results found by this systematic review highlights the need to put more efforts into improving the quality of methodology used to evaluate the effectiveness of app interventions, not only in terms of high-quality study design but also of an approach to mHealth technology.

Goodyear et al. (2021)	RCT; and non-randomized controlled trial	First study: Both immersive and non-immersive apps were used. Second study: Mobile Applications	8 to 14 weeks	First study showed that time to complete 1-mile run/walk decreased in both intervention groups (immersive and non-immersive apps) but changes were not statistically different to the control group (immersive app vs control p=0.20; non-immersive app vs control p=0.32). No intervention effects found for self-reported PA (immersive app vs control p=0.78; non-immersive app vs control p=0.42). The second study showed a significant decrease in PAQ-A scores in the control group (p<0.001) and non-significantly in the intervention group (p=0.505).	The studies in this review provide a convincing rationale for the use of online interventions to support engagement with physical activity, due to the positive effects on physical and affective outcomes. The positive outcomes of this review suggest that online interventions are promising research.
He et al. (2021)	RCT	Both immersive and non-immersive apps were used.	8 weeks	No significant differences for self-reported PA were found. The short-term intervention effects may be attributed to the curiosity of the participants in the early stages of the intervention, but the decline in the interest and compliance of the participants led to the intervention effect not being maintained (the second and subsequent weeks decrease adherence).	Interventions with smartphones may be a promising strategy to increase the number of steps and total physical activity of children and adolescents, but the effect of intervention in moderate to vigorous physical activity remain to be studied. Additional studies are needed to determine the effects.
Lee et al. (2021)	RCT	Pokémon Go	8 weeks	The study showed that players walked 54 km and spent 40 minutes per day playing Pokémon Go. Thus, this app increases the amount of daily exercise in adolescents.	Findings indicate that Pokémon Go was associated with increased light intensity physical activity and walking. Future studies are needed with rigorous study design, as well as validated and homogeneous outcome measures to confirm the findings and explore ways to improve the game's current inability for players' long-term engagements and higher intensity physical activity.

Mazeas et al. (2022)	RCT	Both immersive and non-immersive apps were used.	8 weeks	There was no statistically significant effect of gamification on MVPA.	Gamified interventions appear to be a promising avenue for promoting physical activity. Gamification is an interesting way to improve daily PA and appears more efficient than equivalent non-gamified interventions, such as mobile health apps. However, the effect decreases with time with a smaller long-term effect. Future rigorous trials are required to explore these perspectives.
Pakarinen et al. (2016)	RCT	Both immersive and non-immersive apps were used.	8 weeks	The study measured physical activity levels and time to complete the 1-mile walk/run fitness test, and no intervention effects were found on measured variables compared to the control group.	Given the small number of included studies, the lack of uniformity and the low quality of evidence, there is a need for further, high-quality research that provides more sound evidence regarding clinical practice and health promotion. In the future, mobile apps should be explored in more detail since children increasingly prefer mobiles games to console games. More individualized and tailored game-based intervention should be developed.
Rose et al. (2017)	RCT	Both Immersive and non-immersive apps.	8 weeks	No significant effects for outcomes of physical activity, either self-reported or collected via accelerometer. All p-values are greater than 0.4 and most are above 0.9.	In the area of mobile applications, this review did not find any significant results for app interventions. Evidence is limited on the effectiveness of mobile applications, despite the constantly growing number of interventions using these resources, due to the paucity of well-designed trials of these interventions. Smartphone based interventions are widely accessible and low cost and make use of resources already used by most adolescents. It is important that more high-quality trials be conducted and published in the academic literature, and apps that have already been developed should be formally trialed to inform the development of future behavior change interventions.

Schoeppe et al. (2016)	RCT	Immersive exergame app and non-immersive app	8 weeks	The study did not show significant changes in light physical activity, moderate to vigorous physical activity and overall physical activity. No significant changes in cardiorespiratory fitness.	Interventions using apps to improve physical activity did not show effective behaviour change in adolescents. Very few app interventions have targeted children and adolescents. There is still considerable a scope to improve the efficacy of app-based interventions. Intervention studies should gather more app usage statistics to identify factors that improve user engagement and retention, and its relationship with intervention efficacy. More formative research is needed to determine the optimal number and combination of app features, behaviour change techniques, and level of participant contact needed to maximize user engagement and ultimately intervention efficacy.
Shin et al. (2019)	RCT; and non-randomized controlled trial	Smartphone applications (immersive and non-immersive apps included)	8-10 weeks	Interventions with mobile health apps were not effective in increasing physical activity compared to other interventions with wearables or other electronic devices (0.235; CI: -0.067 to 0.537). According to BMI, results favored mobile phone interventions (-0.042; CI: -0.182 to 0.098), with short-term and health application interventions being more effective than long-term and text messages, but differences were not statistically significant. Like BMI, short-term and health app interventions exhibited greater effects in changes on body weight, but differences were not statistically significant (-0.077; CI: -0.566 to 0.402).	The results indicate that mobile phone interventions are associated with physical health and fitness improvement among adolescents. Future studies with long-term period follow-ups are required for analyzing physical fitness outcomes. Having far-reaching impact, mobile phone interventions would benefit adolescents. Proper strategies to increase durability and user satisfaction would ensure active engagement that leads to improved physical fitness after long-term use.
Xu et al. (2022)	RCT	Gamification mobile apps (immersive and non-immersive apps)	8 weeks	The study showed that gamification interventions generated no significant differences between the intervention and control groups for step counts (p=0.98), light physical activity (p=0.91), moderate physical activity (p=0.90) nor vigorous physical activity (p=0.96).	There are few high-quality empirical studies. Thus, more empirical research is required in the future to explore the efficacy of a combination of gamification and mobile applications in promoting PA.

Table 3. Inclusion of external validity components.

	External validity components reported						
	Attrition (%)	Differential attrition (%)	Compared dropouts	Effect moderators tested	Baseline characteristics	Recruitment strategies	Cost of program sustainability
Badawy et al. (2017)	Y	Y	N	NA	N	Y	N
Böhm et al. (2019)	Y	N	Y	NA	Y	Y	N
Covolo et al. (2017)	Y	N	N	NA	N	Y	N
Goodyear et al. (2021)	N	N	N	NA	Y	Y	N
He et al. (2021)	N	N	N	Y	N	Y	N
Lee et al. (2021)	N	N	N	NA	N	Y	N
Mazeas et al. (2022)	N	N	Y	Y	Y	Y	Y
Pakarinen et al. (2016)	Y	N	Y	NA	N	Y	N
Rose et al. (2017)	Y	N	Y	NA	Y	Y	Y
Schoeppe et al. (2016)	Y	N	Y	NA	Y	Y	N
Shin et al. (2019)	Y	N	N	Y	N	Y	Y
Xu et al. (2022)	N	N	N	NA	N	Y	N

N: No; NA: Not applicable; Y: Yes.

inclusion criteria according to PICO (1); explicit statement that the review methods were defined prior to the review (2); selection of the study designs (3); comprehensive literature search strategy (4); study selection in duplicate; (5) data extraction in duplicate (6); list of excluded studies and their justification (7); description of the included studies (8); satisfactory technique for assessing risk of bias (9); sources of funding (10); appropriate methods for statistical analysis (11); assessment of the potential impact of risk of bias on meta-analysis (12); consideration of risk of bias when interpreting the results (13); explanation of heterogeneity in results of review (14); investigation of publication bias and discussion of its impact on the results (15); and reporting potential sources of conflict of interest (16). Two reviewers (A. M.-O. and R. V.-C.) independently analysed the quality of the included systematic reviews, and their disagreement was resolved by a third reviewer (L. A.-C.). After establishing compliance with each item of the AMSTAR-2 scale, the quality of the systematic review was determined: critically low (more than one critical flaw with or without non-critical weaknesses: the review has more than one critical flaw and should not be relied on to provide an accurate and comprehensive summary of the available studies); low (one critical flaw with or without non-critical weaknesses: the review has a critical flaw and may not provide an accurate and comprehensive summary of the available studies that address the question of interest); moderate (more than one non-critical weakness: the systematic review has more than one weakness but no critical flaws. It may provide an accurate summary of the results of the available studies that were included in the review); or high (no or one non-critical weakness: the systematic review provides an accurate and comprehensive summary of the results of the available studies that address the question of interest) (Shea et al., 2017). The seven critical flaws were items 2, 4, 7, 9, 11, 13 and 15.

In addition, the analysis of the external validity of the included reviews was carried out by two reviewers (A. M.-O. and R. V.-C.), through the use of the instrument adopted by Hayba et al. (2021) in their systematic review of systematic reviews, adapted to the context of this umbrella review. The components reported using this instrument were attrition (%), differential attrition (%), compared dropouts, effect moderators tested, baseline characteristics, recruitment strategies and cost of programme sustainability (Table 4). Attrition is the number of participants who left the research; differential attrition is the number of those who dropped out, differentiating between intervention and control group; and compared dropouts refers to comparing dropouts to completers for baseline characteristics, primary and/or secondary outcomes. To analyse external validity, a distinction was made between 'no' (N) when the review did not meet the criterion analysed and 'not applicable' (NA) when the criterion was not relevant in the systematic review; for example, if the systematic review did not include meta-analysis, the criterion 'effect moderators tested' could not be analysed (Hayba et al., 2021).

2.4. Results

2.4.1. Review selection

The search for articles in the Web of Science, Google Scholar, PubMed, and SCOPUS databases yielded a total of 10 634 systematic reviews. After the screening phase, 835 duplicate articles were eliminated, and a total of 9799 systematic reviews were included in the subsequent process. After excluding articles that were written in languages other than English or Spanish (n = 71), 9728 articles were selected. Once the eligibility phase was completed, where 7682 articles were excluded after analysing the title and 1908 after analysing the abstract (1360 for not corresponding to the population studied, 27 for not being systematic reviews, 80 for not using new technologies as the main instrument and 441 because physical activity was not the main study variable), 138 reviews were selected for full-text analysis. Finally, 12 systematic reviews were included in the present study (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022), excluding 126 for the following reasons: the age of the participants was outside the range allowed (n = 47), the study population presented pathologies (n = 7), mobile applications were used together with other forms of intervention (n = 69) and the duration was less than 8 weeks (n = 3). The review selection process is shown in Figure 1.

Table 4. AMSTAR-2 Measurement Tool to Assess Systematic Reviews.

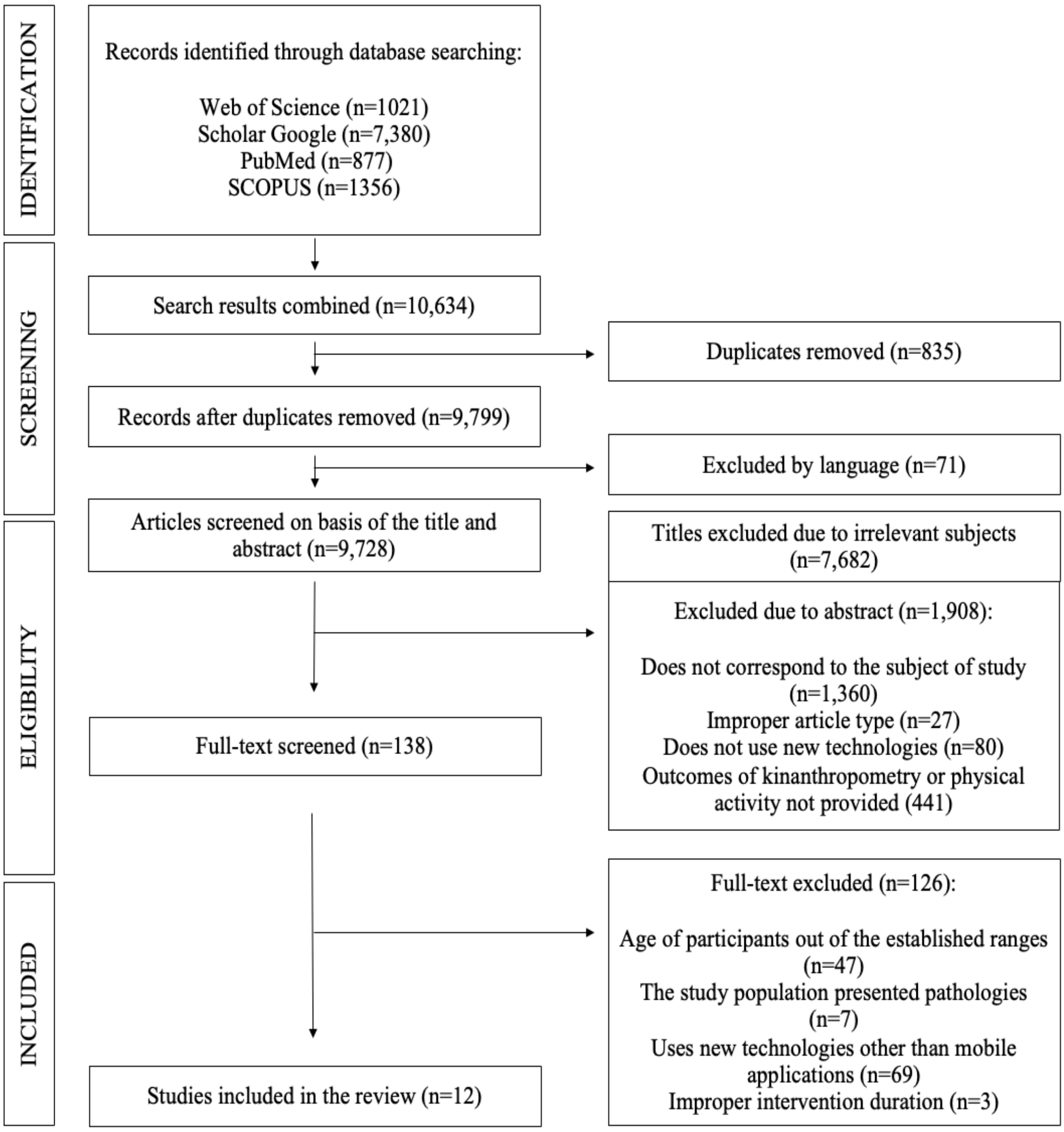
	Badawy et al. (2017)	Böhm et al. (2019)	Covolo et al. (2017)	Goodyear et al. (2021)	He et al. (2021)	Lee et al. (2021)	Mazeas et al. (2022)	Pakarinen et al. (2016)	Rose et al. (2017)	Schoeppe et al. (2016)	Shin et al. (2019)	Xu et al. (2022)
1. Did the research question and inclusion criteria include components of PICO?	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	N
2. Did the report of the review contain an explicit statement that the review methods were established prior conducting the review and did the report justify any significant deviations from the protocol?	Y	N	N	Y	Y	N	N	N	N	N	N	N
3. Did the review authors explain their selection of the study designs for inclusion in the review?	N	N	N	N	N	N	N	N	N	N	N	N
4. Did the review authors use a comprehensive literature search strategy?	PY	PY	PY	PY	PY	PY	PY	PY	Y	PY	PY	PY
5. Did the review authors perform study selection in duplicate?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Did the review authors perform data extraction in duplicate?	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
7. Did the authors provide a list of excluded studies and justify the exclusions?	N	N	N	N	N	N	Y	N	N	N	N	N
8. Did the review authors describe the included studies in adequate detail?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

9. Did the review authors use a satisfactory technique for assessing the risk of bias in individual studies that were included in the review?	N	Y	N	N	Y	Y	Y	Y	Y	N	Y	Y
10. Did the review authors report on the sources of funding for the studies included in the review?	N	N	N	N	N	N	N	N	N	N	N	N
11. If meta-analysis was performed, did the review authors use appropriate methods for statistical combination of results?	NA	NA	NA	NA	Y	NA	Y	NA	NA	NA	Y	NA
12. If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?	NA	NA	NA	NA	Y	NA	Y	NA	NA	NA	Y	NA
13. Did the review authors account for RoB individual studies when interpreting/discussing results of the review?	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y
14. Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results?	Y	N	Y	N	Y	N	Y	Y	Y	N	Y	Y

15. If they performed a quantitative summary, did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?	Y	Y	NA	NA	Y	NA	Y	Y	NA	NA	N	NA
16. Did the authors report any potential sources of conflict of interest, including any funding they received for conducting the review?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Individual Rating	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low	Crit. Low

RoB: Risk of bias; N: No; NA: Not applicable; Y: Yes; PY: Partial Yes.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart of included systematic reviews.



This diagram has four distinct phases. Identification: the articles found in the databases that included the search keywords were collected; screening: repeated articles and those that were not written in English were excluded; eligibility: the abstracts were reviewed and, after this first filter, the complete articles; included: the articles that met all the inclusion criteria were selected.

2.4.2. Characteristics of included reviews

Tables 1 and 2 show the characteristics of the systematic reviews included in the present review, as well as the variables analysed in each of them. The 12 systematic reviews were conducted between 2016 and 2022, and all performed the literature search in a minimum of 3 databases. None of the systematic reviews included only studies with mobile apps, as other devices such as wearables or websites were also included. Therefore, the 12 systematic reviews included a total of 273 articles, of which 14 used only mobile apps with adolescents aged 12–16 years old to promote changes in physical activity. All of the systematic reviews included a randomized controlled trial (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022), and only two also included non-randomized controlled trials (Goodyear et al., 2021; Shin et al., 2019). These designs were characterized by including at least one intervention group and a control group that were measured before (pre) and after (post) the intervention, which allowed comparing the effects produced by the mobile apps.

A total of 1011 adolescents were included in the 12 systematic reviews analysed, with 407 belonging to the control group and 604 to the intervention group (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022). All of the systematics reviews included at least one study with male and female adolescents (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022). According to the country in which the research was conducted, 10 of the reviews included at least one article from New Zealand (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022), two included studies conducted in Spain (Goodyear et al., 2021; Lee et al., 2021) and one included data from South Korea (Shin et al., 2019). Notably, one study indicated that the included research was conducted in Europe, the United States, Australia, New Zealand, Canada, and Asia but did not specify where each of the mobile app interventions had been carried out (Mazeas et al., 2022). In addition, only three of the included systematic reviews considered the socioeconomic characteristics of the adolescents in the articles analysed, including research conducted on socio-economically disadvantaged adolescents (Böhm et al., 2019; Rose et al., 2017; Shin et al., 2019).

Eleven systematic reviews included interventions delivered with immersive and non-immersive apps (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022), with immersive apps defined as those in which the subject entered a virtual world, in which movement in real life was movement in the virtual world, whereas non-immersive apps did not introduce the subject into a virtual world, so there was no interaction between the real and virtual world; one review focused exclusively on interventions using Pokémon Go (Lee et al., 2021); and two reviews included interventions with different mobile apps, without determining which specific apps (Goodyear et al., 2021; Shin et al., 2019). The systematic reviews included intervention studies with mobile apps that lasted 8 weeks (Direito et al., 2015a; Ruiz-Ariza et al., 2018), 10 weeks (Park et al., 2015) or 14 weeks (Benítez-Andrades et al., 2020).

Regarding the study variables of the systematic reviews, changes in physical activity performed by adolescents were evaluated in all the systematic reviews (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022), and some systematic reviews also recorded changes in physical fitness (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016), body composition or kinanthropometric variables (Shin et al., 2019).

Regarding the measurement of physical activity, five systematic reviews included studies that used Actigraph GT1M accelerometers (Badawy & Kuhns, 2017; Böhm et al., 2019; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022); four included studies that used Actigraph GT3X accelerometers (Böhm et al., 2019; Mazeas et al., 2022; Rose et al., 2017; Schoeppe et al., 2016); three systematic reviews did not indicate the type of accelerometers used in the intervention studies (He et al., 2021; Pakarinen et al., 2017; Shin et al., 2019); seven systematic reviews included studies in which the physical activity questionnaire for adolescents (PAQ-A) was used (Badawy & Kuhns, 2017; Böhm et al., 2019; Goodyear et al., 2021; Mazeas et al., 2022; Rose et al., 2017; Shin et al., 2019; Xu et al., 2022); in two, intervention studies that used the physical activity self-efficacy scale (PASES) were included (Badawy & Kuhns, 2017; Böhm et al., 2019); and four systematic reviews did not specify the type of physical activity questionnaire used in the intervention studies (Covolo et al., 2017; Lee et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016). According to physical fitness tests, most of the intervention studies included in the systematic reviews used a 1-mile run/walk test (Badawy & Kuhns, 2017; Böhm et al., 2019; Goodyear et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016), and one systematic review did not specify the cardiorespiratory test used in the intervention studies (Covolo et al., 2017). To assess body composition and kinanthropometric variables, one systematic review included studies that used body mass index (BMI) (Shin et al., 2019) and body weight (Shin et al., 2019).

2.4.3. Results found on study variables

2.4.3.1. Effectiveness of mobile apps in increasing physical activity

The systematic reviews that included a meta-analysis (He et al., 2021; Mazeas et al., 2022; Shin et al., 2019) concluded that there was a significant effect on the physical activity performed. He et al. (2021) showed significant increases in light physical activity and the number of daily steps but did not observe changes in vigorous physical activity. Shin et al. (2019) also showed significant changes in overall physical activity, and Mazeas et al. (2022) found a statistically significant effect of gamified interventions on adolescents' daily steps, but no differences were found in moderate to vigorous physical activity. However, these are the generic conclusions of the systematic reviews, which did not differentiate whether the studies used mobile apps or other devices (wearables, text messaging, web-based intervention). Considering the meta-analysis' statistical values of the studies that only used mobile apps, the results were different, with an absence of significance in the three reviews that included meta-analyses (He et al., 2021; Mazeas et al., 2022; Shin et al., 2019), highlighting that mobile apps were the least effective strategy, as compared with other interventions. In addition, it should be noted that the most significant changes with the use of mobile apps occurred at the beginning of the intervention, but after 2 weeks, when the initial novelty wore off, the effect was much smaller (He et al., 2021).

The nine systematic reviews (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Lee et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022) that did not include meta-analyses due to a lack of homogeneity in the data obtained from the included articles summarized the most relevant results. One study reported reduced changes in moderate to vigorous physical activity performed exclusively with non-immersive mobile apps (Böhm et al., 2019). Another systematic review showed increases in the number of minutes per day of physical activity performed by adolescents (Lee et al., 2021). However, most of the included studies were of low to moderate quality, and they required improvements in the methodological designs proposed. Most of the studies analysed did not show an increase in physical activity or daily steps (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022).

2.4.3.2. ***Effect produced by physical activity in kinanthropometric variables, body composition and physical fitness***

According to the differences in body composition and kinanthropometric variables, it should be noted that only one review considered them (Shin et al., 2019). Shin et al. (2019) included a meta-analysis and showed that the differences in BMI between the intervention and control groups, after an intervention with mobile apps, were not statistically significant in any of the included studies ($p = 0.450–1.000$), as was the case for body weight ($p = 0.970$).

With respect to the physical fitness variables, six reviews analysed cardiorespiratory fitness (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016). All the systematic reviews that included intervention studies that analysed cardiorespiratory fitness did not find a significant improvement in this variable or in the time required to complete the test as compared with the improvement in the control group (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016).

2.4.4. External validity

Only five of the systematic reviews (Böhm et al., 2019; Goodyear et al., 2021; Mazeas et al., 2022; Rose et al., 2017; Schoeppe et al., 2016) included studies in which baseline or pretest values of the intervention participants were provided. A total of seven reviews included studies in which the percentage of attrition was indicated (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019), only one review included articles in which the differential attrition was indicated (Badawy & Kuhns, 2017) and five reviews included studies comparing dropouts (Böhm et al., 2019; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016). The three systematic reviews that included meta-analyses tested effect moderators (He et al., 2021; Mazeas et al., 2022; Shin et al., 2019). Only three reviews included articles referring to the cost of programme sustainability (Mazeas et al., 2022; Rose et al., 2017; Shin et al., 2019). Rose et al. (2017) indicated that none of the studies included in the review assessed programme cost; Shin et al. (2019) indicated that although mobile phone interventions were cost-effective, only one of the included studies performed an economic assessment, making it difficult to draw firm conclusions; and Mazeas et al. (2022) indicated that the cost-effectiveness ratio of gamified interventions may be better than that of many current interventions, considering the ease of implementation and generalizability of gamification.

2.4.5. Quality assessment

The individual analysis of the items included in the AMSTAR-2 scale showed that all but three systematic reviews (Covolo et al., 2017; Lee et al., 2021; Xu et al., 2022) clearly included the PICO components in the research question and inclusion criteria. Only three systematic reviews (Badawy & Kuhns, 2017; Goodyear et al., 2021; He et al., 2021) recorded the protocol and method prior to the start of the investigation. None of the systematic reviews explained the rationale for selecting the study designs that were included in the research. Eleven systematic reviews searched at least two databases, provided keywords and search strategy, and indicated publication restrictions; two systematic reviews also included reviews from other sources (Mazeas et al., 2022; Xu et al., 2022); and only one systematic review expanded the search with bibliographic references of included studies, searched trial/study registries and consulted experts in the field (Rose et al., 2017). All the reviews performed study selection independently by two reviewers. Data extraction was also performed by two reviewers independently in all but one review (Covolo et al., 2017). Only one review (Mazeas et al., 2022) indicated the studies excluded in the final phase of the selection and justified the reasons for the exclusion, whereas the rest of the reviews did not expressly indicate the excluded articles or did not justify the reasons. All the reviews described the included studies (sample, intervention, type of design) in sufficient detail. Regarding the risk of bias, eight systematic reviews used a satisfactory technique for its measurement (Böhm et al., 2019; He et al., 2021; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Shin et al., 2019; Xu et al., 2022). None of the systematic reviews included information on the sources of funding received by the included studies. The three systematic reviews that performed meta-analyses used appropriate statistical methods to obtain the results and analysed the potential impact of risk of bias on the results of the meta-analysis (He et al., 2021; Mazeas et al., 2022; Shin et al., 2019). Nine systematic reviews took risk of bias into consideration when interpreting and discussing the results (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Lee et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Shin et al., 2019; Xu et al., 2022). It should be noted that two of the systematic reviews (Badawy & Kuhns, 2017; Covolo et al., 2017) did not use an adequate method to analyse the risk of bias but did take this factor into consideration in the analysis and discussion of the results. Eight reviews performed an adequate analysis and justification of the heterogeneity present in the results (Badawy & Kuhns, 2017; Covolo et al., 2017; He et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017; Rose et al., 2017; Shin et al., 2019; Xu et al., 2022). Five reviews analysed the publication bias and discussed the possible impact on the results (Badawy & Kuhns, 2017; Böhm et al., 2019; He et al., 2021; Mazeas et al., 2022; Pakarinen et al., 2017). Of note, three of the five reviews did not perform meta-analyses but did take publication bias into consideration when discussing the results (Badawy & Kuhns, 2017; Böhm et al., 2019; Pakarinen et al., 2017). All the systematic reviews included information on funding sources and/or possible conflicts of interest among authors.

Lastly, it should be noted that none of the reviews met all the criteria present in the AMSTAR-2 scale to be considered of high quality. Thus, all the systematic reviews included more than one critical flaw (from 2 to 5) together with non-critical weakness (from 2 to 4), so they were all classified as critically low quality. These gives a low confidence to the results obtained and makes the systematic reviews unreliable.

2.5. Discussion

The first and second aims of this novel umbrella review were to summarize the available evidence and results found by systematic reviews that analysed the effectiveness of mobile applications in increasing the level of physical activity in adolescents and their effect on other variables such as kinanthropometric variables, body composition or physical fitness of adolescents aged 12–16 years old. In this regard, the results from the 12 systematic reviews showed that most of the interventions carried out with mobile applications did not show significant changes in the level of physical activity of the adolescents (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022). Only one systematic review showed no significant changes for moderate to vigorous physical activity when using non-immersive apps (Böhm et al., 2019), whereas one review concluded that the use of Pokémon Go increased the number of minutes of daily physical activity (Lee et al., 2021). As for the kinanthropometric and body composition variables, no significant differences were found in the intervention groups in a systematic review (Shin et al., 2019), and for physical fitness, no reviews reported significant changes in the cardiorespiratory capacity of the adolescents studied after using the mobile apps (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016).

2.5.1. Effectiveness of mobile apps in increasing physical activity

According to the level of physical activity, 3 (He et al., 2021; Mazeas et al., 2022; Shin et al., 2019) of the 12 systematic reviews included performed meta-analyses of the results obtained. Although the conclusions of these reviews confirmed the existence of changes in light physical activity, number or daily steps or overall physical activity, they did not consider the differences in the age of the participants, or the electronic device used in the intervention when making the conclusions. Consequently, when exclusively analysing the interventions with mobile applications in the target adolescent population, no significant differences were found in any of the variables related to physical activity (light, moderate or vigorous physical activity, overall physical activity, number of steps). In addition, the low methodological quality of these systematic reviews should be underlined. Considering the external validity components, only Shin et al. included percentage attrition (Shin et al., 2019), but none of the reviews included differential attrition (He et al., 2021; Mazeas et al., 2022; Shin et al., 2019), and only Mazeas et al. (2022) included compared dropouts and base- line characteristics.

The remaining nine systematic reviews (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Lee et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022) did not include meta-analyses, with the heterogeneity of the included studies being the main reason for this, as the sample sizes and the variables measured differed between the studies, making statistical comparisons difficult. However, the systematic reviews provided qualitative and quantitative summaries of research findings, and the results obtained in most of the systematic reviews did not show significant differences neither in the level of physical activity (light, moderate or vigorous), nor in the daily steps (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022) when comparing the intervention group with mobile applications and the control group.

However, some of the studies selected to carry out the systematic reviews showed differences in some variables, as is the case of Böhm et al. (2019), in which one of the studies showed reduced benefits in the level of moderate to vigorous physical activity with the use of non-immersive mobile applications, although this was not significant; or the review by Lee et al. (2021) in which a study showed significant changes in the amount of daily exercise, mainly light intensity physical activity and walking, with the use of Pokémon Go. The differences found in Bohm et al.'s review (Böhm et al., 2019) may be due to the fact that immersive apps conditioned the type of use given to them (Beach et al., 2021a). Thus, previous research has shown that when an immersive app such as Pokémon Go is used intermittently (stopping to capture Pokémons), the benefits obtained in physical activity are not significant, as compared with when the app is used continuously (without stopping) (Beach et al., 2021), with continuous use being a characteristic of non-immersive apps. In addition, it should be noted that the authors indicated that the non-immersive application group was the weakest of all in terms of physical activity values at baseline, so that the improvement obtained could be due to the participant's initial level being very low (Böhm et al., 2019). Along the same lines, the use Pokémon Go by adolescents, in the study included by Lee et al. (2021), should be analysed, as this may only be improving daily walking time and light physical activity but not necessarily moderate to vigorous intensity physical activity. Therefore, differences may be found between immersive and non-immersive apps and the type of use given to immersive apps, but future research is needed that defines the type of use given to immersive apps, as it will allow us to discover if 'playing' with the app will benefit the physical activity of the adolescent's population aged 12–16 years old.

It should be noted that similar to reviews with meta-analysis, the methodological quality of the systematic reviews that did not include meta-analyses was very low and that the external validity components included were very different, which made it difficult to summarize and extrapolate the results. Regarding the cost of programme sustainability, only the work by Rose et al. (2017) included information on the investment made in the studies. Six systematic reviews (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016) included the percentage of attrition, but only Badawy and Kuhns (2017) included differential attrition. Compared dropouts (Böhm et al., 2019; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016) and baseline characteristics (Böhm et al., 2019; Goodyear et al., 2021; Rose et al., 2017; Schoeppe et al., 2016) were only included in four reviews. In addition, the systematic reviews that did not include meta-analyses were also highly heterogeneous, with sample sizes ranging from 50 (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022) to 200 (Goodyear et al., 2021; Lee et al., 2021) adolescents; and with different immersive and non-immersive apps (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Xu et al., 2022), with the exclusive use of Pokémon Go (Lee et al., 2021) or without determining which specific apps were used (Goodyear et al., 2021).

As it has been previously shown that randomized controlled trials conducted with a smaller sample size report that positive results 2.2 times fewer than studies with a larger sample size (Singh et al., 2010), it is worth noting that of the 12 systematic reviews, only two included at least one study with more than 100 subjects (Goodyear et al., 2021; Lee et al., 2021). In addition, most of the authors of the systematic reviews concluded that most of the mobile apps used were not designed for the adolescent population, so they did not include useful technological resources (information on lifestyle habits, attractive games, possibilities of confrontation in the same class group), which could influence adherence to the interventions. Therefore, the results of the present umbrella review show that presently, mobile apps are not useful tools for the promotion of physical activity in the adolescent population, although this could be influenced by the lack of methodological rigor and the small sample size. Future research is needed for analysing the effectiveness of mobile applications, with greater methodological rigor (better experimental designs, longer follow-up, larger sample, standardized instruments), as well as a better design of apps specific for this population, which could contribute towards obtaining more beneficial results and drawing more positive conclusions.

2.5.2. Effect produced by physical activity on kinanthropometric variables, body composition and physical fitness

No significant differences were found in BMI (Shin et al., 2019), nor body weight (Shin et al., 2019) between the pre and post measurements of the intervention groups, nor between the intervention and control groups after the use of the mobile apps. A possible explanation for these results could be that the changes in kinanthropometric and derived variables, as well as in body composition, are subject to an increase in physical activity, as shown by previous research, which indicated that less active adolescents have a greater accumulation of fat mass (Mateo-Orcajada, González-Gálvez, et al., 2022). According to the results of the present umbrella review, the use of mobile apps did not produce a significant increase in any type of physical activity (light, moderate, vigorous), which could explain why there were no changes in the body composition variables of adolescents aged 12–16 years old.

As for the physical fitness variables, six reviews analysed cardiorespiratory fitness (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; Pakarinen et al., 2017; Schoeppe et al., 2016), and although changes were observed in the intervention groups, none showed significant differences with respect to the control group, regardless of the test used to assess this capacity.

Therefore, the results obtained in the present study show that the use of mobile applications in the adolescent population aged 12– 16 years old does not seem to have a significant effect on body composition and physical fitness of adolescents, which could be due to the lack of a significant increase in physical activity or daily steps through the use of mobile apps. Therefore, future research is needed that includes new mobile application designs that can be truly useful, as previous research has shown that the mobile apps currently on the market are not suitable for use in physical education classes, as they do not facilitate their didactic use (Alonso-Fernández et al., 2022). This, together with the results obtained, should be considered in future research studies that use mobile apps, as the promotion of their use from physical education classes could have great potential, but not with the designs currently available on the market.

2.5.3. Important aspects to consider in systematic reviews that could affect the results obtained

It is important to consider that the interventions included in this umbrella review should have had a minimum duration of 8 weeks. This is because previous research conducted with adolescents for the promotion of physical activity and health has shown that interventions of short and medium duration are the most effective in producing changes, as compared with those of longer duration, as the adherence of this population to the interventions is drastically reduced after the first few weeks (van de Kop et al., 2019). However, neither the 8-week interventions nor those of longer duration (10 or 14 weeks) showed significant effects on physical activity in the adolescent population aged 12–16 years old. One possible explanation for these results could be that as the design of the mobile apps is inadequate for use in the adolescent population studied. They may not be generating sufficient adherence for longer interventions to be more effective, and when the initial novelty of the use of this type of app is lost, all the effects are lost as well (He et al., 2021).

Regarding the countries in which the research was carried out, a great heterogeneity was found, although most of the reviews included studies carried out in New Zealand (Badawy & Kuhns, 2017; Böhm et al., 2019; Covolo et al., 2017; Goodyear et al., 2021; He et al., 2021; Pakarinen et al., 2017; Rose et al., 2017; Schoeppe et al., 2016; Shin et al., 2019; Xu et al., 2022). Regardless of the country, no significant differences were observed in physical activity, body composition or physical fitness variables, so future research with greater methodological rigor will be necessary to provide truly useful data for comparing the different geographical areas.

2.5.4. Systematic review of reviews strengths and limitations

The third aim of this umbrella review was to determine the strengths and limitations present in the interventions carried out through mobile applications with adolescents aged 12–16 years old, to provide recommendations for future research. With respect to the main limitations, it should be noted that most of the systematic reviews found it difficult to perform a meta-analysis with the results found, due to the lack of concordance in the variables measured in the interventions carried out with mobile applications, so only three systematic reviews included this analysis, making it impossible to perform meta-analyses on the systematic reviews. The search for articles written in English and Spanish is another limitation to be considered. As for the strengths, the present umbrella review is a summary of the scientific evidence available to date, with regard to the possibilities offered by mobile applications in increasing the physical activity of adolescents aged 12–16 years old, and the effects this may have on other kinanthropometric variables, body composition and physical fitness. The breadth of the scientific literature reviewed, the methods used to assess the quality and external validity of each of the reviews included and the ability to provide a summary of the available systematic reviews add value to this work.

2.5.5. Practical implications for future research

According to the scientific literature available to date on the use of mobile applications to promote physical activity, future research with better methodological designs that allow the comparison of the results obtained between studies is needed. For this, it is necessary that the instruments used, and the variables measured be similar, as it is not possible to compare the number of daily steps with the level of physical activity, with this being one of the main problems found in systematic reviews in general. In addition, sample sizes should be increased. Regarding attrition, many studies did not include it, or did not specify whether it was in the intervention or control group, so the adherence of the adolescent population to this type of intervention is unknown, and research is needed to determine at what point does the participation of adolescents aged 12–16 years old begin to decline. It would also be interesting to know whether the mobile applications used so far with adolescents are interesting for in this population, or whether, on the contrary, the lack of interest is one of the reasons why they abandon the interventions. This information would be of great relevance for the development of a specific application for adolescents aged 12–16 years old that could promote increased physical activity.

2.6. Conclusions

The systematic reviews available to date in the scientific literature lack the methodological quality and scientific rigor necessary to confirm that interventions with mobile applications are effective in promoting physical activity. Nevertheless, these reviews are a starting point to be considered for future longitudinal research using mobile applications with adolescents aged 12–16 years old. These should standardize the methodological designs, follow-up times, the main and secondary outcomes and the instruments used and should also include larger samples to carry out research that can be compared and allow meta-analyses that provide quality to the studies. As a final conclusion, mobile applications cannot be considered as a useful tool to improve the health of adolescents, due to the absence of results on physical activity level and changes in kinanthropometric and physical fitness variables, but future research is required to corroborate these initial results.

III – OBJETIVOS

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3.1. OBJETIVOS GENERALES

1. Analizar las diferencias en las variables cineantropométricas, la composición corporal, la condición física y el uso de las nuevas tecnologías de la población adolescente según el nivel de actividad física practicado, el nivel de adherencia a la dieta mediterránea, el estado de peso y el estado psicológico de los adolescentes.

2. Determinar la influencia de una intervención con aplicaciones móviles en horario extraescolar promocionada desde la asignatura de educación física en el incremento del nivel de actividad física practicado, y su efecto sobre las variables cineantropométricas, la composición corporal, el estado psicológico y la condición física de los adolescentes.

3.2. OBJECTIVOS ESPECÍFICOS

1. Establecer las diferencias en la composición corporal, la condición física y la adherencia a la dieta mediterránea entre los adolescentes activos y sedentarios.

2. Analizar las diferencias entre los adolescentes activos y sedentarios de acuerdo al paradigma "fat but fit", considerando los diferentes estados de peso.

3. Determinar las diferencias existentes en la condición física, el nivel de actividad física y las variables cineantropométricas de los chicos y chicas adolescentes con diferente nivel de adherencia a la dieta mediterránea.

4. Analizar las diferencias existentes en la condición física, el nivel de actividad física y las variables cineantropométricas de los adolescentes con diferente índice de masa corporal y nivel de adherencia a la dieta mediterránea.

5. Examinar las variaciones en la actividad física, la adherencias a la dieta mediterránea, las variables cineantropométricas y derivadas, y la condición física de los adolescentes con diferente nivel de satisfacción de las necesidades psicológicas básicas.

6. Evaluar las diferencias en el nivel de actividad física, la adherencia a la dieta mediterránea, las variables cineantropométricas y derivadas, y la condición

física de los adolescentes en función de si las necesidades psicológicas básicas se satisfacían de manera individual o en conjunto.

7. Determinar las diferencias en el nivel de actividad física, las variables cineantropométricas y de condición física, la adherencia a la dieta mediterránea, el estado psicológico y la condición física de los adolescentes de acuerdo al género y a los diferentes niveles de uso problemático de internet y el teléfono móvil.

8. Establecer las diferencias en el nivel de actividad física, las variables cineantropométricas y de composición corporal, la adherencia a la dieta mediterránea, el estado psicológico, y la condición física entre los adolescentes cuando se considera el uso problemático conjunto de internet y el teléfono móvil.

9. Establecer las diferencias entre los chicos y chicas adolescentes en las variables cineantropométricas, el estado psicológico y la condición física.

10. Determinar si la práctica de actividad física puede compensar las diferencias encontradas en función del género en las variables cineantropométricas y derivadas, el estado psicológico y la condición física de los adolescentes.

11. Analizar si una adherencia óptima a la dieta mediterránea puede compensar las diferencias de género halladas en las variables cineantropométricas y derivadas, el estado psicológico y la condición física de los adolescentes.

12. Evaluar si el mantenimiento de un estado de peso adecuado puede compensar las diferencias de género halladas en las variables cineantropométricas y derivadas, el estado psicológico y la condición física de los adolescentes.

13. Determinar los cambios producidos por un periodo de diez semanas de uso obligatorio de las aplicaciones móviles de seguimiento de pasos en horario extraescolar sobre el nivel de actividad física, la composición corporal, la condición física y la adherencia a la dieta mediterránea de los adolescentes de doce a dieciséis años.

14. Comparar los beneficios obtenidos por cada una de las aplicaciones móviles en el nivel de actividad física, la composición corporal, la condición física y la adherencia a la dieta mediterránea de los adolescentes.

15. Establecer las diferencias en el nivel de actividad física y su influencia sobre las variables cineantropométricas y de composición corporal en la población adolescente considerando el estilo de juego de Pokémon Go.

16. Analizar si el nivel de actividad física previo influye en el efecto producido por el uso de Pokémon Go sobre el nivel de actividad física y los cambios en las variables cineantropométricas y la composición corporal de los adolescentes.

3.3. GENERAL OBJECTIVES

1. To analyze the differences in kinanthropometric variables, body composition, fitness, and the use of new technologies in the adolescent population according to the level of physical activity practiced, the level of adherence to the Mediterranean diet, weight status and psychological state of the adolescents.

2. To determine the influence of an intervention with mobile applications in out-of-school hours promoted from the physical education subject on the increase in the level of physical activity practiced, ant its effect on kinanthropometric variables, body composition, psychological state, and fitness of adolescents.

3.4. SPECIFIC OBJECTIVES

1. To establish the differences in body composition, physical performance, and AMD between active and sedentary adolescents.

2. To analyze the differences between active and sedentary adolescents according to the "fat but fit" paradigm considering different weight status.

3. To analyze the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in males and females with different AMD.

4. To determine the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in adolescents with different body mass index (BMI) and AMD.

5. To examine the variances in physical activity, AMD, kinanthropometric and derived variables, and fitness among adolescents with different degree levels of satisfaction of each of the BPNs.

6. To assess the differences in the level of physical activity, AMD, kinanthropometric and derived variables, and physical fitness of the adolescents according to whether the BPNs are satisfied individually or jointly.

7. To determine the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness according to gender and different levels of problematic use of the internet and mobile phones.

8. To establish the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness among adolescents when considering problematic use of the internet and mobile phone in combination.

9. To establish the differences between male and female adolescents in anthropometric and derived variables, psychological state, and physical fitness.

10. To determine whether the practice of physical activity can compensate for the differences found according to gender, in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents.

11. To analyze whether optimal AMD can compensate for the gender differences found in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents.

12. To establish whether the maintenance of an adequate weight status can compensate for the differences found according to gender in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents.

13. To determine the changes produced by a compulsory ten-week period of after-school intervention with mobile step-tracking applications on the level of physical activity, body composition, physical fitness, and AMD of adolescents aged twelve to sixteen years old.

14. To compare the benefits obtained by each of the mobile applications on the level of physical activity, body composition, physical fitness, and AMD of adolescents.

15. To establish the differences in the level of physical activity and its influence on the kinanthropometric and body composition of the adolescent population considering the Pokémon Go playing style.

16. To analyze whether the practice of previous physical activity has an influence on the effects of the use of Pokémon Go on the level of physical activity and changes in kinanthropometric and body composition variables.

IV - HIPÓTESIS

IV - HIPÓTESIS

4.1. HIPÓTESIS GENERALES

1. Los adolescentes que presenten un mayor nivel de actividad física, una adherencia óptima a la dieta mediterránea, un estado de peso normal y un adecuado estado psicológico presentarán una mejor composición corporal, una mejor condición física y un uso menos problemático de las nuevas tecnologías que los adolescentes con menor práctica física, peor adherencia a la dieta mediterránea, sobrepeso u obesidad y un peor estado psicológico.

2. El uso de aplicaciones móviles promocionadas desde la asignatura de educación física permitirá aumentar la actividad física practicada por los adolescentes, influyendo positivamente sobre las variables cineantropométricas, la composición corporal, el estado psicológico y la condición física.

4.2. HIPÓTESIS ESPECÍFICAS

1. Los adolescentes activos mostraron mejor composición corporal, condición física y adherencia a la dieta mediterránea que los sedentarios.

2. Atendiendo a las investigaciones previas sobre el paradigma "fat but fit", los adolescentes con un mejor nivel de actividad física presentarán una mejor condición física y composición corporal, independientemente de su estado de peso.

3. Las diferencias en el nivel de condición física, el nivel de actividad física y las variables relacionadas con la masa grasa serán significativas en los adolescentes según su nivel de adherencia a la dieta mediterránea, aunque con diferencias en función del género.

4. Los adolescentes con mayor adherencia a la dieta mediterránea realizarán más actividad física, presentarán mejor composición corporal y un mayor rendimiento en las pruebas de condición física, independientemente de su estado de peso.

5. Los adolescentes con una mayor satisfacción de las necesidades psicológicas básicas exhibirán mayores niveles de actividad física, adherencia a la

dieta mediterránea, mejor condición física y mejores variables cineantropométricas y derivadas.

6. En ausencia de investigaciones previas que permitan establecer una hipótesis certera sobre qué necesidad psicológicas es más determinante para las variables de estudio, se hipotetiza que los adolescentes que presenten todas las necesidades psicológicas básicas satisfechas de forma conjunta mostrarán niveles superiores de actividad física, adherencia a la dieta mediterránea, condición física y mejores variables cineantropométricas y derivadas.

7. Las chicas adolescentes mostrarán un mayor uso problemático de internet y el teléfono móvil, hallándose también diferencias en el nivel de actividad física, las variables cineantropométricas y de condición física, la adherencia a la dieta mediterránea, el estado psicológico y la condición física en comparación con los chicos.

8. El uso problemático conjunto de internet y el teléfono móvil presentará diferencias respecto al uso problemático individual de internet o el teléfono móvil en el nivel de actividad física, las variables cineantropométricas y de composición corporal, la adherencia a la dieta mediterránea, el estado psicológico y la condición física de los adolescentes.

9. Los chicos adolescentes mostrarán una mayor puntuación en todas las variables en comparación con las chicas, excepto en las relacionadas con la grasa corporal y la flexibilidad.

10. Para las chicas adolescentes, la práctica regular de actividad física compensará las diferencias en las variables cineantropométricas y derivadas, en el estado psicológico y en la condición física respecto a los chicos.

11. Para las chicas adolescentes, una adherencia óptima a la dieta mediterránea compensará las diferencias en las variables cineantropométricas y derivadas, el estado psicológico y la condición física respecto a los chicos.

12. Para las chicas, el mantenimiento de un estado de peso normal compensará las diferencias en las variables cineantropométricas y derivadas, el estado psicológico y la condición física respecto a los chicos.

13. El uso obligatorio de las aplicaciones móviles como “deberes” de la asignatura de educación física hará que un elevado número de adolescentes completen la intervención, y su uso mostrará mejoras en el nivel de actividad física,

la composición corporal, la condición física y la adherencia a la dieta mediterránea, en comparación con el grupo control.

14. No habrá diferencias significativas entre los grupos de intervención que utilicen diferentes aplicaciones móviles en los cambios en el nivel de actividad física, la composición corporal, la condición física y la adherencia a la dieta mediterránea.

15. El modo de juego continuo de Pokémon Go incrementará el nivel de actividad física en mayor medida que el modo de juego intermitente, y los cambios en la composición corporal serán más significativos en el modo de juego continuo en comparación con el modo de juego intermitente y con el grupo control.

16. Los cambios en el nivel de actividad física y en las variables cineantropométricas y de composición corporal serán significativos en el grupo de adolescentes que son previamente inactivos, pero no en el grupo de adolescentes activos.

4.3. GENERAL HYPOTHESIS

1. Adolescents with a higher level of physical activity, optimal adherence to the Mediterranean diet, normal weight status and adequate psychological state will present better body composition, better fitness, and less problematic use of new technologies than adolescents with less physical practice, poorer adherence to the Mediterranean diet, overweight or obesity and worse psychological state.

2. The use of mobile applications promoted from the subject of physical education will increase the physical activity practiced by adolescents, positively influencing kinanthropometric variables, body composition, psychological state, and fitness.

4.4. SPECIFIC HYPOTHESIS

1. Active adolescents will show better body composition, physical fitness, and AMD than sedentary adolescents.

2. Considering the “fat but fit” paradigm, and in line with previous research conducted with cardiorespiratory fitness and handgrip strength as discriminatory variables, adolescents who show a higher level of physical activity will present

higher physical fitness and also better body composition, regardless of their weight status.

3. Differences will be significant in physical fitness, physical activity level, and fat-mass-related variables in adolescents according to AMD level, although there will be differences according to gender.

4. Adolescents with higher AMD will perform more physical activity, present better body composition, and higher performance in physical fitness tests regardless of their weight status.

5. Adolescents who experience higher levels of satisfaction with BPNs are expected to exhibit increased levels of physical activity, greater AMD, better physical performance and better kinanthropometric and derived variables.

6. In the absence of previous research that would allow us to establish an accurate hypothesis as to which BPN is more relevant to the study variables, we hypothesize that adolescents who have all BPNs satisfied collectively will demonstrate elevated levels of physical activity, AMD, physical performance and improved kinanthropometric and derived variables.

7. Adolescent females will show a greater problematic use of the internet and the mobile phone, with differences also being found in the level of physical activity, kinanthropometric and fitness variables, adherence to the Mediterranean diet, psychological state and fitness compared to males.

8. Joint problematic use of the internet and the mobile phone will present differences with respect to individual problematic use of the internet or the mobile phone in the level of physical activity, kinanthropometric and body composition variables, adherence to the Mediterranean diet, psychological state, and fitness of adolescents.

9. Males will show higher scores in all variables, except in those related to body fat and flexibility, compared to females.

10. For females, the regular practice of physical activity will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness with respect to males.

11. For females, optimal AMD will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness with respect to males.

12. For females, maintaining a normal weight will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness with respect to males.

13. The mandatory use of the mobile application as "homework" for the physical education subject will lead to a high number of adolescents completing the intervention, and its use will show improvements in the level of physical activity, body composition and physical fitness, and AMD, as compared to the control group.

14. There will be no significant differences between intervention groups using different mobile apps in physical activity level, body composition, physical fitness, and AMD.

15. The continuous style of Pokémon Go gameplay will increase the level of physical activity to a greater extent than the intermittent style, and changes in body composition will be more significant in the continuous use group as compared to the intermittent and control groups.

16. The changes in the level of physical activity and in the kinanthropometric and body composition variables will be significant in the group of adolescents who were previously inactive, but not in the group of active adolescents.

V – MÉTODOS, RESULTADOS Y DISCUSIÓN

V - MÉTODOS, RESULTADOS Y DISCUSIÓN

El método, los resultados y la discusión de la presente tesis doctoral se componen de siete artículos científicos aceptados, encontrándose además seis artículos científicos más en proceso de revisión por pares. A continuación, se detallan las referencias de los artículos ya publicados:

Artículo 1

Mateo-Orcajada, A., Vaquero-Cristóbal, R., Esparza-Ros., F. & Abenza-Cano, L. (2022). Physical and body composition differences between active and sedentary adolescents according to the "Fat but Fit" paradigm**.** *International Journal of Environmental Research and Public Health*, *19*(17), 1-24.

Impact Factor: 0.83 (SJR)
Quartile: Q2
Category: Public Health, Environmental and Occupational Health

Artículo 2

Mateo-Orcajada, A., Vaquero-Cristóbal, R., Montoya-Lozano, J. M. & Abenza-Cano, L. (2023). Differences in kinanthropometric variables and physical fitness of adolescents with different adherence to the Mediterranean diet and weight status: "Fat but Healthy Diet" paradigm**.** *Nutrients, 15*(5), 1-21.

Impact Factor: 5.9
Quartile: Q1
Category: Nutrition & Dietetics
Journal Position: 17
Number of journals in the category: 88

Artículo 3

Mateo-Orcajada, A., Vaquero-Cristóbal, R., Rey-López, J. P., Martín-Campoy, R. & Abenza-Cano, L. (2023). The role of basic psychological needs in the adoption of healthy habits by adolescents. *Behavioral Sciences, 13*(7), 1-15.

Impact Factor: 2.6
Quartile: Q2
Category: Psychology, Multidisciplinary
Journal Position: 61
Number of journals in the category: 147

Artículo 4

Mateo-Orcajada, A., Vaquero-Cristóbal, R., Albaladejo-Saura, M. D. & Abenza-Cano, L. (2023). The degree of problematic technology use negatively affects physical activity level, adherence to Mediterranean diet and psychological state of adolescents. *Healthcare, 11*(12), 1-19.

Impact Factor: 2.8
Quartile: Q2
Category: Health Policy & Services
Journal position: 43
Number of journals in the category: 87

Artículo 5

Mateo-Orcajada, A., Abenza-Cano, L., Cano-Martínez, A. & Vaquero-Cristóbal, R. (2022). The importance of healthy habits to compensate for differences between adolescent males and females in anthropometric, psychological, and physical fitness variables. *Children, 9*(12), 1-33.

Impact Factor: 2.4
Quartile: Q2
Category: Pediatrics
Journal position: 58
Number of journals in the category: 130

Artículo 6

Mateo-Orcajada, A., Abenza-Cano, L., Albaladejo-Saura, M. D. & Vaquero-Cristóbal, R. (2023). Mandatory after-school use of step tracker apps improves physical activity, body composition, and fitness of adolescents. *Education and Information Technologies*, *28*(8), 10235-10266.

Impact Factor: 5.5
Quartile: Q1
Category: Education & Educational Research
Journal position: 19
Number of journals in the category: 269

Artículo 7

Mateo-Orcajada, A., Vaquero-Cristóbal, R. & Abenza-Cano, L. (2023). Influence of Pokémon Go playing style on physical activity and its effect on kinanthropometry variables and body composition in adolescents. *Journal of Physical Activity & Health*, *20*(9), 1-14.

Impact Factor: 3.1
Quartile: Q2
Category: Public, Environmental & Occupational Health
Journal position: 85
Number of journals in the category: 180

Va – ESTUDIO 1: Physical and body composition differences between active and sedentary adolescents according to the “Fat but Fit” paradigm

ESTUDIO 1 – PHYSICAL AND BODY COMPOSITION DIFFERENCES BETWEEN ACTIVE AND SEDENTARY ADOLESCENTS ACCORDING TO THE "FAT BUT FIT" PARADIGM

5.1. Abstract

The practice of physical activity during adolescence is essential for the proper development of the population. In recent decades, the relevance of physical activity has been increasing, due to the development of the "fat but fit" paradigm. This paradigm shows that adolescents with a high level of physical fitness are healthier than adolescents with poorer physical fitness, regardless of their weight, giving importance to sports practice over other aspects. However, few previous studies have analyzed the differences in physical and body composition between active and sedentary adolescents in this paradigm. For this reason, the objectives of the present study were to establish the differences in body composition, physical performance, and adherence to the Mediterranean diet between active and sedentary adolescents; and to analyze the differences between active and sedentary adolescents according to the "fat but fit" paradigm. The sample consisted of 791 adolescent whose body composition, level of physical activity, adherence to the Mediterranean diet, and physical fitness were measured. It was found significant between active and sedentary adolescents in most of the anthropometric, AMD, and physical fitness variables, with a significant effect of the covariates gender, age, BMI, and biological maturation on the model. The binary logistic regression analysis performed shows that anthropometric variables, AMD, and VO2 max can be considered as primary outcomes to distinguish between active and sedentary groups of adolescents. Furthermore, the results showed that the active adolescents, regardless of their weight status, had lower fat mass and greater muscle mass, as well as a higher performance in the physical fitness tests, and greater adherence to the Mediterranean diet than the sedentary adolescents. To conclude, the practice of physical activity is a determinant for the improvement of body composition, physical performance, and adherence to the Mediterranean diet of the adolescent population, regardless of their gender, age, weight, or maturity status.

5.2. Introduction

The practice of physical activity during adolescence is fundamental for the prevention and treatment of different chronic diseases (Anderson & Durstine, 2019), among which obesity (Lee & Yoon, 2018), hypertension (Wellman et al., 2020), diabetes (Fernandes & Zanesco, 2010), or metabolic syndrome (Neto et al., 2011) stand out. Despite its relevance, the level of physical practice is annually reduced by 3.4% in boys and 5.3% in girls from the age of nine (Farooq et al., 2020). The decrease in the level of daily physical activity and the adoption of sedentary behaviors are related to lower adherence to the Mediterranean diet (AMD) (García-Hermoso et al., 2020), lower performance on physical fitness tests (Bravo-Sánchez et al., 2021), and higher percentage of fat mass (Agata & Monyeki, 2018). This forms a serious problem for the health of the adolescent population because in recent years there has been a decline in physical capacities, mainly affecting strength (Ferrari et al., 2015) and cardiorespiratory capacity (Arboix-Alió et al., 2020; Tomkinson et al., 2019), as well as an increased number of diseases related to poor nutrition (Roura et al., 2016) and accumulation of fat mass (Yan et al., 2019).

Unfortunately, the reasons why the adolescent population has decreased the practice of physical activity and adherence to certain healthy habits are very diverse. Among them, the barriers found for the practice of physical activity, among which fatigue, obligations, lack of time, and environment/facilities stand out (Castedo et al., 2020); the COVID-19 pandemic experienced in recent years has not helped either, decreasing the level of physical activity and sports practice of the adolescent population during and after lockdown (Castañeda-Babarro et al., 2020; Reche-García et al., 2022); and the emergence of new forms of leisure that favor an increase in sedentary time and decrease the physical activity level and the outdoor time (Auhuber et al., 2019). All these reasons hinder the practice of physical activity, with considerable repercussions on the health of adolescents during this and later stages.

Therefore, the practice of physical activity during adolescence is necessary due to the benefits in physical condition and body composition, with previous research finding improvements in muscle mass and decreases in fat percentage with the practice of daily physical activity, as well as improvements in physical fitness (Dewi et al., 2021). Physical fitness acquires special relevance in this regard because scores obtained in physical fitness tests during adolescence can predict health-related fitness in adulthood (Yu & Mao, 2010), with cardiorespiratory capacity, upper limb strength, speed, and flexibility being the physical capacities most valued in previous research conducted with adolescents due to their relationship with health (Marques et al., 2021). So much so that research conducted in recent years has given rise to a phenomenon known as "fat but fit", in which overweight or obese individuals, but with a high level of cardiorespiratory fitness or a good fitness level, have a lower risk of metabolic and cardiovascular diseases, regardless of their weight status (Ortega et al., 2018; Torres-Costoso et al., 2021), giving even more relevance to the practice of physical activity.

Although scientific research conducted to date has demonstrated the importance of the practice of physical activity for adolescents, few studies have analyzed the differences between active and sedentary adolescents, and also have limitations that make it difficult to extrapolate the results to adolescents aged 12–16 years old, such as the use of different methodologies to measure the study variables; the small sample size; the different age ranges; or the inclusion of a disparate number of adolescent boys and girls, or adolescents of only one sex (Mateo-Orcajada, González-Gálvez, et al., 2022).

Regarding the "fat but fit" paradox, few studies have been carried out in adolescents, and these are observational studies that have used cardiorespiratory fitness or handgrip strength as variables to determine physical fitness (Ortega et al., 2018; Torres-Costoso et al., 2021). However, part of the variability in fitness is explained by genetics and hormonal changes, so that adolescents who are not very active can present moderate levels of these variables, which is a factor to be taken into account when considering subjects as fit (Andersen, 1994). One variable that could solve this problem would be the level of physical activity performed, but no previous research is known that has grouped adolescents according to this variable. The level of physical activity is related to adolescents' health and physical fitness (Saevarsson et al., 2021) and presents numerous valid and reliable ways of being measured, including electronic devices based on accelerometry, or self-reported questionnaires (Ara et al., 2015). With respect to the self-reported questionnaires, the physical activity questionnaire for adolescents (PAQ-A) is the most valid and reliable in the adolescent population (Martínez-Gómez et al., 2009) and makes it possible to distinguish between active and sedentary adolescents (Benítez-Porres et al., 2016).

Therefore, there is a gap in the scientific literature because no previous research has considered the level of physical activity as a variable to determine which adolescents are fit and how this relates to the rest of the health-related variables. Therefore, further scientific research is needed to include the level of physical activity as a discriminating variable, since it provides a great deal of information in this regard and will make it possible to determine the differences between adolescents who are truly active and those who are sedentary. In addition, the limitations found in previous research conducted with adolescents with respect to methodological rigor, non-validated instruments, and reduced samples will be addressed. For these reasons, the objectives of the present study were (a) to establish the differences in body composition, physical performance, and AMD between active and sedentary adolescents; and (b) to analyze the differences between active and sedentary adolescents according to the "fat but fit" paradigm considering different weight status.

Based on the results of previous research, two hypotheses are put forward for the present investigation: (a) active adolescents will show better body composition, physical fitness, and AMD than sedentary adolescents; and (b) considering the "fat but fit" paradigm, and in line with previous research conducted with cardiorespiratory fitness and handgrip strength as discriminatory variables, adolescents who show a higher level of physical activity will present higher physical fitness and also better body composition, regardless of their weight status.

5.3. Materials and Methods

5.3.1. Design

The present study was cross-sectional, with non-probability convenience sampling. Prior to the start of the study, the institutional ethics committee reviewed and approved the protocol designed in accordance with the World Medical Association code (CE022102). The measurement protocol was registered before the start of the study at ClinicalTrials.gov (code: NCT04860128). The research design and the development of the manuscript also followed the STROBE statement (Vandenbroucke et al., 2014). The sample was chosen non-probabilistically by convenience.

5.3.2. Participants

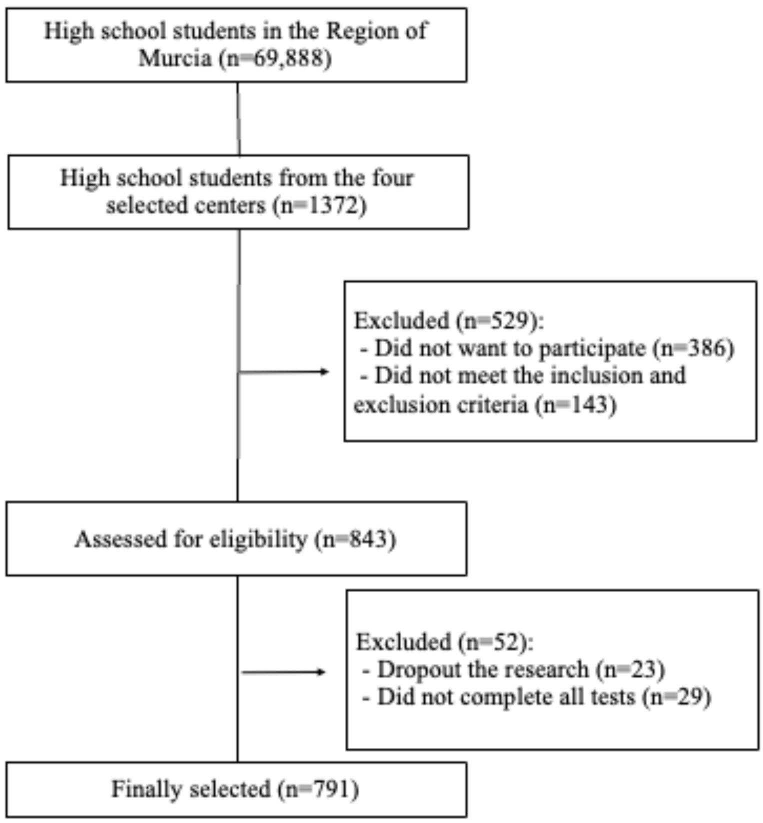
Sample size was calculated using Rstudio 3.15.0 statistical software (Rstudio Inc., Boston, MA, USA) and using standard deviations (SD) from previous research that examined physical activity level (SD = 0.58) (Palacios-Cartagena et al., 2022) of adolescents aged 12–16 years old. The estimated error (d) for a 99% confidence interval was 0.05 for the level of physical activity. The minimum sample necessary for the development of the research was 750 adolescents.

The final sample consisted of 791 adolescents (404 boys and 387 girls) between the ages of 12 and 16 (mean age: 14.39 ± 1.26 years). Of the total sample, 348 adolescents were active, of whom 226 were boys and 122 girls; while 443 adolescents were sedentary, of whom 186 were boys and 257 girls. The average score (from a minimum score of 1 to a maximum score of 5) of physical activity performed was 2.63 ± 0.67 (boys: 2.81 ± 0.67; girls: 2.46 ± 0.62).

In order to obtain a representative sample of the urban areas of Region of Murcia (Spain) and in accordance with the data collected by the Regional Statistics Centre of Murcia (Centro Regional de Estadística de Murcia, 2021), which municipality had the largest school-age population of secondary school students in the north, west, east, and south of the Region was determined. After this, based on the Regional Ministry of Education of the Region of Murcia data (Consejería de Educación. Comunidad Autónoma de la Región de Murcia, 2022), the high school with the highest number of students enrolled in compulsory secondary education was selected within each of these municipalities. All of them decided to participate in this study on a voluntary basis. After explaining the objectives and the procedure to be followed to the directors of the schools and those responsible for the physical education area, an informative meeting was held with the students and parents of each school to explain the objectives of the research, the questionnaires, and physical fitness tests to be carried out, as well as the confidential treatment of the data. After this, the adolescents who wished to participate voluntarily provided an informed consent signed by them and their parents. Figure 1 shows the sample selection flow chart.

All adolescents who participated in the research met the following inclusion criteria: (a) age between 12 and 16 years old; (b) attending compulsory secondary education; (c) not presenting any incapacitating disease that prevented participation; and (d) completing all the questionnaires and physical tests in their entirety.

Figure 1. Sample selection flow chart.



5.3.3. Instrumentation

5.3.3.1. Questionnaire measures

For data collection, tests were selected that had been previously validated in the adolescent population and used in previous studies. To obtain the level of physical activity of the adolescents, the PAQ-A was used, which had been previously validated in Spanish. It had an intraclass correlation coefficient of 0.71 for the final score of the questionnaire (Martínez-Gómez et al., 2009). This questionnaire is a 7-day recall and self-administered questionnaire composed of nine items that assess the level of physical activity performed in the week prior to the study. The first eight items of the questionnaire have a Likert scale of 1–5 points for completion (1: no physical activity; 5: a lot of physical activity), while the ninth item is answered dichotomously (yes or no). The final physical activity score was calculated as the arithmetic mean of the scores from the first eight items, the minimum score being 1 and the maximum score 5. Subsequently, the subjects were classified according to the score obtained in the questionnaire, those with a score higher than 2.75 being active, and those who obtained a lower score were sedentary, as done in previous research (Benítez-Porres et al., 2016).

The "Mediterranean Diet Quality Index for children and adolescents" (KIDMED) questionnaire (Serra-Majem et al., 2004) was used to assess the nutritional habits of adolescents, specifically the AMD. This questionnaire is composed of 16 items that are answered with a dichotomous scale (yes or no), and whose score varies between −1 (negative connotation) and +1 (positive connotation). Twelve questions had positive scores and four negative scores, with the total score ranging from 0 to 12 (Štefan, Čule, et al., 2017).

5.3.3.2. ***Body composition measurement***

The body composition analysis was performed by three accredited International Society for the Advancement of Kinanthropometry (ISAK) anthropometrists (one level 2, one level 3, and one level 4). Three basic measurements (body mass, height, sitting height), three skinfolds (triceps, thigh, and calf), and five girths (arm relaxed, waist, hip, thigh, and calf) were measured according to the protocol standardized by the International Society for the Advancement of Kinanthropometry (ISAK) (Esparza-Ros et al., 2019).

The variables were measured twice, with a third measurement being necessary when the difference between the first two measurements was greater than 5% for the skinfolds and 1% in the rest of the measurements. The mean of the measured values, when two measurements were performed, and the median of the values, when three measurements were performed, were used as the final value

(Esparza-Ros et al., 2019). All measurements corresponding to each subject were performed by the same anthropometrist.

To measure girths, an inextensible tape, Lufkin W606PM (Lufkin, Missouri City, TX, USA), with a 0.1 cm accuracy was used; a skinfold caliper (Harpenden, Burgess Hill, UK) with an accuracy of 0. 2 mm was used for measuring skinfolds; for body mass, a TANITA BC 418-MA Segmental (TANITA, Tokyo, Japan) with an accuracy of 100 g; and for height and sitting height an SECA stadiometer 213 (SECA, Hamburg, Germany) with an accuracy of 0.1 cm was used. All the instruments were previously calibrated.

The intra- and inter-evaluator technical error of measurements (TEM) were calculated in a sub-sample. The intra-evaluator TEM was 0.02% for the basic measurements; 1.21% for skinfolds, and 0.04% for the girths; and the inter-evaluator TEM was 0.03% for the basic measurements; 1.98% for skinfolds and 0.06% for the girths.

The final values of the anthropometric measurements were used to calculate the BMI, fat mass (%) (Slaughter et al., 1988), muscle mass (Poortmans et al., 2005), Σ3 skinfolds (triceps, thigh, and calf), waist-to-hip ratio (waist girth/hip girth) (NHLBI Obesity Education Initiative Expert Panel on the Identification, 1998), and waist-to-height ratio (waist girth/height) (Yan et al., 2007). Muscle girths were estimated by correcting limb girths for the appropriate skinfold using a circular model of the limb cross-section and assuming that the adipose tissue thickness was half the skinfold thickness (Jelliffe & Jelliffe, 1969; Spenst et al., 1993). Thus, the corrected girths of the arm [arm relaxed girth—(π * triceps skinfold)], thigh [middle thigh girth—(π * thigh skinfold)], and calf [calf girth—(π * calf skinfold)] were calculated.

The sex-specific formula from Mirwald et al. (Mirwald et al., 2002) was used to estimate the maturity offset of the adolescents. From the maturity offset, the biological maturation of each subject was calculated using the formula: biological maturation = chronological age—maturity offset result (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). This method proved to be valid for estimating the maturity offset with respect to the gold standard using regression equations with an $R^2 = 0.92–0.89$ in the case of boys and an $R^2 = 0.91–0.88$ in the case of girls (Albaladejo-Saura, Vaquero-Cristóbal, & Esparza-Ros, 2022).

5.3.3.3. ***Physical fitness test***

Regarding physical condition, the sit-and-reach test was used to measure hamstring flexibility (Mayorga-Vega et al., 2014) (Figure 2). The participants were seated with knees extended, feet hip-width apart, ankles at 90° flexion, toes pointed upward, and the sole of the foot fully supported on an Acuflex Tester III box (Novel Products, Rockton, IL, USA). From that position, the subjects had to perform a maximum trunk flexion, keeping the knees and arms fully extended, and reach the maximum possible distance by sliding the palms of the hands, one on top of the other, on the box (López-Miñarro et al., 2015).

Figure 2. Physical performance tests.

Handgrip strength CMJ test

Sit-and-reach 20 m shuttle run test 20 m sprint test

The handgrip strength has been shown to be a valid test to measure musculoskeletal fitness in adolescents (Matsudo et al., 2014) (Figure 2). Considering previous research, the participants performed the test with the elbow fully extended, this being the most appropriate position to assess maximal strength in adolescents (España-Romero et al., 2010). A Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo, Japan) was used to measure the force produced.

The 20 m sprint indicated the minimum possible time taken by the subject to cover the indicated distance (Figure 2). For its performance, the participant stood statically on the initial line until the sprint began at maximum speed (García-Manso et al., 1996). Single-beamed photocells (Polifemo Light, Microgate, Italy) located at hip height were used, the probability of being cut by the arms when running decreasing to 4%, compared to 60% probability when placed at chest height (Altmann et al., 2017; Cronin & Templeton, 2008).

The countermovement jump (CMJ) test was used to evaluate the explosive power of the lower limbs through the height of the jump (Figure 2). This test consists of a vertical jump in which the participants had to stand in a standing position with their hands on their waists, flex their knees to a 90° position, and perform a full knee extension to reach the maximum possible height, keeping their hands on their hips and their trunk fully extended in the flight phase (Barker et al., 2018). A force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) was used to perform the test.

The 20 m shuttle run (Léger et al., 1988) is an incremental test with high validity and reliability for measuring cardiorespiratory fitness in adolescents (G. Tomkinson, Lang, Blanchard, et al., 2019) (Figure 2). The test ends when the participant reaches exhaustion or when he/she is not able to run the 20 m before the beep occurs. The speed at which the subject leaves the test is used to predict maximal oxygen consumption (VO2 max.) using the formula from Leger et al. (Léger et al., 1988).

5.3.4. Procedure

The physical fitness tests were carried out in the selected high schools, using the class hour belonging to the physical education session and taking advantage of the covered sports pavilions to reduce the polluting variables of the environment as much as possible. All tests were performed on the same day.

For data collection, a protocol was established in which the adolescents first completed questionnaires on their level of physical activity and nutritional habits. Subsequently, anthropometric measurements were taken to determine body composition by three accredited ISAK anthropometrists. Next, the sit-and-reach test was performed before the warm-up because previous research has reported the influence of warm-up on sit-and-reach performance in adolescents (Díaz-Soler et al., 2015). Once this test was completed, the execution of the hand grip strength, CMJ, and 20 m sprint tests were explained to the adolescents, familiarizing them for the correct execution of each test and participants completed a warm-up. The warm-up consisted of 5 minutes of progressive running and 10 minutes of joint mobility of the joints involved in the physical condition tests (ankles, knees, hips, wrists, and shoulders, mainly). A researcher supervised the warm-up and at the end of the warm-up told the participant which physical test to go to. Handgrip strength, the CMJ, and 20 m sprint tests took place randomly for each adolescent. After completion of the handgrip, CMJ, and 20 m sprint tests, the 20 m shuttle run test was performed. All fitness tests were performed twice for each adolescent, leaving two minutes between the two attempts of each test, and five minutes between tests, considering the best value reported, except for the sit-and-reach test and the 20 m run test, which were performed once. Four researchers with previous experience on the assessment of physical fitness tests oversaw the familiarization and assessment of these tests, with the same researcher being responsible for each test during all the measurements, in order to avoid inter-evaluator error in the assessments.

The order of the tests was selected according to the recommendations of the National Strength and Conditioning Association (NSCA), which bases its recommendation on the fatigue generated by the different tests, as well as the metabolic pathways required by each of them (Coburn & Malek, 2014).

5.3.5. Data analysis

The distribution of the data was initially evaluated using the Kolmogorov–Smirnov normality test, with all the variables having a normal distribution and allowing statistical analyses based on parametric tests. Descriptive statistics were used to find the mean values and standard deviation. A one-factor ANCOVA was performed to analyze the differences between physically active and sedentary adolescents, with gender, age, BMI, and biological maturation as covariates in the model. A binary logistic regression analysis was used to determine the primary outcomes for establishing differences between active and sedentary adolescents. A MANOVA analysis was performed to establish the differences based on the two independent variables physical activity practice and BMI between sedentary normal weight, sedentary over-weight, sedentary under-weight, active normal weight, active over-weight, and active under-weight adolescents in all analyzed variables. Bonferroni's pairwise comparison was used for variables that were statistically significant. Partial eta squared (η^2) was used to calculate the effect size and was defined as: small: ES ≥ 0.10; moderate: ES ≥ 0.30; large: ≥1.2; or very large: ES ≥ 2.0, with an error of $p < 0.05$ (Hopkins et al., 2009). A value of $p < 0.05$ was set to determine statistical significance. The statistical analysis was performed with the SPSS statistical package (v. 25.0; SPSS Inc., Chicago, IL, USA).

5.4. Results

5.4.1. Intraclass correlation coefficients (ICC) and coefficient of variation (CV) in fitness tests

The intraclass correlation coefficients (ICC) and coefficient of variation (CV) were calculated for the fitness tests that were performed twice. The results were: handgrip strength right arm: ICC = 0.940, CV = 3.14%; handgrip strength left arm: ICC = 0.953, CV = 3.10%; CMJ: ICC = 0.892, CV = 3.35%; and 20 m sprint: ICC = 0.913, CV = 2.15%.

5.4.2. Differences between active and sedentary adolescents

The results of the comparison between active and sedentary adolescents in the variables analyzed, and the main effect of the covariates, can be found in Table 1. The differences were significant between active and sedentary adolescents (p = 0.019–<0.001) in most of the anthropometric, AMD, and physical fitness variables, with a significant effect of the covariates gender, age, BMI, and biological maturation (p = 0.039–< 0.001) on the model. Specifically, according to the basic measurements, only height showed significant differences between active and sedentary adolescents (p = 0.019), with active adolescents being taller than sedentary adolescents, with a small effect size. Most of the anthropometric variables showed significant differences ($p < 0.001$), with fat mass and sum of three skinfolds being higher in sedentary adolescents, while muscle mass, corrected girths, and waist–hip ratio higher in active adolescents, with a small effect size. Additionally, the nutritional habits showed significant differences ($p < 0.001$), with AMD being higher in active adolescents, with a small effect size. Regarding physical fitness variables, significant differences were found in all variables ($p < 0.001$), with active adolescents showing the greatest cardiorespiratory fitness, strength, speed, and jump height, with a small effect size.

The covariate gender showed main effects in all variables (<0.001), except in BMI ($p = 0.210$) and hip girth ($p = 0.691$); the covariate age showed main effects in all variables ($p <$ 0.001–0.002), except in the waist–height ratio ($p = 0.247$); the covariate BMI showed main effects in all variables ($p < 0.001$), except in the sit-and-reach test ($p = 0.395$); and the covariate biological maturation showed main effects in all variables ($p <$ 0.001–0.039) except in body mass ($p = 0.233$), height ($p = 0.068$), and BMI ($p = 0.101$).

5.4.3. Binary logistic regression analysis to determine the primary outcome among the significant variables to distinguish active and sedentary

Table 2 shows the explanatory model for the level of physical activity. The results show that body mass ($p = 0.017$), BMI ($p = 0.019$), muscle mass ($p = 0.018$), hip girth (0.024), waist–hip ratio ($p = 0.017$), waist–height ratio ($p = 0.050$), AMD ($p < 0.001$), and VO2 max. ($p < 0.001$) can be considered as primary outcomes to distinguish between active and sedentary groups of adolescents.

5.4.4. Differences between sedentary adolescents according to weight status

Figure 3 and Table 3 show the differences between sedentary normal weight ($n = 253$), sedentary over-weight ($n = 64$), sedentary under-weight ($n = 87$), active normal weight ($n = 212$), active over-weight ($n = 48$), and active under-weight adolescents ($n = 78$) ($p <$ 0.001–0.041). The pairwise comparison between sedentary normal weight–sedentary overweight–sedentary underweight showed significant differences in all variables analyzed except for height ($p =$ 0.136–0.340), AMD ($p =$ 0.316–0.599), and the sit-and-reach test ($p =$ 0.173–0.475). Sedentary overweight adolescents showed higher values for all basic measurements and anthropometric variables than normal weight and underweight adolescents ($p < 0.001$). Regarding physical fitness variables, this group obtained the highest values in handgrip strength, but their performance was significantly lower in cardiorespiratory fitness, jump height, and 20 m sprint ($p <$ 0.001–0.038).

Table 1. Differences in anthropometric, nutritional habits, and physical fitness, between active and sedentary adolescents.

	Descriptive Statistics (M ± SD)		Active vs. Sedentary				Active vs. Sedentary * Gender			Active vs. Sedentary * Age			Active vs. Sedentary * BMI			Active vs. Sedentary * Biological Maturation		
	Active (*n* = 348)	**Sedentary** (*n* = 443)	**F; *p***	**Mean Diff.**	**95% CI**	**Effect Size (η^2)**	**F**	***p***	**Effect Size (η^2)**	**F**	***p***	**Effect Size (η^2)**	**F**	***p***	**Effect Size (η^2)**	**F**	***p***	**Effect Size (η^2)**
Body mass (Kg)	57.70 ± 13.04	56.77 ± 13.32	0.967; $p = 0.326$	0.956	−0.953; 2.864	0.001	26.954	<0.001	0.068	73.228	<0.001	0.165	1133.628	<0.001	0.754	1.461	0.233	0.004
Height (cm)	164.33 ± 9.18	162.76 ± 8.73	5.547; $p = 0.019$	1.545	0.257; 2.832	0.007	76.630	<0.001	0.165	109.171	<0.001	0.228	11.684	<0.001	0.031	2.702	0.068	0.007
Sitting height (cm)	85.52 ± 4.91	84.80 ± 5.21	3.786; $p = 0.052$	0.734	−0.007; 1.474	0.005	18.754	<0.001	0.048	105.134	<0.001	0.222	23.915	<0.001	0.061	31.681	<0.001	0.078
BMI (kg/m²)	21.30 ± 3.70	21.33 ± 4.06	0.001; $p = 0.980$	−0.007	−0.574; 0.559	0.001	1.566	0.210	0.004	24.320	<0.001	0.059	-	-	-	2.299	0.101	0.006
Fat mass (%)	21.22 ± 9.96	24.14 ± 10.39	13.519; $p < 0.001$	−2.768	−4.246; −1.290	0.018	27.233	<0.001	0.068	7.180	0.001	0.019	420.481	<0.001	0.532	27.853	<0.001	0.070
Muscle mass (kg)	20.11 ± 5.22	18.06 ± 4.80	29.505; $p < 0.001$	2.010	1.284; 2.737	0.038	245.187	<0.001	0.397	98.176	<0.001	0.210	179.129	<0.001	0.327	40.475	<0.001	0.098
Sum 3 skinfolds	47.67 ± 23.80	55.03 ± 25.81	14.400; $p < 0.001$	−6.969	−10.574; −3.364	0.019	35.162	<0.001	0.086	7.823	<0.001	0.021	390.044	<0.001	0.514	29.562	<0.001	0.074
Corrected arm girth (cm)	21.79 ± 3.05	20.96 ± 2.89	13.850; $p < 0.001$	0.819	0.387; 1.250	0.018	81.292	<0.001	0.179	80.181	<0.001	0.178	272.147	<0.001	0.424	13.971	<0.001	0.036
Corrected thigh girth (cm)	41.12 ± 5.21	39.52 ± 4.56	19.682; $p < 0.001$	1.598	0.891; 2.305	0.026	61.327	<0.001	0.142	72.638	<0.001	0.164	249.192	<0.001	0.403	11.850	<0.001	0.031
Corrected calf girth (cm)	29.87 ± 3.30	28.97 ± 3.13	12.340; $p < 0.001$	0.835	0.369; 1.302	0.016	47.761	<0.001	0.114	69.306	<0.001	0.158	82.276	<0.001	0.182	9.412	<0.001	0.025
Waist girth (cm)	70.19 ± 8.40	69.38 ± 9.06	1.534; $p = 0.216$	0.803	−0.470; 2.076	0.002	49.803	<0.001	0.118	27.476	<0.001	0.069	1258.918	<0.001	0.773	3.721	0.025	0.010
Hip girth (cm)	90.50 ± 9.05	91.12 ± 9.26	0.685; $p = 0.408$	−0.558	−1.881; 0.765	0.001	0.370	0.691	0.001	73.275	<0.001	0.165	1459.358	<0.001	0.798	11.716	<0.001	0.031
Waist–hip ratio	0.78 ± 0.60	0.76 ± 0.51	13.239; $p < 0.001$	0.015	0.007; 0.023	0.018	227.949	<0.001	0.380	11.213	<0.001	0.029	29.043	<0.001	0.073	87.132	<0.001	0.190

Waist–height ratio	0.43 ± 0.46	0.43 ± 0.53	0.060; $p = 0.807$	0.001	−0.006; 0.008	0.001	12.746	<0.001	0.033	1.401	0.247	0.004	1204.244	<0.001	0.765	3.250	0.039	0.009
AMD	6.97 ± 2.37	6.15 ± 2.46	21.885; $p < 0.001$	0.818	0.475; 1.161	0.029	12.177	<0.001	0.032	12.546	<0.001	0.033	11.292	<0.001	0.030	14.621	<0.001	0.038
VO2 max. (ml/kg/min)	41.81 ± 5.59	37.86 ± 5.19	100.51; $p < 0.001$	3.967	3.190; 4.744	0.120	138.648	<0.001	0.272	59.119	<0.001	0.138	70.858	<0.001	0.161	69.683	<0.001	0.158
Handgrip right arm (kg)	28.15 ± 8.78	25.64 ± 7.70	18.554; $p < 0.001$	2.603	1.417; 3.789	0.024	105.525	<0.001	0.221	127.609	<0.001	0.257	53.076	<0.001	0.126	24.235	<0.001	0.061
Handgrip left arm (kg)	26.09 ± 7.73	23.85 ± 7.27	17.497; $p < 0.001$	2.303	1.222; 3.383	0.023	119.805	<0.001	0.244	111.783	<0.001	0.232	48.736	<0.001	0.117	26.244	<0.001	0.066
Sit-and-reach (cm)	15.69 ± 8.98	16.03 ± 8.56	0.350; $p = 0.554$	−0.382	−1.650; 0.886	0.001	60.494	<0.001	0.140	23.031	<0.001	0.059	0.929	0.395	0.003	10.127	<0.001	0.027
CMJ (cm)	25.26 ± 7.12	22.20 ± 6.74	37.472; $p < 0.001$	3.073	2.088; 4.059	0.048	78.278	<0.001	0.174	51.549	<0.001	0.122	28.046	<0.001	0.071	53.184	<0.001	0.125
20 m sprint (s)	3.80 ± 0.46	4.03 ± 0.57	35.442; $p < 0.001$	−0.230	−0.305; −0.154	0.046	78.655	<0.001	0.175	57.034	<0.001	0.134	20.885	<0.001	0.053	55.954	<0.001	0.131

BMI: body mass index; AMD: Adhesion to Mediterranean Diet; VO2 max: maximum oxygen consumption; CMJ: countermovement jump; * : indicates that the model analyzed is composed of both variables.

Between sedentary normal weight and underweight adolescents, the normal weight adolescents presented higher values in body mass and anthropometric variables ($p < 0.001$). Significant differences were also observed in handgrip strength, with normal weight adolescents showing higher values ($p < 0.001$), but no significant differences were found in the rest of the physical fitness variables.

Table 2. Binary logistic regression analysis of the analyzed variables to explain the differences between active and sedentary adolescents.

Variable	B	Standard Error	Sig.	Exp (B) Odds Ratios	95% CI
Body mass (Kg)	−0.194	0.081	0.017	0.823	0.702; 0.966
Height (cm)	−0.146	0.085	0.085	0.864	0.732; 1.020
Sitting height (cm)	0.056	0.039	0.151	1.057	0.980; 1.140
BMI (kg/m^2)	0.533	0.228	0.019	1.704	1.090; 2.664
Fat mass (%)	0.014	0.050	0.785	1.014	0.919; 1.118
Muscle mass (kg)	0.242	0.103	0.018	1.274	1.042; 1.558
Sum 3 skinfolds	−0.003	0.021	0.903	0.997	0.958; 1.039
Corrected arm girth (cm)	−0.048	0.081	0.551	0.953	0.814; 1.116
Corrected thigh girth (cm)	−0.075	0.059	0.207	0.928	0.826; 1.042
Corrected calf girth (cm)	−0.049	0.049	0.317	0.952	0.866; 1.048
Waist girth (cm)	0.054	0.283	0.848	1.056	0.606; 1.839
Hip girth (cm)	0.342	0.152	0.024	1.407	1.046; 1.895
Waist–hip ratio	41.361	17.368	0.017	0.001	0.002; 0.765
Waist–height ratio	−83.247	42.382	0.050	0.001	0.001; 0.836
AMD	0.148	0.036	<0.001	1.160	1.081; 1.244
VO2 max. (ml/kg/min)	0.113	0.020	<0.001	1.120	1.078; 1.164
Handgrip right arm (kg)	0.002	0.026	0.935	1.002	0.952; 1.055
Handgrip left arm (kg)	−0.030	0.028	0.286	0.970	0.918; 1.026
Sit-and-reach (cm)	0.008	0.011	0.469	1.008	0.987; 1.029
CMJ (cm)	0.019	0.016	0.236	1.019	0.988; 1.052
20 m sprint (s)	−0.157	0.218	0.470	0.854	0.558; 1.309

BMI: body mass index; AMD: Adhesion to Mediterranean Diet; VO2 max: maximum oxygen consumption; CMJ: countermovement jump.

5.4.5. Differences between active adolescents according to weight status

Similarly, the differences between active normal weight–active overweight–active underweight adolescents were significant in all variables except for AMD and 20 m sprint. Significantly higher values were found in active overweight adolescents compared to active normal weight and active underweight in all anthropometric variables ($p < 0.001$–0.007). Regarding the physical fitness variables, active underweight adolescents showed significantly higher VO2 max values compared to active overweight ones ($p = 0.024$); handgrip strength was higher in active overweight than in active normal weight (p = 0.002–0.005) and active underweight ($p < 0.001$), as well as higher in active normal weight than in active underweight ($p < 0.001$). Lastly, active normal weight showed greater sit-and-reach distance than active underweight ($p = 0.006$), and greater jump height than active overweight ($p = 0.013$).

5.4.6. Differences between active and sedentary adolescents with the same weight status

When comparing the results obtained for sedentary normal weight and active normal weight, the differences were significant in all the anthropometric variables (p < 0.001–0.030), with sedentary adolescents showing higher values for fat mass and sum of three skinfolds, while active adolescents showed more muscle mass, corrected girths, waist girth, and waist– hip ratio. AMD was significantly higher in active adolescents ($p < 0.001$). With respect to the physical condition variables, the active adolescents showed higher performance in all the tests (p < 0.001–0.001), except for the sit-and-reach test, in which no significant differences were observed ($p = 0.995$).

The differences were also significant in sedentary and active overweight adolescents. In this case, sedentary adolescents had higher levels of fat mass and sum of three skinfolds, while active adolescents had more muscle mass and corrected thigh and calf girth (p < 0.001–0.034). Active overweight adolescents showed better performance in all physical fitness tests (p < 0.001–0.041), except for the sit-and-reach test, where no significant differences were found ($p = 0.898$).

Regarding active and sedentary underweight adolescents, the differences were significant in fat mass, muscle mass, and waist–hip ratio, with active adolescents having higher muscle mass and waist–hip ratio (p = 0.006–0.038). AMD and performance in the physical fitness tests were higher in the active adolescents (p < 0.001–0.039), except for the sit-and-reach test, where no significant differences were found ($p = 0.262$).

Table 3. Bonferroni post hoc analysis of anthropometric, nutritional, and physical fitness variables of active and sedentary adolescents according to their BMI.

Variable	Comparison Groups	Mean Differences	95% CI	*p*	(η^2)
Body mass (Kg)	Sedentary normal weight–sedentary overweight	−20.873	−23.858; −17.889	<0.001	0.402
	Sedentary normal weight–sedentary underweight	11.533	8.882; 14.185	<0.001	0.402
	Sedentary overweight–sedentary underweight	32.407	28.894; 35.920	<0.001	0.402
	Active normal weight–active overweight	−20.620	−24.029; −17.210	<0.001	0.350
	Active normal weight–active underweight	11.834	9.009; 14.659	<0.001	0.350
	Active overweight–active underweight	32.454	28.540; 36.367	<0.001	0.350
Height (cm)	Active overweight–sedentary overweight	3.488	0.172; 6.804	0.039	0.001
	Active overweight–active underweight	4.541	0.647; 8.435	0.016	0.011
Sitting height (cm)	Active normal weight–sedentary normal weight	1.043	0.126; 1.960	0.026	0.007
	Sedentary overweight–sedentary underweight	2.668	0.685; 4.651	0.004	0.014
	Active normal weight–active underweight	2.609	1.015; 4.204	<0.001	0.030
	Active overweight–active underweight	3.974	1.765; 6.183	<0.001	0.030
Fat mass (%)	Active normal weight–sedentary normal weight	−1.786	3.243; −0.328	0.016	0.008
	Active overweight–sedentary overweight	−4.909	−7.898; −1.920	0.001	0.014
	Active underweight–sedentary underweight	−2.582	−5.023; −0.141	0.038	0.006
	Sedentary normal weight–sedentary overweight	−16.021	−18.698; −13.344	<0.001	0.287
	Sedentary normal weight–sedentary underweight	5.953	3.575; 8.330	<0.001	0.287
	Sedentary overweight–sedentary underweight	21.973	18.823; 25.124	<0.001	0.287
	Active normal weight–active overweight	−12.898	−15.956; −9.840	<0.001	0.197
	Active normal weight–active underweight	6.749	4.215; 9.282	<0.001	0.197
	Active overweight–active underweight	19.647	16.137; 23.156	<0.001	0.197
Muscle mass (kg)	Active normal weight–sedentary normal weight	2.251	1.441; 3.060	<0.001	0.039
	Active overweight–sedentary overweight	2.662	1.002; 4.321	0.002	0.013
	Active underweight–sedentary underweight	1.465	0.109; 2.820	0.034	0.006
	Sedentary normal weight–sedentary overweight	−4.166	−5.653; −2.680	<0.001	0.122
	Sedentary normal weight–sedentary underweight	3.199	1.879; 4.520	<0.001	0.122
	Sedentary overweight–sedentary underweight	7.365	5.616; 9.115	<0.001	0.122
	Active normal weight–active overweight	−4.577	−6.275; −2.879	<0.001	0.133
	Active normal weight–active underweight	3.986	2.579; 5.393	<0.001	0.133
	Active overweight–active underweight	8.563	6.614; 10.511	<0.001	0.133
Sum 3 skinfolds	Active normal weight–sedentary normal weight	−4.189	−7.784; −0.594	0.022	0.007
	Active overweight–sedentary overweight	−14.808	−22.180; −7.436	<0.001	0.021
	Sedentary normal weight–sedentary overweight	−39.596	−46.198; −32.993	<0.001	0.286
	Sedentary normal weight–sedentary underweight	14.361	8.496; 20.226	<0.001	0.286
	Sedentary overweight–sedentary underweight	53.957	46.186; 61.728	<0.001	0.286
	Active normal weight–active overweight	−28.977	−36.519; −21.434	<0.001	0.175
	Active normal weight–active underweight	16.099	9.850; 22.349	<0.001	0.175
	Active overweight–active underweight	45.076	36.419; 53.733	<0.001	0.175
Corrected arm girth (cm)	Active normal weight–sedentary normal weight	1.044	0.594; 1.495	<0.001	0.027
	Sedentary normal weight–sedentary overweight	−3.142	−3.969; −2.315	<0.001	0.204
	Sedentary normal weight–sedentary underweight	2.434	1.699; 3.169	<0.001	0.204
	Sedentary overweight–sedentary underweight	5.576	4.602; 6.550	<0.001	0.204
	Active normal weight–active overweight	−2.799	−3.744; −1.854	<0.001	0.179
	Active normal weight–active underweight	2.814	2.031; 3.597	<0.001	0.179
	Active overweight–active underweight	5.613	4.528; 6.698	<0.001	0.179

Corrected thigh girth (cm)	Active normal weight–sedentary normal weight	1.920	1.180; 2.659	<0.001	0.034
	Active overweight–sedentary overweight	1.878	0.361; 3.394	0.015	0.008
	Sedentary normal weight–sedentary overweight	−4.292	−5.650; −2.933	<0.001	0.189
	Sedentary normal weight—sedentary underweight	4.366	3.160; 5.573	<0.001	0.189
	Sedentary overweight—sedentary underweight	8.658	7.060; 10.257	<0.001	0.189
	Active normal weight–active overweight	−4.249	−5.801; −2.698	<0.001	0.189
	Active normal weight–active underweight	5.138	3.853; 6.424	<0.001	0.189
	Active overweight–active underweight	9.388	7.607; 11.169	<0.001	0.189
Corrected calf girth (cm)	Active normal weight–sedentary normal weight	0.899	0.352; 1.446	0.001	0.014
	Active overweight–sedentary overweight	1.213	0.091; 2.334	0.034	0.006
	Sedentary normal weight–sedentary overweight	−1.757	−2.762; −0.753	<0.001	0.076
	Sedentary normal weight–sedentary underweight	2.014	1–122; 2.907	<0.001	0.076
	Sedentary overweight–sedentary underweight	3.772	2.590; 4.954	<0.001	0.076
	Active normal weight–active overweight	−2.072	−3.219; −0.924	<0.001	0.080
	Active normal weight–active underweight	2.223	1.272; 3.173	<0.001	0.080
	Active overweight–active underweight	4.294	2.977; 5.611	<0.001	0.080
Waist girth (cm)	Active normal weight–sedentary normal weight	1.153	0.113; 2.193	0.030	0.006
	Sedentary normal weight–sedentary overweight	−15.773	−17.683; −13.863	<0.001	0.451
	Sedentary normal weight–sedentary underweight	6.860	5.163; 8.557	<0.001	0.451
	Sedentary overweight–sedentary underweight	22.633	20.385; 24.881	<0.001	0.451
	Active normal weight–active overweight	−15.033	−17.215; −12.851	<0.001	0.367
	Active normal weight–active underweight	6.341	4.533; 8.148	<0.001	0.367
	Active overweight–active underweight	21.374	18.869; 23.878	<0.001	0.367
Hip girth (cm)	Sedentary normal weight–sedentary overweight	−14.500	−16.435; −12.566	<0.001	0.465
	Sedentary normal weight–sedentary underweight	9.476	7.758; 11.194	<0.001	0.465
	Sedentary overweight–sedentary underweight	23.976	21.700; 26.253	<0.001	0.465
	Active normal weight–active overweight	−13.601	−15.811; −11.391	<0.001	0.399
	Active normal weight–active underweight	9.700	7.870; 11.531	<0.001	0.399
	Active overweight–active underweight	23.301	20.765; 25.837	<0.001	0.399
Waist–hip ratio	Active normal weight–sedentary normal weight	0.014	0.004; 0.024	0.005	0.010
	Active underweight–sedentary underweight	0.023	0.007; 0.039	0.006	0.010
	Sedentary normal weight–sedentary overweight	−0.046	−0.064; −0.028	<0.001	0.049
	Sedentary overweight–sedentary underweight	0.041	0.020; 0.063	<0.001	0.049
	Active normal weight–active overweight	−0.043	−0.064; −0.023	<0.001	0.034
	Active overweight–active underweight	0.030	0.006; 0.053	0.007	0.034
Waist–height ratio	Sedentary normal weight–sedentary overweight	−0.097	−0.107; −0.086	<0.001	0.486
	Sedentary normal weight–sedentary underweight	0.037	0.027; 0.046	<0.001	0.486
	Sedentary overweight–sedentary underweight	0.133	0.121; 0.146	<0.001	0.486
	Active normal weight–active overweight	−0.084	−0.096; −0.072	<0.001	0.365
	Active normal weight–active underweight	0.033	0.023; 0.043	<0.001	0.365
	Active overweight–active underweight	0.118	0.104; 0.131	<0.001	0.365
AMD	Active normal weight–sedentary normal weight	0.785	0.351; 1.219	<0.001	0.017
	Active underweight–sedentary underweight	1.124	0.397; 1.850	0.002	0.012
VO2 max. (ml/kg/min)	Active normal weight–sedentary normal weight	3.906	2.941; 4.872	<0.001	0.079
	Active overweight–sedentary overweight	4.713	2.733; 6.694	<0.001	0.029
	Active underweight–sedentary underweight	3.401	1.784; 5.018	<0.001	0.023
	Sedentary normal weight–sedentary overweight	2.656	0.882; 4.430	0.001	0.027
	Sedentary overweight–sedentary underweight	−3.888	−5.976; −1.800	<0.001	0.027
	Active overweight–active underweight	−2.575	−4.901; −0.250	0.024	0.010

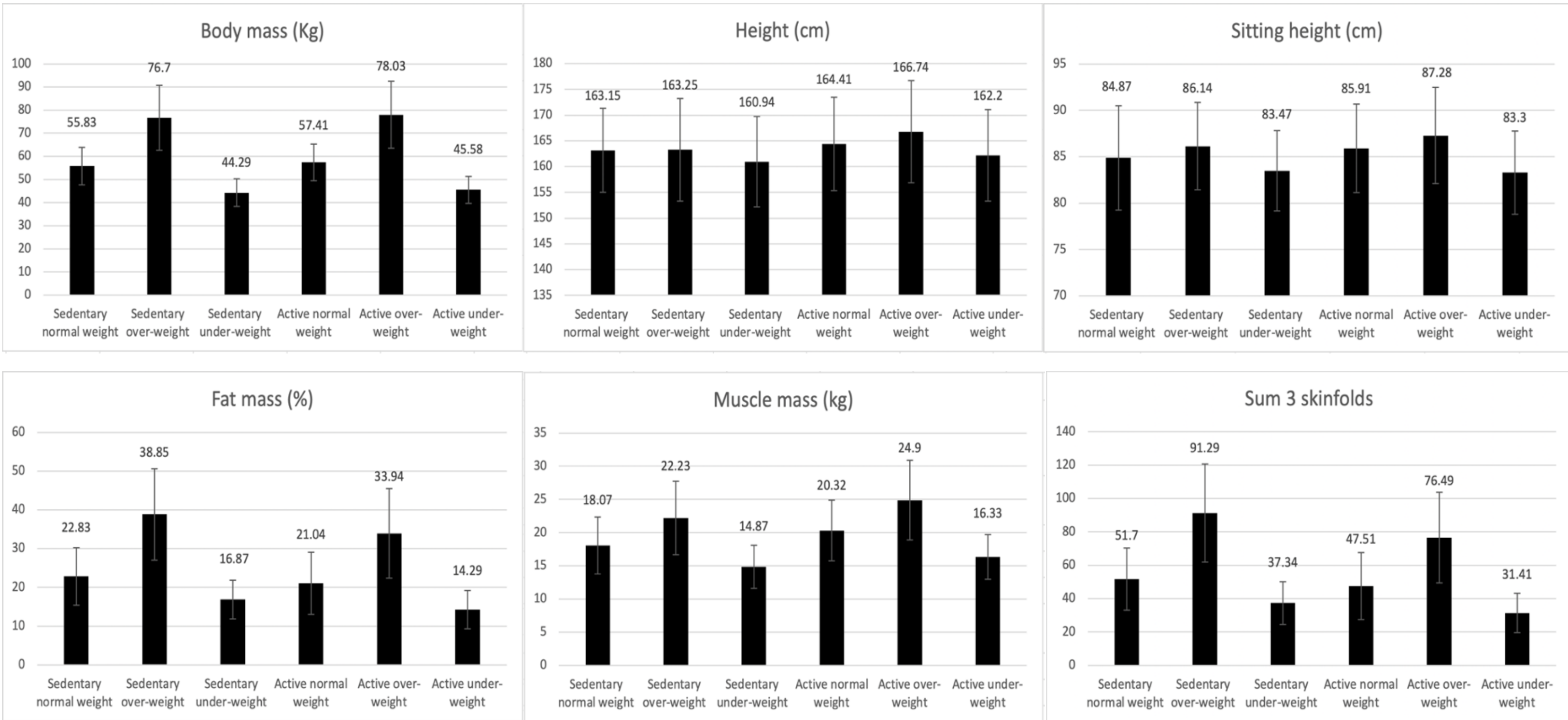
Handgrip right arm (kg)	Active normal weight–sedentary normal weight	2.609	1.180; 4.038	<0.001	0.017
	Active overweight–sedentary overweight	3.587	0.657; 6.517	0.016	0.008
	Active underweight–sedentary underweight	2.515	0.122; 4.907	0.039	0.006
	Sedentary normal weight–sedentary overweight	−3.315	−5.939; −0.690	0.008	0.050
	Sedentary normal weight–sedentary underweight	4.443	2.112; 6.774	<0.001	0.050
	Sedentary overweight–sedentary underweight	7.757	4.669; 10.846	<0.001	0.050
	Active normal weight–active overweight	−4.293	−7.291; −1.295	0.002	0.051
	Active normal weight–active underweight	4.537	2.053; 7.021	<0.001	0.051
	Active overweight–active underweight	8.830	5.389; 12.270	<0.001	0.051
Handgrip left arm (kg)	Active normal weight–sedentary normal weight	2.149	0.842; 3.456	0.001	0.014
	Active overweight–sedentary overweight	2.802	0.121; 5.483	0.041	0.006
	Active underweight–sedentary underweight	2.909	0.720; 5.099	0.009	0.009
	Sedentary normal weight–sedentary overweight	−2.988	−5.390; −0.587	0.009	0.052
	Sedentary normal weight–sedentary underweight	4.245	2.112; 6.378	<0.001	0.052
	Sedentary overweight–sedentary underweight	7.233	4.407; 10.060	<0.001	0.052
	Active normal weight–active overweight	−3.641	−6.384; −0.898	0.005	0.040
	Active normal weight–active underweight	3.485	1.212; 5.757	0.001	0.040
	Active overweight–active underweight	7.126	3.977; 10.274	<0.001	0.040
Sit-and-reach (cm)	Active normal weight–active underweight	3.584	0.821; 6.348	0.006	0.014
CMJ (cm)	Active normal weight–sedentary normal weight	2.892	1.663; 4.120	<0.001	0.028
	Active overweight–sedentary overweight	3.548	1.028; 6.067	0.006	0.010
	Active underweight–sedentary underweight	3.068	1.011; 5.126	0.004	0.012
	Sedentary normal weight–sedentary overweight	3.726	1.469; 5.982	<0.001	0.021
	Sedentary overweight–sedentary underweight	−2.853	−5.509; −0.197	0.030	0.021
	Active normal weight–active overweight	3.070	0.492; 5.648	0.013	0.011
20 m sprint (s)	Active normal weight–sedentary normal weight	−0.227	−0.323; −0.132	<0.001	0.029
	Active overweight–sedentary overweight	−0.287	−0.482; −0.091	0.004	0.011
	Active underweight–sedentary underweight	−0.191	−0.350; −0.031	0.019	0.007
	Sedentary normal weight–sedentary overweight	−0.182	−0.357; −0.007	0.038	0.008

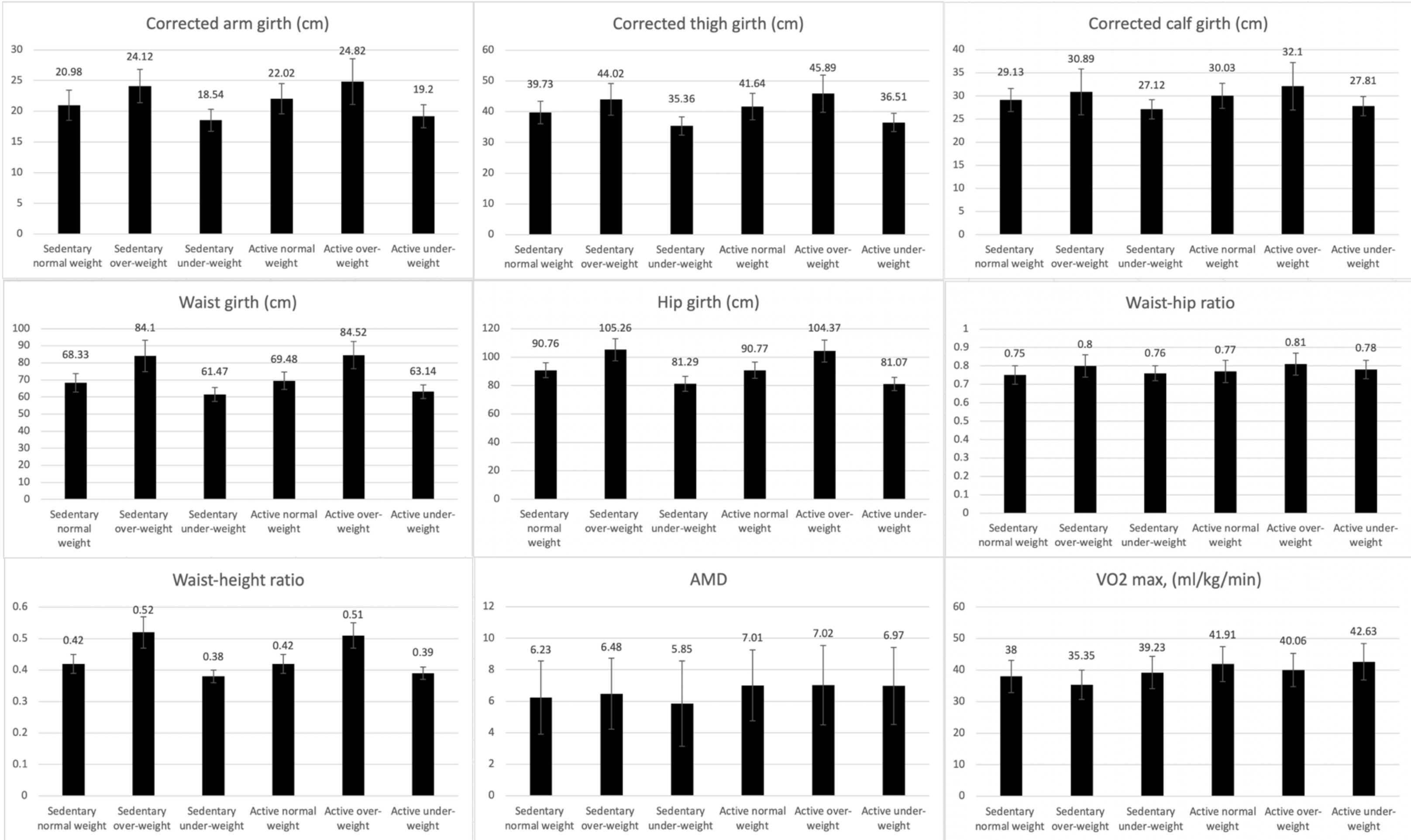
BMI: body mass index; APHV: age at peak height velocity; AMD: Adhesion to Mediterranean Diet; VO2 max: maximum oxygen consumption; CMJ: countermovement jump.

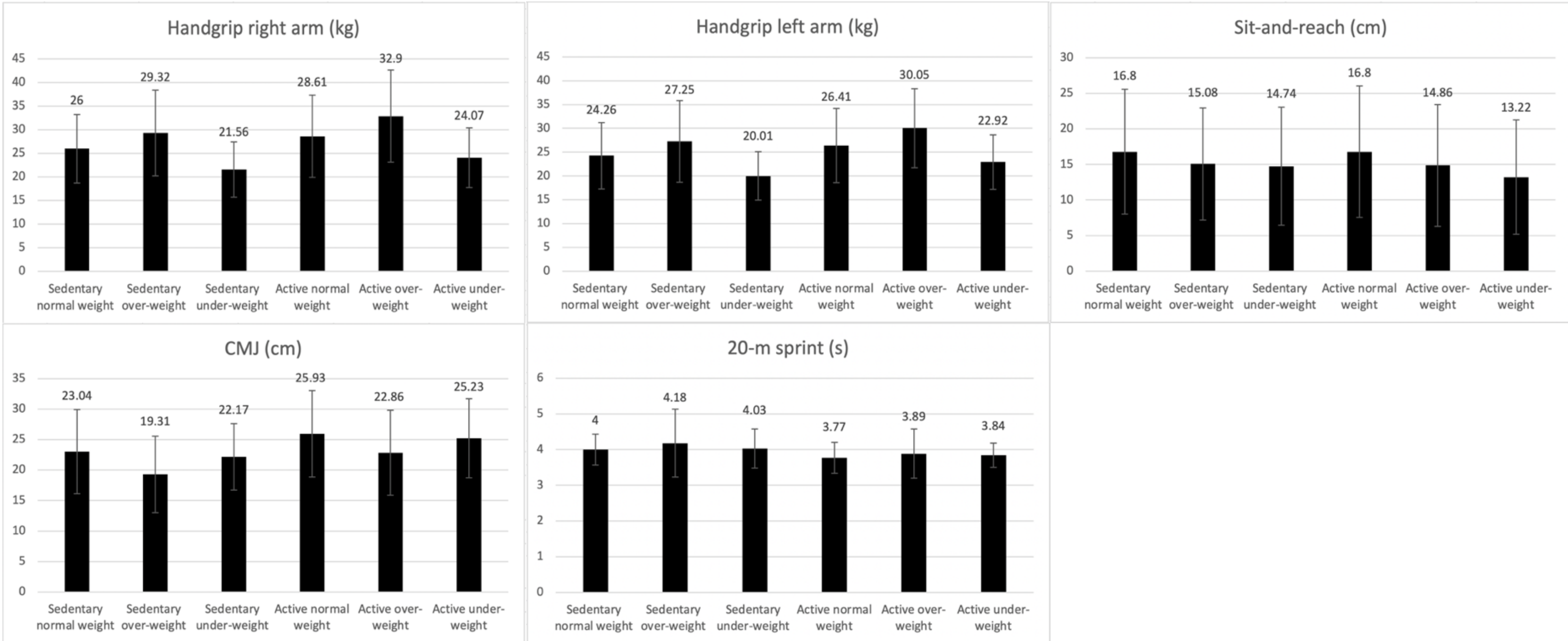
5.5. Discussion

The main objectives of the present investigation were (a) to establish the differences in body composition, physical performance, and AMD between active and sedentary adolescents; and (b) to analyze the differences between active and sedentary adolescents according to the “fat but fit” paradigm considering different weight statuses. Based on the results of previous research, the following hypotheses were put forward: (a) active adolescents will show better body composition, physical fitness, and AMD than sedentary adolescents; and (b) adolescents who show a higher level of physical activity will present higher physical fitness and better body composition, independently of their weight status. A significant difference was found between active and sedentary adolescents in most of the anthropometric, AMD, and physical fitness variables, with a significant

Figure 3. Descriptive values of anthropometric, nutritional, and physical fitness variables of active and sedentary adolescents according to their BMI.




Corrected arm girth (cm)
20.98
24.12
18.54
22.02
24.82
19.2
Corrected thigh girth (cm)
39.73
44.02
35.36
41.64
45.89
36.51
Corrected calf girth (cm)
29.13
30.89
27.12
30.03
32.1
27.81
Waist girth (cm)
68.33
84.1
61.47
69.48
84.52
63.14
Hip girth (cm)
90.76
105.26
81.29
90.77
104.37
81.07
Waist-hip ratio
0.75
0.8
0.76
0.77
0.81
0.78
Waist-height ratio
0.42
0.52
0.38
0.42
0.51
0.39
AMD
6.23
6.48
5.85
7.01
7.02
6.97
VO2 max, (ml/kg/min)
38
35.35
39.23
41.91
40.06
42.63
Sedentary normal weight
Sedentary over-weight
Sedentary under-weight
Active normal weight
Active over-weight
Active under-weight


Handgrip right arm (kg)
45
40
35
30
25
20
15
10
5
0
26
29.32
21.56
28.61
32.9
24.07
Sedentary normal weight
Sedentary over-weight
Sedentary under-weight
Active normal weight
Active over-weight
Active under-weight
Handgrip left arm (kg)
45
40
35
30
25
20
15
10
5
0
24.26
27.25
20.01
26.41
30.05
22.92
Sedentary normal weight
Sedentary over-weight
Sedentary under-weight
Active normal weight
Active over-weight
Active under-weight
Sit-and-reach (cm)
30
25
20
15
10
5
0
16.8
15.08
14.74
16.8
14.86
13.22
Sedentary normal weight
Sedentary over-weight
Sedentary under-weight
Active normal weight
Active over-weight
Active under-weight
CMJ (cm)
35
30
25
20
15
10
5
0
23.04
19.31
22.17
25.93
22.86
25.23
Sedentary normal weight
Sedentary over-weight
Sedentary under-weight
Active normal weight
Active over-weight
Active under-weight
20-m sprint (s)
6
5
4
3
2
1
0
4
4.18
4.03
3.77
3.89
3.84
Sedentary normal weight
Sedentary over-weight
Sedentary under-weight
Active normal weight
Active over-weight
Active under-weight

effect of the covariates gender, age, BMI, and biological maturation on the model. The binary logistic regression analysis performed shows that the variables body mass, BMI, muscle mass, hip girth, waist-to-hip ratio, waist-to-height ratio, AMD, and VO2 max can be considered as primary outcomes to distinguish between active and sedentary groups of adolescents, and special attention should be paid to the differences in these variables. When comparing the differences between groups according to physical activity and BMI, it was found that, in general, at the same level of physical activity, adolescents with higher BMI showed higher values for anthropometric variables and worse values in the physical fitness tests. On the other hand, at the same BMI, sedentary adolescents generally showed higher values for anthropometric variables and worse values in the physical fitness tests and the AMD.

According to the first objective of the present study, to establish the differences in body composition, physical performance, and AMD between active and sedentary adolescents, the results obtained showed that active adolescents had lower values of fat mass and sum of skinfolds, and higher values of height, muscle mass, corrected girths, and waist–hip ratio. In fact, body mass and BMI, muscle mass, hip girth, waist-to-hip ratio, and waist-to-height ratio were found as primary outcomes to distinguish between active and sedentary groups. Previous studies have also found that active adolescents presented higher values of muscle mass and lower values of fat mass, as compared to sedentary adolescents (Agata & Monyeki, 2018; Bravo-Sánchez et al., 2021; Dewi et al., 2021), which could be because regular physical activity produces improvements in body composition during adolescence (Bogataj et al., 2021).

Surprisingly, the present study also found that active adolescents were taller than sedentary adolescents. Only one previous study has analyzed the difference in height between active and sedentary subjects and found no difference between them (Gea-García et al., 2020). However, previous studies have shown that early maturers develop a series of physical and anthropometric capacities as a result of the maturational effect, including being taller than normal and late maturers during this period of growth (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a; Baxter-Jones et al., 2020). This aspect could be a competitive advantage in sports involving strength, power, speed, agility, and endurance (Nevill et al., 2021), i.e., most competitive sports played by adolescents, including basketball, football, and martial arts (Albaladejo-Saura et al., 2021; Mateo-Orcajada et al., 2021). Also, in those sports that are usually practiced in Physical Education sessions within the school environment, among which volleyball, basketball, handball, and football standout (Albaladejo-Saura et al., 2021; Robles Rodríguez et al., 2015). The fact that early maturing adolescents have a competitive advantage over their peers, albeit temporary, could lead them to have a greater sense of their level of competence (Williams et al., 2020), this being a key aspect for the maintenance of an activity according to the self-determination theory (Teixeira et al., 2012). Not surprisingly, previous studies have suggested that the adolescent's perception of being unable to meet the demands of sport leads to withdrawal from sport (Purcell, 2005). This could lead to late maturers tending to abandon sport to a greater extent (Figueiredo et al., 2009), which would explain the differences found in height between the active and sedentary adolescents in the present study.

However, the fact that significant differences between active and sedentary adolescents were found in the present study may be because adolescents who are taller in their age range could practice physical activity for a longer period of time than those who are shorter. This could be due to the fact that early maturation, the development of physical capacities, and height, are determining factors for sports performance (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a; Baxter-Jones et al., 2020), and could influence the level of sports participation, with taller adolescents maintaining their level of sports practice. However, this should be corroborated in future studies.

AMD was also shown to be higher in active adolescents and a primary outcome to distinguish between those who are active and sedentary. Previous studies have suggested that there may be a link between healthy physical activity habits and nutritional habits (García-Hermoso et al., 2020b; Zurita-Ortega et al., 2018). This could be because the establishment of a certain healthy lifestyle habit, such as regular physical activity, facilitates the adoption of other healthy lifestyle habits, such as maintaining a healthy diet (Couture-Wilhelmy et al., 2021).

Regarding the physical condition variables, upper and lower limb strength, sprint speed, and cardiorespiratory fitness, were higher in active adolescents, while the distance reached in the sit-and-reach test showed no significant differences with respect to sedentary adolescents. Scientific evidence has highlighted an association between higher physical activity practice and an increase in physical fitness levels

(Rauner et al., 2013; Schutte et al., 2016). This is evidence that, from an early age, being physically active is synonymous with less difficulty and effort in facing physical tasks (Jaakkola et al., 2016). More specifically, previous studies have already pointed out that there might be differences in all physical tests that depend on cardiorespiratory endurance, muscle strength, muscle endurance, muscle power, speed, balance, coordination, accuracy, and agility between active and sedentary subjects, but not in tests that depend on flexibility (Agata & Monyeki, 2018; Gea-García et al., 2020). This could be because the practice of regular physical activity increases muscular fitness and cardiorespiratory fitness in adolescents (Aires et al., 2011; Smith et al., 2019), but flexibility requires a high volume of stretching for range of motion to improve, which is not common in most sports practices (Vaquero-Cristóbal, Molina-Castillo, et al., 2020). In addition, a significant finding of our study was that only cardiorespiratory fitness showed itself to be a primary outcome to distinguish between active and sedentary individuals. Cardiorespiratory fitness has been proposed by previous studies as the parameter of the physical condition variables most related to healthy lifestyle (Lang et al., 2019). Therefore, it could be the most important physical condition parameter to differentiate between active and sedentary adolescents. After these promising results, questions remain for future studies, such as whether gender influences this or whether it would be the same in children.

The gender covariate showed main effects in all variables analyzed, except in BMI and hip girth. Previous studies have already pointed out that males tend to show lower values for anthropometric variables related to adiposity and higher values for variables related to muscle development (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022b) than females. It has been suggested that during this stage a sexual dimorphism occurs as a result of the differences in hormone production after puberty (Gilsanz et al., 2018) which favors men to increase their muscle mass, while women have a greater tendency to accumulate adiposity (Albaladejo-Saura et al., 2021; Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a, 2022c). Gender differences have also been found in adolescents, with males showing a higher level of physical fitness than females (Steene-johannessen et al., 2020), which could be due to biological differences between them (Albaladejo-Saura et al., 2021; Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a, 2022c), but also to adaptive issues, as males are generally more active than females (Steene-johannessen et al., 2020). Gender differences are less clear with regard to dietary habits as, while previous studies have suggested that they may have similar AMD (De Santi et al., 2020; Rosi et al., 2020), other studies have indicated that dietary patterns may be different according to gender (Pinho et al., 2014). Therefore, these remaining questions need to be addressed in future studies.

The inclusion of the covariate age showed significant differences in all variables analyzed, except for the waist–height ratio. Previous studies have found that older adolescents presented higher scores in physical fitness tests, greater muscle development, greater AMD, and higher levels of fat mass than the youngest (Gerber et al., 2015; Handelsman, 2017). This is because adolescents are in the midst of a maturation process in which the production of growth hormone and sex steroid hormones increases with age (Clark & Rogol, 1996), being related to the changes produced in muscle mass and fat mass (Handelsman, 2017), and physical capabilities that rely on strength, power, or endurance (Albaladejo-Saura et al., 2021). Regarding the waist–height ratio variable, it is limited by the height of the adolescents, and it increases throughout adolescence (Gerber et al., 2015), with this being a possible explanation for the absence of significant differences when considering this covariate.

The BMI covariate also showed significant differences in all variables, except for the sit-and-reach score. These results are not surprising and are in agreement with those found in previous research in which adolescents with higher BMI scores had higher levels of fat mass and muscle mass (Kryst et al., 2022), as well as worse performance in physical fitness tests (Zhang et al., 2019). This is a determinant during adolescence, because difficulties in physical performance and distorted body image hinder the relationship with peers (Bacchini et al., 2017). The absence of significant differences in the sit-and-reach score is also in line with previous research (Lovecchio & Zago, 2019) and could indicate that BMI is not a determining factor in the flexibility of adolescents.

On the inclusion of the covariate biological maturation, it was found that it had a significant effect on the differences found between the sedentary and active adolescents in all anthropometric and physical variables and AMD, except for the variables body mass, height, and BMI. Previous studies have already pointed to the influence of maturation on anthropometric and derived variables and physical performance among males (Albaladejo-Saura et al., 2021; Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a). More specifically, it has been found that adolescent boys whose maturational process is more advanced have a competitive advantage during the growth period in all physical condition variables that depend on the ability to produce strength and power (Albaladejo-Saura et al., 2021; Fitts et al., 1991), which could be due in part to their greater muscle mass as a result of hormonal changes in general, and specifically the increase in the amounts of testosterone that occurs during this stage (Fitts et al., 1991; Handelsman et al., 2018). Results are much weaker among adolescent females, although the trend appears to be similar (Albaladejo-Saura et al., 2021; Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a). Moreover, no previous studies have analyzed the interaction of physical activity and maturation on eating habits. This should be addressed in future research.

The second objective of the present investigation was to analyze the differences be- tween active and sedentary adolescents according to the "fat but fit" paradigm considering different weight status. When comparing the groups of active and sedentary adolescents with normal weight, the differences were significant in the variables of fat and muscle mass, performance in physical fitness tests, and AMD, with the active adolescents obtaining greater values in all variables. Similar results were found when comparing active and sedentary overweight and underweight adolescents, except for AMD, in which overweight adolescents showed no differences according to the level of physical activity practiced. Paying special attention to the group of overweight/obese adolescents, previous studies have found that active adolescents show better physical performance and lower body fat than sedentary adolescents despite being overweight, giving rise to the so-called "fat but fit" paradigm (Ortega et al., 2018). However, the absence of differences in AMD between active and sedentary adolescents in the group of overweight adolescents could indicate that the practice of physical activity in this group is not as decisive for the adoption of healthy lifestyle habits as in the normal weight group. Previous studies have suggested that there is a relationship between physical exercise and AMD, but without addressing the issue from a "fat but fit" paradigm (Štefan, Čule, et al., 2017). This is an issue that should be pursued in future studies. Therefore, on the basis of the results of the present investigation, a combined intervention of physical activity and healthy nutritional habits would be necessary in the overweight population if changes in adiposity accumulation are to occur.

Regarding the comparison of overweight, normal weight, and underweight sedentary subjects, as well as overweight, normal weight, and underweight active subjects, the results in the sedentary and active adolescent groups showed higher values in overweight adolescents in the anthropometric variables as compared to normal weight and underweight adolescents. In addition, overweight adolescents presented lower scores in physical fitness tests, except for handgrip strength, in both the active and sedentary adolescent groups, when compared to normal weight and underweight adolescents. Previous research has also shown that overweight adolescents showed lower scores in jump height, cardiorespiratory fitness, and speed tests, but higher scores in handgrip strength, than normo- and under- weight adolescents (Manzano-Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Gallardo, et al., 2020; Mendoza-Muñoz et al., 2020). An explanation could be that in physical tests in which body mass is mobilized, overweight and obese adolescents present limitations due to excess weight. However, the development of muscle strength in overweight subjects is greater than that of normal and underweight subjects, as they have higher levels of bone and muscle mass (Vandewalle et al., 2013).

Notably, in underweight active adolescents, the handgrip strength score was significantly lower compared to overweight and normal weight adolescents, while VO2 max was significantly higher than that of overweight active subjects. Previous data has shown that underweight adolescents had better cardiorespiratory fitness than overweight adolescents (Xu et al., 2020), while other research has shown that underweight adolescents had worse cardiorespiratory fitness than normal weight adolescents (García-Hermoso et al., 2019). Therefore, it seems evident that the physical condition of adolescents does not differ only when considering weight status, and that factors such as the type of sports practice or the frequency of training may have an influence. Future research is needed to further analyze the factors influencing the development of physical capacities during adolescence.

Regarding the practical implications of this research, the practice of physical activity during adolescence is essential for an adequate development of body composition, physical capacities, and AMD. In view of the current curriculum and the reduced hours of school physical activity in Spain, the main solution is to give more importance to the subject of physical education within the framework of compulsory education, by increasing the number of hours of physical education in the Spanish educational curriculum, but also by carrying out programs to raise awareness among all those involved in the educational process (teachers of other areas, teachers of the area itself, parents, students, etc.) of its importance and influence on the future health of adolescents. As a secondary solution, greater importance should be given to the promotion of out-of-school physical activity, increasing the weekly hours of practice, and facilitating access to practice by adolescents, encouraging them to be active for longer each day. These strategies should place special emphasis on overweight and obese adolescents, since they are less active, and the health benefits obtained would be similar to those of adolescents with a better weight status.

The present study is not free of limitations. Since this was a cross-sectional design, it was not possible to establish a causal relationship between the variables analyzed. The sample was selected by convenience in the educational centers that could be accessed. Another possible limitation could be the selection of the questionnaire chosen to classify the subjects into active and sedentary, since, although it had been previously validated in a sample of Spanish adolescents, showing adequate validity and reliability for measuring physical activity (Martínez-Gómez et al., 2009), the results could be influenced by the measurement instrument, being a possible limitation of this study. For this reason, it would be interesting to support the results already obtained by using better measuring instruments for a direct quantification of the PA levels. Further research is needed in order to corroborate the main findings. Furthermore, the fact that the adolescents were classified as underweight, normal weight, and overweight/obese according to the World Health Organization classification, was not considered a limitation, but it is an aspect to be considered in future research, although there are other classifications that could modify the results obtained. Finally, BMI does not allow differentiation between adipose and muscle components (Esparza-Ros et al., 2022), and future research will need to analyze this “fat but fit” phenomenon by using variables exclusively related to adiposity, such as the skinfold sums, the adipose/fat mass, or the adipose/fat percentage, to classify adolescents as “fat”.

5.6. Conclusions

Considering the results obtained in the present research, it can be concluded that active adolescents have lower fat mass, higher values of muscle mass and height, greater AMD, greater strength, speed, and cardiorespiratory fitness than sedentary adolescents. Body mass, BMI, muscle mass, hip girth, waist-to-hip ratio, waist-to-height ratio, AMD, and VO2 max were considered as primary outcomes to distinguish between active and sedentary groups of adolescents. The comparison between adolescents with different weight status showed higher results in anthropometric variables and lower performance in physical fitness tests, except for handgrip strength, in overweight or obese adolescents, regardless of whether they are active or sedentary. In addition, the more active adolescents within the same weight status group had greater muscle mass, physical performance, and AMD diet than the more sedentary adolescents, in accordance with the "fat but fit" paradigm.

Vb – ESTUDIO 2: Differences in kinanthropometric variables and physical fitness of adolescents with different adherence to the Mediterranean diet and weight status: "Fat but Healthy diet" paradigm

ESTUDIO 2 – DIFFERENCES IN KINANTHROPOMETRIC VARIABLES AND PHYSICAL FITNESS OF ADOLESCENTS WITH DIFFERENT ADHERENCE TO THE MEDITERRANEAN DIET AND WEIGHT STATUS: "FAT BUT HEALTHY DIET" PARADIGM

5.1. Abstract

The present investigation provides a new paradigm, the fat but healthy diet, through which to analyze the importance of adherence to the Mediterranean diet (AMD) in the adolescent population. To this end, the objectives were to analyze the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in males and females with different AMD and to determine the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in adolescents with different body mass index and AMD. The sample consisted of 791 adolescent males and females whose AMD, level of physical activity, kinanthropometric variables, and physical condition were measured. The results showed that when analyzing the whole sample, the differences were only significant in the level of physical activity among adolescents with different AMD. However, when considering the gender of the adolescents, the males also showed differences in the kinanthropometric variables, while the females did so in the fitness variables. In addition, when considering gender and body mass index, the results showed that overweight males with better AMD showed less physical activity and higher body mass, sum of three skinfolds, and waist circumference, and females did not show differences in any variable. Therefore, the benefits of AMD in anthropometric variables and physical fitness of adolescents are questioned, and the fat but healthy diet paradigm cannot be confirmed in the present research.

5.2. Introduction

In the adolescent population, nutritional habits are one of the most important factors for the establishment of healthy lifestyles (González-Gross et al., 2008; Malheiros et al., 2021). Thus, a correct diet facilitates the prevention of chronic diseases such as obesity (Aydin & Yilmaz, 2021), contributes to better glycemic control (Dominguez-Riscart et al., 2022), and has a fundamental anti-inflammatory and antioxidant effect in this population (Augimeri et al., 2022).

In recent decades, the adherence to the Mediterranean diet (AMD) of adolescents has been used in Europe as a criterion for assessing their diet because it is one of the healthiest dietary patterns known to date (Serra-Majem et al., 2004; Willet et al., 1995). Previous research conducted in adolescents has tried to establish differences in AMD according to gender (Rosi et al., 2020; Tapia-López, 2019) and to analyze the relationship between AMD and other determinant variables for health such as body composition (Galan-Lopez et al., 2019; Santana et al., 2018), level of physical activity (Moral García et al., 2019; Santana et al., 2018), or physical fitness (Manzano-Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Clavel, et al., 2020).

Regarding some components of physical fitness and physical activity levels of adolescents according to AMD, the results found were very disparate. Some of the results found in previous research were: (1) higher values in handgrip strength and vertical jump in males with a higher AMD but not in females (Manzano-Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Clavel, et al., 2020); (2) a higher performance in cardiorespiratory endurance tests in males and females with moderate-high AMD (Galan-Lopez et al., 2019; Manzano-Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Clavel, et al., 2020); (3) a higher level of physical activity in adolescents with a higher AMD (Moral García et al., 2019); or (4) absence of significant differences in the level of physical activity and physical fitness among adolescents with different AMD (Santana et al., 2018).

Similarly, the existing relationship between body composition and AMD shows contradictory results. Some previous research found: (1) no significant differences in males or females in body composition when considering the level of AMD (Galan-Lopez et al., 2019; Santana et al., 2018); and (2) significant differences in fat percentage when considering AMD, with males with moderate-high AMD showing the lowest fat percentage (Galan-Lopez et al., 2018; Manzano-Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Clavel, et al., 2020).

Although previous research has investigated the differences between males and females in AMD as well as the differences in body composition, level of physical activity, and physical fitness of adolescents according to AMD, the conclusions are not clear. In the field of physical activity, a paradigm known as “fat but fit” has been considered in recent years (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022; Torres-Costoso et al., 2021). In this paradigm, overweight and obese adolescents with a better level of physical fitness showed lower cardiometabolic risks than adolescents with the same weight status but with a worse level of physical fitness (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022; Torres-Costoso et al., 2021). Extrapolating this theory to the field of nutrition, it could be that a similar phenomenon occurs, whereby differences in body composition, physical fitness, and physical activity level of adolescents could differ according to AMD and adolescent weight. Thus, a paradigm called “fat but healthy diet” could be proposed in which, hypothetically, adolescents with optimal AMD would present higher levels of physical activity, better kinanthropometric variables, and higher performance in fitness tests compared to adolescents with worse AMD within the same weight status group. It could provide key information on the relevance of diet in the adolescent population regardless of weight status. However, no known study has addressed this joint approach to AMD and weight status.

For this reason, the main objectives of the present investigation were (a) to analyze the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in males and females with different AMD and (b) to determine the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in adolescents with different body mass index (BMI) and AMD.

Based on previous research, the following research hypotheses are posed: (H1) differences will be significant in physical fitness, physical activity level, and fat-mass-related variables in adolescents according to AMD level, although there will be differences according to gender; and (H2) adolescents with higher AMD will perform more physical activity, present better body composition, and higher performance in physical fitness tests regardless of their weight status.

5.3. Materials and Methods

5.3.1. Design

A descriptive and cross-sectional design with non-probabilistic convenience sampling was carried out. Before starting the study, the institutional ethics committee of the Catholic University of Murcia approved the protocol designed for the research study (protocol code: CE022102, 26 February 2021) according to the Helsinki declaration. The STROBE statement was followed for the development of the manuscript (Vandenbroucke et al., 2014).

5.3.2. Participants

The minimum sample size was calculated using the statistical software Rstudio 3.15.0 (Rstudio Inc., Boston, MA, USA) using the standard deviations from previous studies that analyzed diet in adolescents (SD = 2.32) (Galan-Lopez et al., 2019). The minimum sample size for the development of the present research was 750 adolescents considering an estimated error (d) of 0.22 for a 99% confidence interval.

The final sample consisted of 791 adolescents (404 males and 387 females; mean age: 14.39 ± 1.26 years) who decided to voluntarily participate in the study. Informed consent was signed before the start of the study by the adolescents and their parents, accrediting their participation in the study. The participants were enrolled in four secondary schools in the (Region of Murcia) (two located in the north, one in the center, and one in the southeast). These schools were selected because they had a high number of students enrolled in compulsory secondary education. In Spain, during this formative stage, students receive notions of nutrition and dietetics in the subjects of Biology and Geology as well as in Physical Education (Real Decreto 1105/2014, 2015). Adolescents learn about the importance of macronutrients and micronutrients of general importance for the functionality of the body as well as the importance of a healthy diet in lifestyle habits and health improvement, but this is always learned in a secondary and complementary way and not as the main content of any of the aforementioned subjects.

The inclusion criteria of the sample were as follows: (a) enrolled in compulsory secondary education with ages between twelve and sixteen years old and (b) not having any incapacitating disease that would make it impossible to complete the questionnaires and physical tests.

5.3.3. Instruments

5.3.3.1. Questionnaire measurements

The KIDMED questionnaire (Serra-Majem et al., 2004) was used to determine the AMD of these adolescents. This questionnaire presents moderate reliability and reproducibility values for use in adolescents (α = 0.79 and kappa: 0.66). The questionnaire is composed of 16 questions that were rated by the adolescents with a score of 1 or 0 depending on whether the criterion was met. Subsequently, the scores obtained were added up considering that twelve of the questions had a positive connotation (+1) (favoring a good adherence), and four had a negative connotation (−1) (favoring an inadequate adherence). The final score was between 0 and 12 points for all the participants, establishing three classifications: poor adherence to the Mediterranean diet (0–3 points), need to improve adherence (4–7 points) or optimal adherence (8–12 points) (Serra-Majem et al., 2004).

The level of physical activity was determined using the Spanish version of the "Physical Activity Questionnaire for Adolescents" (PAQ-A) (Martínez-Gómez et al., 2009). This questionnaire has an intraclass correlation coefficient of 0.71 and an internal consistency of 0.74 for the final score. It is composed of nine questions that provide information on the physical activity performed in the last seven days, considering different time slots during the day. A Likert scale of 1 to 5 points is used for its completion, with 1 being an absence of physical activity and 5 a high level of physical activity (Martínez-Gómez et al., 2009).

5.3.3.2. Kinanthropometric measurements

The kinanthropometric analysis was composed of (1) three basic measurements (body mass, height, and sitting height); (2) three skinfolds (triceps, thigh, and calf); and (3) five girths (arm relaxed, waist, hip, thigh, and calf). To carry them out, the protocol established by the International Society for the Advancement of Kinanthropometry (ISAK) was followed (Esparza-Ros et al., 2019). ISAK-accredited anthropometrists (levels 2 to 4) measured each variable twice, performing a third measurement when the differences between the first and second measurements were greater than 5% in the skinfolds and 1% in the rest of the measurements. The mean of the measured values was used when two measurements were performed, while the median was used when a third measurement was performed (Esparza-Ros et al., 2019).

The variables from the measurements were used to calculate BMI, Σ3 skinfolds (triceps, thigh, and calf), corrected girths of the arm [arm relaxed girth − (π × triceps skinfold)], thigh [middle thigh girth − (π × thigh skinfold)], and calf [calf girth − (π × calf skinfold)], fat mass (%) (Slaughter et al., 1988), muscle mass (Poortmans et al., 2005), and waist-to-hip ratio (waist girth/hip girth).

The intra- and inter-evaluator technical error of measurements (TEM) were calculated in a sub-sample. The intra-evaluator TEM was 0.02% for the basic measurements; 1.21% for skinfolds, and 0.04% for the girths; and the inter-evaluator TEM was 0.03% for the basic measurements; 1.98% for skinfolds, and 0.06% for the girths.

The kinanthropometric equipment used was calibrated prior to the measurements. A TANITA BC 418-MA Segmental (TANITA, Tokyo, Japan), with an accuracy of 100 g, was used for body mass. For height and sitting height, a SECA stadiometer 213 (SECA, Hamburg, Germany) with an accuracy of 0.1 cm was used. A skinfold caliper (Harpenden, Burgess Hill, UK) was used for measuring skinfolds, with an accuracy of 0.2 mm. An inextensible tape (Lufkin W606PM, Missouri City, TX, USA) was used to measure girths with a 0.1 cm accuracy.

5.3.3.3. ***Physical fitness test***

The familiarization and correct performance of the physical fitness tests by the adolescents was supervised by four investigators with previous experience in the field. Each investigator oversaw the same physical fitness tests during all measurements to avoid inter-evaluator error.

Three physical fitness tests were performed, which were chosen for their validity and reliability in this population (Castro-Piñero et al., 2010; Markovic et al., 2004; Matsudo et al., 2014). The 20 m shuttle run test was chosen to assess cardiorespiratory endurance in adolescents. This is an incremental test that consists of running twenty meters as many times as possible. This test ends when the distance is not covered two consecutive times before the allotted time ends or when the adolescent reaches exhaustion. The formula by Leger et al. (Léger et al., 1988) was used to determine the maximum oxygen consumption (VO2 max) of each adolescent.

Handgrip strength was assessed using the handgrip strength test, in which the adolescents had to apply the greatest possible force on a Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo, Japan). The adolescents' elbow was fully extended, as this is the optimal position for applying the maximum force (España-Romero et al., 2010).

The countermovement jump (CMJ) was used to assess the explosive power of the lower limbs. For its execution, following the protocol by Barker et al. (2018), the adolescents had to perform a maximal vertical jump. The adolescents' hands were to be placed at the waist, and the legs and back must be fully extended during the flight phase. In the starting position, the adolescents had to stand on the force platform (MuscleLab, Stathelle, Norway) with hands on their waist and feet hip-width apart. Subsequently, they performed a knee flexion to 90° as quickly as possible, followed by a full knee extension to reach the maximum possible height in the vertical jump.

5.3.4. Procedure

The tests were carried out during Physical Education class time using covered sports pavilions of the participating compulsory secondary education centers to reduce contaminating variables that could affect the results.

First, all the adolescents completed the KIDMED and PAQ-A questionnaires. Subsequently, the kinanthropometric measurements were taken. Next, the correct execution of the handgrip strength and CMJ tests was explained to the students so that they became familiar with them. Once the familiarization process was completed, a warm-up consisting of running and joint mobility exercises was carried out, after which the tests were performed. Finally, the 20 m shuttle run test was performed. All the physical condition tests were performed twice, leaving two minutes of recovery time between the two measurements of each test and five minutes between the different tests. The best value of each test was recorded, except for the 20 m shuttle run test, which was performed only once. The testing protocol was established based on previous research (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022b) and following the recommendations of the National Strength and Conditioning Association (NSCA). These recommendations consider the fatigue generated by each test and establish sufficient recovery time between them to minimize possible interferences (Coburn & Malek, 2014).

5.3.5. Data analysis

The Kolmogorov–Smirnov test was used to assess the normality of the data. As all variables showed a normal distribution, parametric tests were used to analyze them. Descriptive statistics were used to find the mean and standard deviations. An ANOVA was performed to establish the existing differences in the physical activity level, physical condition, and kinanthropometric variables according to the AMD of adolescents. Next, an ANCOVA was performed to determine the existing differences in the measured variables as a function of AMD, considering gender and BMI as covariates of the model. Subsequently, a MANOVA was performed to determine the differences in the variables measured between males and females according to AMD and to establish the differences between the different weight statuses according to AMD in general and for males and females. The Bonferroni post hoc analysis was used to determine the differences between groups. Partial eta squared ($\eta 2$) was used to establish whether the effect size was small (ES ≥ 0.10), moderate (ES ≥ 0.30), large (ES ≥ 1.2), or very large (ES ≥ 2.0), with an error of $p < 0.05$. A $p < 0.05$ value was used to determine statistical differences (Hopkins et al., 2009). The SPSS statistical software was used to perform the statistical analysis (v.25.0; SPSS Inc., Chicago, IL, USA).

5.4. Results

5.4.1. Differences in the study variables according to the AMD level

The differences in the level of physical activity, kinanthropometric variables, and physical fitness of adolescents with different levels of AMD are shown in Table 1. The differences were significant only in the level of physical activity, with the adolescents with an optimal adherence being those who practiced sports the most ($p < 0.001$). The inclusion of the covariates gender and BMI in the model showed significant differences for gender ($p < 0.001$–0.004) in all analyzed variables, except for BMI ($p = 0.064$) and hip girth ($p = 0.121$); however, when considering BMI, significant differences were found in all the variables ($p < 0.001–0.013$) except for height ($p = 0.081$).

Figure 1 shows the differences among males with poor AMD, males that need to improve AMD, and males with an optimal AMD as well as among females with poor AMD, females that need to improve their AMD, and females with an optimal AMD. With respect to males, the differences were significant in the level of physical activity and kinanthropometric variables but not in physical fitness. Females showed differences in the level of physical activity and physical fitness variables but not in kinanthropometric variables.

Bonferroni's pairwise comparison showed that males with a poor AMD had a lower level of physical activity ($p < 0.001–0.039$), body mass ($p = 0.032$), BMI ($p = 0.030$), hip girth ($p = 0.021$), corrected thigh girth ($p = 0.044$), fat mass ($p = 0.031$), and muscle mass ($p = 0.050$) than males with an optimal and/or need to improve AMD. Regarding the females, whose who showed a poor AMD or need to improve AMD had a lower level of physical activity ($p = 0.001–0.003$) and VO2 max ($p = 0.037$) than females with an optimal AMD.

5.4.2. Differences in the study variables according to the gender, AMD level, and weight status

The differences in the analyzed variables according to the AMD and the BMI of the adolescents are shown in Figure 2. In the normal weight ($p < 0.001$) and underweight ($p = 0.007–0.026$) groups, adolescents with an optimal AMD showed a significantly higher level of physical activity. In the overweight group, adolescents with an optimal AMD showed significantly higher values in body mass ($p = 0.014$).

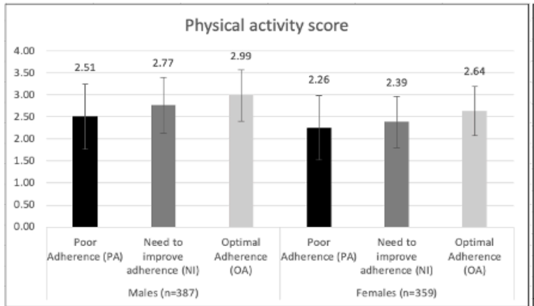
Tables 2–4 show the differences in the level of physical activity, kinanthropometric variables, and physical fitness in males and females who were normal weight, overweight and underweight with different levels of AMD. In normal weight males and females, differences were significant in the level of physical activity ($p = 0.001–0.011$), with males and females with an optimal AMD showing higher scores in both groups (Table 2). In the overweight group, significant differences were found in BMI ($p = 0.027$), sum of three skinfolds ($p = 0.044$), and waist girth ($p = 0.016$), with males with an optimal AMD showing higher

Table 1. Differences in physical activity, kinanthropometric, and physical fitness variables among adolescents with different levels of AMD.

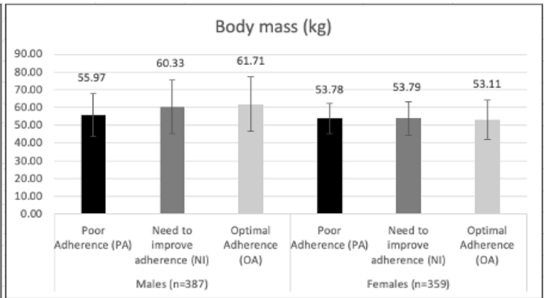
Variable	Descriptors (M±SD)			Level of AMD			Level of AMD*Gender			Level of AMD*BMI		
	PA (n=92)	NI (n=412)	OA (n=287)	F	p	η2	F	p	η2	F	p	η2
Physical activity score	2.40±0.74	2.59±0.64	2.82±0.60	18.059	<0.001	0.046	20.271	<0.001	0.120	5.252	<0.001	0.054
Body mass (kg)	54.97±10.54	57.15±13.07	57.57±14.00	1.173	0.310	0.003	12.062	<0.001	0.075	113.056	<0.001	0.551
BMI (kg/m²)	20.51±3.23	21.38±3.89	21.38±4.08	1.729	0.178	0.005	2.098	0.064	0.014	-	-	-
Height (cm)	163.32±8.28	163.28±9.04	163.60±9.09	0.106	0.899	0.001	29.660	<0.001	0.167	1.763	0.081	0.019
Sitting height (cm)	84.90±3.81	85.12±5.60	85.14±4.71	0.068	0.935	0.001	8.174	<0.001	0.052	4.095	<0.001	0.043
Sum 3 skinfolds (mm)	47.10±20.83	51.35±25.13	53.38±26.06	1.942	0.144	0.005	14.833	<0.001	0.091	55.955	<0.001	0.378
Waist girth (cm)	68.90±6.92	69.78±8.87	69.81±9.15	0.354	0.702	0.001	21.064	<0.001	0.125	129.482	<0.001	0.584
Hip girth (cm)	89.18±8.14	90.76±9.26	91.18±9.23	1.436	0.238	0.004	1.750	0.121	0.012	142.728	<0.001	0.608
Corrected arm girth (cm)	21.10±2.39	21.40±2.98	21.28±3.19	0.347	0.707	0.001	33.501	<0.001	0.185	42.107	<0.001	0.314
Corrected thigh girth (cm)	39.34±4.11	40.27±4.79	40.33±5.34	1.292	0.275	0.003	25.120	<0.001	0.145	40.746	<0.001	0.307
Corrected calf girth (cm)	29.07±2.53	29.43±3.20	29.33±3.50	0.423	0.655	0.001	19.266	<0.001	0.115	15.161	<0.001	0.141
Fat mass (%)	20.86±8.35	22.64±10.23	23.60±10.80	2.248	0.106	0.006	11.806	<0.001	0.074	60.219	<0.001	0.395
Muscle mass (kg)	18.40±4.12	19.02±5.05	19.04±5.47	0.523	0.593	0.001	99.578	<0.001	0.402	25.097	<0.001	0.214
Waist-hip ratio	0.77±0.47	0.77±0.60	0.77±0.52	0.820	0.441	0.002	91.963	<0.001	0.383	8.135	<0.001	0.081
VO_2 max. (ml/kg/min)	38.97±5.81	39.51±5.76	40.13±5.64	1.626	0.197	0.004	44.175	<0.001	0.230	4.315	<0.001	0.045
Handgrip right arm (kg)	26.75±6.77	27.00±8.15	26.43±8.90	0.379	0.684	0.001	43.401	<0.001	0.227	9.633	<0.001	0.095
Handgrip left arm (kg)	25.19±6.70	25.17±7.57	24.37±7.78	0.971	0.379	0.003	49.777	<0.001	0.252	9.022	<0.001	0.089
CMJ (cm)	23.55±7.11	23.85±6.63	23.46±7.46	0.276	0.759	0.001	28.616	<0.001	0.162	4.559	<0.001	0.047

PA: poor adherence; NI: need to improve; OA: optimal adherence; BMI: body mass index; VO2 max: maximum oxygen consumption; η2: effect size.

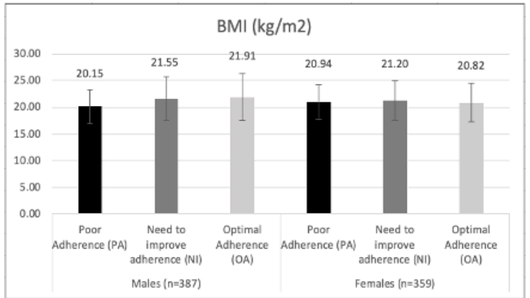
Figure 1. Differences in physical activity, kinanthropometric measurements, and physical fitness variables between males with different AMD and females with different AMD.



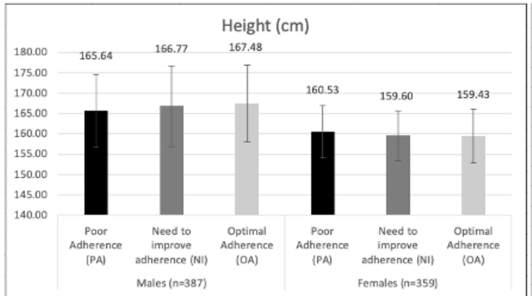
Males	PA vs NI: Mean Diff: −0.259 ; p=0.039; 95% CI: −0.509; −0.009
	PA vs OA: Mean Diff: −0.478; p<0.001; 95% CI: −0.737; −0.219
	NI vs OA: Mean Diff: −0.219; p=0.004; 95% CI: −0.380; −0.058
Females	PA vs NI: Mean Diff: −0.133 ; p=0.716; 95% CI: −0.404; 0.138
	PA vs OA: Mean Diff: −0.386; p=0.003; 95% CI: −0.666; −0.105
	NI vs OA: Mean Diff: −0.253; p=0.001; 95% CI: −0.419; −0.086



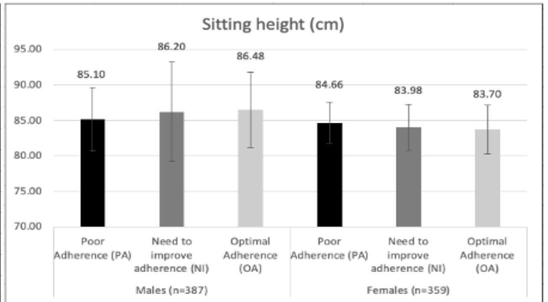
Males	PA vs NI: Mean Diff: −4.364 ; p=0.130; 95% CI: −9.536; 0.809
	PA vs OA: Mean Diff: −5.737; p=0.032; 95% CI: −11.104; −0.371
	NI vs OA: Mean Diff: −1.374; p=0.974; 95% CI: −4.717; 1.970
Females	PA vs NI: Mean Diff: −0.013 ; p=1.000; 95% CI: −5.621; 5.596
	PA vs OA: Mean Diff: 0.670; p=1.000; 95% CI: −5.139; 6.479
	NI vs OA: Mean Diff: 0.683; p=1.000; 95% CI: −2.773; 4.139



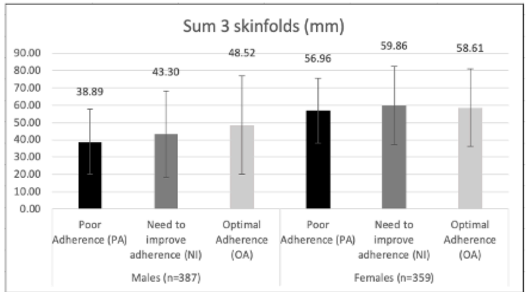
Males	PA vs NI: Mean Diff: −1.405 ; p=0.100; 95% CI: −2.987; 0.176
	PA vs OA: Mean Diff: −1.766; p=0.030; 95% CI: −3.406; −0.125
	NI vs OA: Mean Diff: −0.360; p=1.000; 95% CI: −1.382; 0.662
Females	PA vs NI: Mean Diff: −0.254 ; p=1.000; 95% CI: −1.968; 1.461
	PA vs OA: Mean Diff: 0.128; p=1.000; 95% CI: −1.648; 1.903
	NI vs OA: Mean Diff: 0.381; p=1.000; 95% CI: −0.675; 1.438



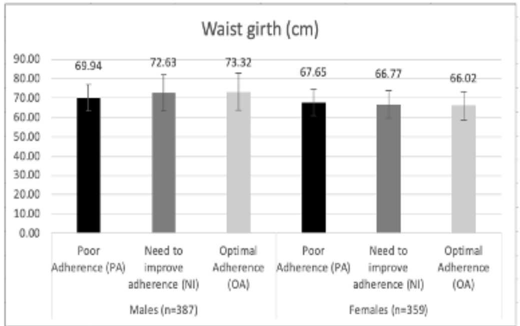
Males	PA vs NI: Mean Diff: −1.128 ; p=1.000; 95% CI: −4.469; 2.214
	PA vs OA: Mean Diff: −1.839; p=0.610; 95% CI: −5.306; 1.628
	NI vs OA: Mean Diff: −0.711; p=1.000; 95% CI: −2.871; 1.449
Females	PA vs NI: Mean Diff: 0.929 ; p=1.000; 95% CI: −2.694; 4.552
	PA vs OA: Mean Diff: 1.098; p=1.000; 95% CI: −2.655; 4.850
	NI vs OA: Mean Diff: 0.169; p=1.000; 95% CI: −2.064; 2.401



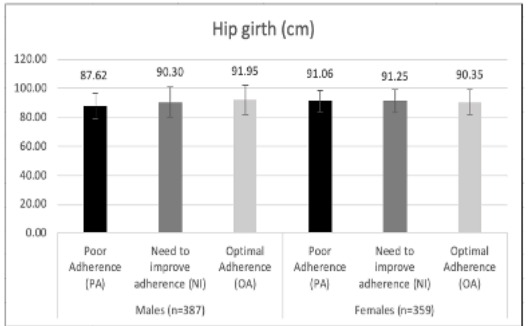
Males	PA vs NI: Mean Diff: −1.098 ; p=0.587; 95% CI: −3.133; 0.936
	PA vs OA: Mean Diff: −1.378; p=0.353; 95% CI: −3.489; 0.733
	NI vs OA: Mean Diff: −0.280; p=1.000; 95% CI: −1.595; 1.035
Females	PA vs NI: Mean Diff: 0.688 ; p=1.000; 95% CI: −1.519; 2.894
	PA vs OA: Mean Diff: 0.967; p=0.931; 95% CI: −1.318; 3.251
	NI vs OA: Mean Diff: 0.279; p=1.000; 95% CI: −1.080; 1.638



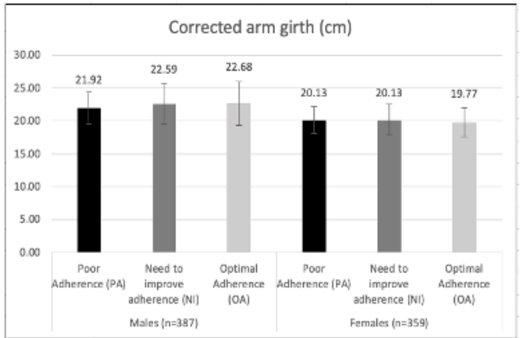
Males	PA vs NI: Mean Diff: −4.415 ; p=0.835; 95% CI: −14.180; 5.349
	PA vs OA: Mean Diff: −9.635; p=0.068; 95% CI: −19.765; 0.495
	NI vs OA: Mean Diff: −5.220; p=0.143; 95% CI: −11.531; 1.091
Females	PA vs NI: Mean Diff: -2.904 ; p=1.000; 95% CI: −13.491; 7.683
	PA vs OA: Mean Diff: -1.649; p=1.000; 95% CI: −12.614; 9.316
	NI vs OA: Mean Diff: 1.255; p=1.000; 95% CI: −5.268; 7.779



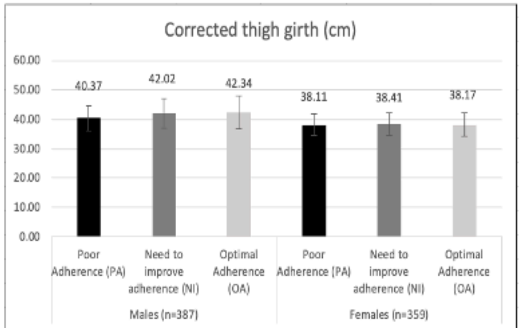
Males	PA vs NI: Mean Diff: −2.683 ; p=0.166; 95% CI: −6.038; 0.671
	PA vs OA: Mean Diff: −3.379; p=0.060; 95% CI: −6.860; 0.101
	NI vs OA: Mean Diff: −0.696; p=1.000; 95% CI: −2.864; 1.472
Females	PA vs NI: Mean Diff: 0.880 ; p=1.000; 95% CI: −2.758; 4.517
	PA vs OA: Mean Diff: 1.627; p=0.901; 95% CI: −2.140; 5.394
	NI vs OA: Mean Diff: 0.748; p=1.000; 95% CI: −1.494; 2.989



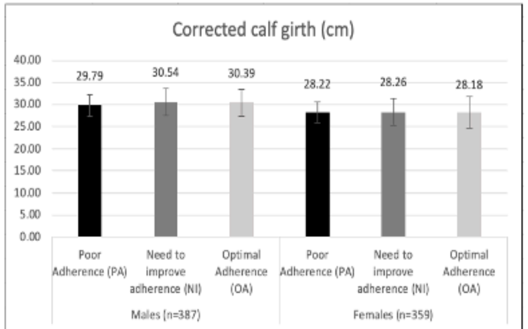
Males	PA vs NI: Mean Diff: −2.679 ; p=0.250; 95% CI: −6.387; 1.029
	PA vs OA: Mean Diff: −4.329; p=0.021; 95% CI: −8.176; −0.482
	NI vs OA: Mean Diff: −1.650; p=0.297; 95% CI: −4.047; 0.747
Females	PA vs NI: Mean Diff: −0.192 ; p=1.000; 95% CI: −4.212; 3.829
	PA vs OA: Mean Diff: 0.702; p=1.000; 95% CI: −3.462; 4.866
	NI vs OA: Mean Diff: 0.894; p=1.000; 95% CI: −1.583; 3.371



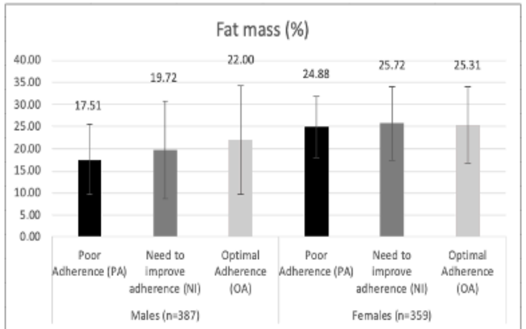
Males	PA vs NI: Mean Diff: −0.673; p=0.436; 95% CI: −1.780; 0.434
	PA vs OA: Mean Diff: −0.764; p=0.333; 95% CI: −1.913; 0.384
	NI vs OA: Mean Diff: −0.091; p=1.000; 95% CI: −0.807; 0.624
Females	PA vs NI: Mean Diff: −0.003 ; p=1.000; 95% CI: −1.204; 1.197
	PA vs OA: Mean Diff: 0.360; p=1.000; 95% CI: −0.884; 1.603
	NI vs OA: Mean Diff: 0.363; p=0.719; 95% CI: −0.377; 1.102



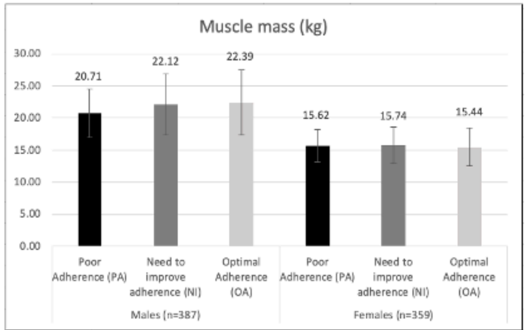
Males	PA vs NI: Mean Diff: −1.649; p=0.102; 95% CI: −3.512; 0.214
	PA vs OA: Mean Diff: −1.969; p=0.044; 95% CI: −3.901; −0.036
	NI vs OA: Mean Diff: −0.320; p=1.000; 95% CI: −1.524; 0.884
Females	PA vs NI: Mean Diff: −0.306 ; p=1.000; 95% CI: −2.326; 1.714
	PA vs OA: Mean Diff: −0.060; p=1.000; 95% CI: −2.152; 2.032
	NI vs OA: Mean Diff: 0.246; p=1.000; 95% CI: −0.999; 1.490



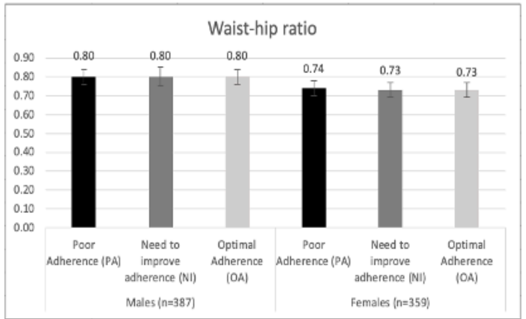
Males	PA vs NI: Mean Diff: −0.757; p=0.436; 95% CI: −2.003; 0.489
	PA vs OA: Mean Diff: −0.604; p=0.787; 95% CI: −1.897; 0.688
	NI vs OA: Mean Diff: 0.152; p=1.000; 95% CI: −0.653; 0.958
Females	PA vs NI: Mean Diff: −0.048 ; p=1.000; 95% CI: −1.399; 1.303
	PA vs OA: Mean Diff: 0.038; p=1.000; 95% CI: −1.361; 1.437
	NI vs OA: Mean Diff: 0.086; p=1.000; 95% CI: −0.746; 0.919



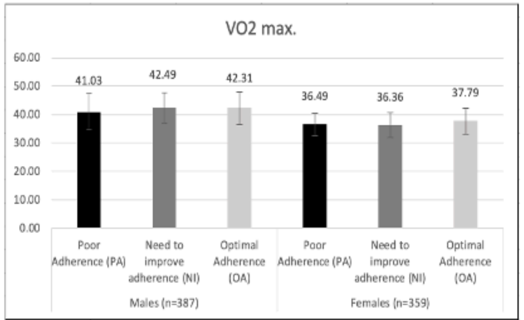
Males	PA vs NI: Mean Diff: −2.212; p=0.568; 95% CI: −6.250; 1.826
	PA vs OA: Mean Diff: −4.493; p=0.031; 95% CI: −8.683; −0.304
	NI vs OA: Mean Diff: −2.281; p=0.109; 95% CI: −4.891; 0.329
Females	PA vs NI: Mean Diff: −0.845 ; p=1.000; 95% CI: −5.224; 3.533
	PA vs OA: Mean Diff: −0.439; p=1.000; 95% CI: −4.974; 4.096
	NI vs OA: Mean Diff: 0.406; p=1.000; 95% CI: −2.292; 3.104



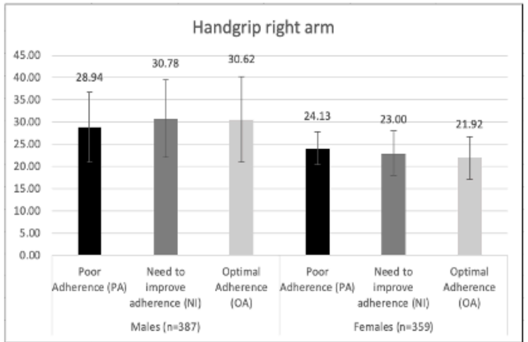
Males	PA vs NI: Mean Diff: −1.405; p=0.111; 95% CI: −3.019; 0.208
	PA vs OA: Mean Diff: −1.675; p=0.050; 95% CI: −3.349; −0.001
	NI vs OA: Mean Diff: −0.270; p=1.000; 95% CI: −1.313; 0.773
Females	PA vs NI: Mean Diff: −0.121 ; p=1.000; 95% CI: −1.870; 1.629
	PA vs OA: Mean Diff: 0.181; p=1.000; 95% CI: −1.631; 1.993
	NI vs OA: Mean Diff: 0.302; p=1.000; 95% CI: −0.776; 1.380



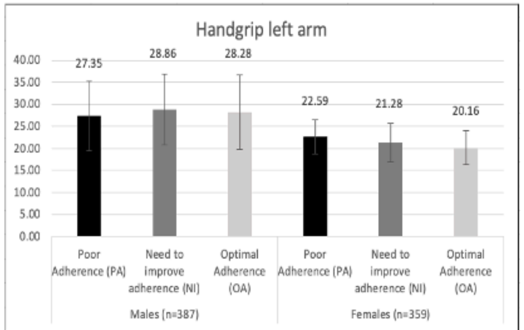
Males	PA vs NI: Mean Diff: −0.006; p=1.000; 95% CI: −0.024; 0.012
	PA vs OA: Mean Diff: 0.002; p=1.000; 95% CI: −0.016; 0.021
	NI vs OA: Mean Diff: 0.008; p=0.279; 95% CI: −0.003; 0.020
Females	PA vs NI: Mean Diff: 0.011 ; p=0.512; 95% CI: −0.008; 0.031
	PA vs OA: Mean Diff: 0.012; p=0.505; 95% CI: −0.009; 0.032
	NI vs OA: Mean Diff: 0.000; p=1.000; 95% CI: −0.012; 0.012



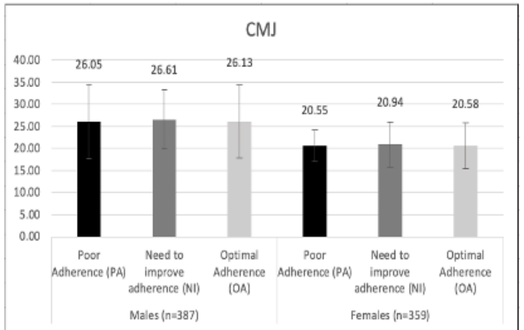
Males	PA vs NI: Mean Diff: −1.461; p=0.263; 95% CI: −3.511; 0.589
	PA vs OA: Mean Diff: −1.282; p=0.445; 95% CI: −3.409; 0.845
	NI vs OA: Mean Diff: 0.179; p=1.000; 95% CI: −1.146; 1.504
Females	PA vs NI: Mean Diff: 0.136 ; p=1.000; 95% CI: −2.086; 2.359
	PA vs OA: Mean Diff: −1.294; p=0.534; 95% CI: −3.596; 1.008
	NI vs OA: Mean Diff: −1.430; p=0.037; 95% CI: −2.800; −0.061



Males	PA vs NI: Mean Diff: −1.839; p=0.416; 95% CI: −4.817; 1.138
	PA vs OA: Mean Diff: −1.677; p=0.579; 95% CI: −4.766; 1.412
	NI vs OA: Mean Diff: 0.162; p=1.000; 95% CI: −1.763; 2.086
Females	PA vs NI: Mean Diff: 1.130 ; p=1.000; 95% CI: −2.099; 4.358
	PA vs OA: Mean Diff: 2.211; p=0.339; 95% CI: −1.133; 5.555
	NI vs OA: Mean Diff: 1.081; p=0.577; 95% CI: −0.908; 3.071

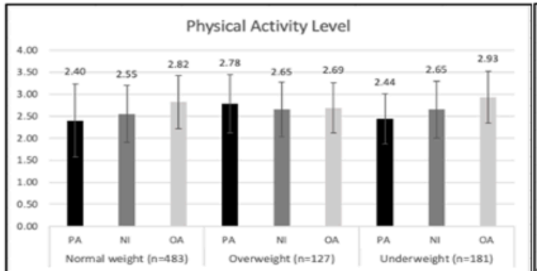


Males	PA vs NI: Mean Diff: −1.504; p=0.530; 95% CI: −4.171; 1.164
	PA vs OA: Mean Diff: −0.930; p=1.000; 95% CI: −3.698; 1.838
	NI vs OA: Mean Diff: 0.574; p=1.000; 95% CI: −1.151; 2.298
Females	PA vs NI: Mean Diff: 1.312 ; p=0.830; 95% CI: −1.580; 4.205
	PA vs OA: Mean Diff: 2.424; p=0.158; 95% CI: −0.572; 5.420
	NI vs OA: Mean Diff: 1.112; p=0.404; 95% CI: −0.670; 2.894

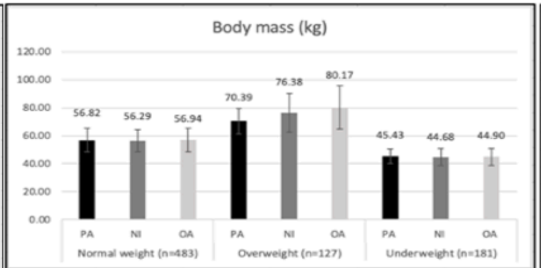


Males	PA vs NI: Mean Diff: −0.563 ; p=1.000; 95% CI: −3.172; 2.046
	PA vs OA: Mean Diff: −0.081; p=1.000; 95% CI: −2.788; 2.625
	NI vs OA: Mean Diff: 0.482; p=1.000; 95% CI: −1.204; 2.168
Females	PA vs NI: Mean Diff: −0.394 ; p=1.000; 95% CI: −3.222; 2.435
	PA vs OA: Mean Diff: −0.034; p=1.000; 95% CI: −2.963; 2.896
	NI vs OA: Mean Diff: 0.360; p=1.000; 95% CI: −1.383; 2.103

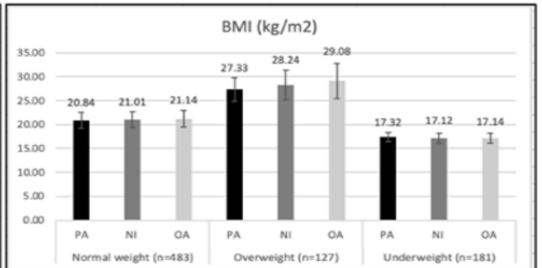
Figure 2. Differences in physical activity, kinanthropometric measurements, and physical fitness variables between adolescents with different AMD and weight status.



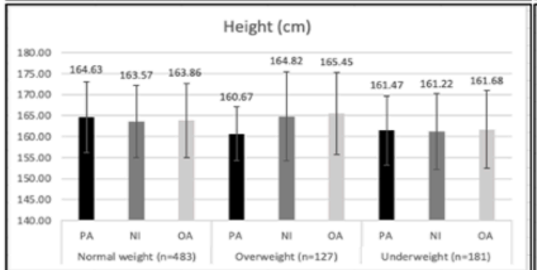
Normal weight	PA vs NI: Mean Diff:−0.155; p=0.382; 95% CI:−0.399; 0.089
	PA vs OA: Mean Diff:−0.420; p<0.001; 95% CI:−0.672;−0.168
	NI vs OA: Mean Diff:−0.265; p<0.001; 95% CI:−0.417;−0.113
Overweight	PA vs NI: Mean Diff:−0.374; p=0.356; 95% CI:−0.948; 0.200
	PA vs OA: Mean Diff:− 0.416; p=0.280; 95% CI:−1.011; 0.178
	NI vs OA: Mean Diff:−0.043; p=1.000; 95% CI:−0.353; 0.268
Underweight	PA vs NI: Mean Diff:−0.202; p=0.563; 95% CI:−0.569; 0.165
	PA vs OA: Mean Diff:−0.485; p=0.007; 95% CI:−0.866;−0.105
	NI vs OA: Mean Diff:−0.284; p=0.026; 95% CI:−0.542;−0.025



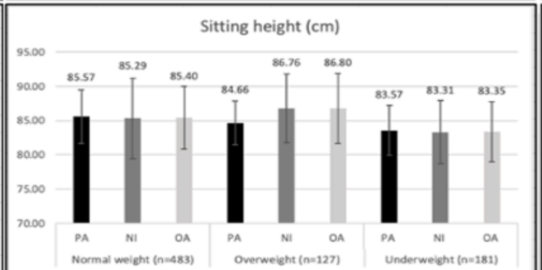
Normal weight	PA vs NI: Mean Diff: 0.525; p=1.000; 95% CI: −2.865; 3.915
	PA vs OA: Mean Diff: −0.116; p=1.000; 95% CI: −3.625; −3.392
	NI vs OA: Mean Diff: −0.641; p=1.000; 95% CI: −2.755; 1.472
Overweight	PA vs NI: Mean Diff: −5.985; p=0.218; 95% CI: −13.972; 2.001
	PA vs OA: Mean Diff: −9.773; p=0.014; 95% CI: −18.046; −1.499
	NI vs OA: Mean Diff: −3.787; p=0.107; 95% CI: −8.105; 0.530
Underweight	PA vs NI: Mean Diff: 0.750; p=1.000; 95% CI: −4.362; 5.861
	PA vs OA: Mean Diff: 0.530; p=1.000; 95% CI: −4.772; 5.831
	NI vs OA: Mean Diff: −0.220; p=1.000; 95% CI: −3.815; 3.375



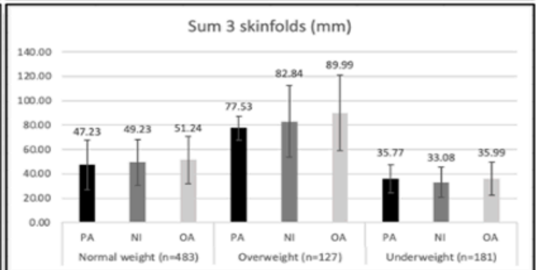
Normal weight	PA vs NI: Mean Diff: −0.165; p=1.000; 95% CI: −0.894; 0.563
	PA vs OA: Mean Diff: −0.301; p=1.000; 95% CI: −1.055; 0.453
	NI vs OA: Mean Diff: −0.136; p=1.000; 95% CI: −0.590; 0.318
Overweight	PA vs NI: Mean Diff: −0.913; p=0.607; 95% CI: −2.629; 0.803
	PA vs OA: Mean Diff: −1.753; p=0.055; 95% CI: −3.531; 0.024
	NI vs OA: Mean Diff: −0.841; p=0.090; 95% CI: −1.768; 0.087
Underweight	PA vs NI: Mean Diff: 0.194; p=1.000; 95% CI: −0.904; 1.292
	PA vs OA: Mean Diff: 0.175; p=1.000; 95% CI: −0.964; 1.314
	NI vs OA: Mean Diff: −0.019; p=1.000; 95% CI: −0.792; 0.753



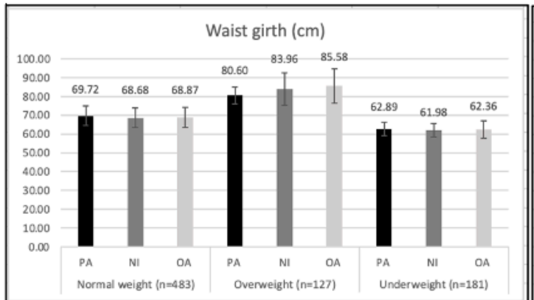
Normal weight	PA vs NI: Mean Diff: 1.063; p=1.000; 95% CI: −2.348; 4.474
	PA vs OA: Mean Diff: 0.767; p=1.000; 95% CI: −2.763; 4.297
	NI vs OA: Mean Diff: −0.296; p=1.000; 95% CI: −2.422; 1.831
Overweight	PA vs NI: Mean Diff: −4.148; p=0.648; 95% CI: −12.184; 3.888
	PA vs OA: Mean Diff: −4.775; p=0.507; 95% CI: −13.100; 3.549
	NI vs OA: Mean Diff: −0.627; p=1.000; 95% CI: −4.971; 3.717
Underweight	PA vs NI: Mean Diff: 0.248; p=1.000; 95% CI: −4.895; 5.391
	PA vs OA: Mean Diff: −0.216; p=1.000; 95% CI: −5.549; 5.118
	NI vs OA: Mean Diff: −0.464; p=1.000; 95% CI: −4.081; 3.153



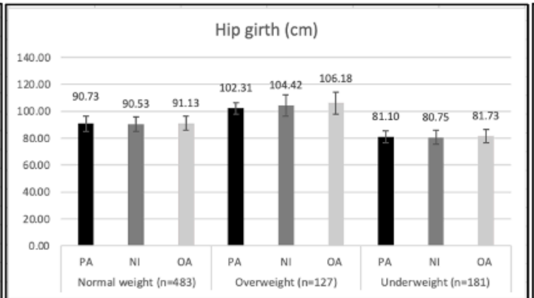
Normal weight	PA vs NI: Mean Diff: 0.277; p=1.000; 95% CI: −1.647; 2.200
	PA vs OA: Mean Diff: 0.172; p=1.000; 95% CI: −1.819; 2.162
	NI vs OA: Mean Diff: −0.105; p=1.000; 95% CI: −1.304; 1.094
Overweight	PA vs NI: Mean Diff: −2.101; p=0.799; 95% CI: −6.633; 2.430
	PA vs OA: Mean Diff: −2.140; p=0.823; 95% CI: −6.834; 2.554
	NI vs OA: Mean Diff: −0.039; p=1.000; 95% CI: −2.488; 2.411
Underweight	PA vs NI: Mean Diff: 0.256; p=1.000; 95% CI: −2.645; 3.156
	PA vs OA: Mean Diff: 0.216; p=1.000; 95% CI: −2.792; 3.224
	NI vs OA: Mean Diff: −0.040; p=1.000; 95% CI: −2.080; 2.000



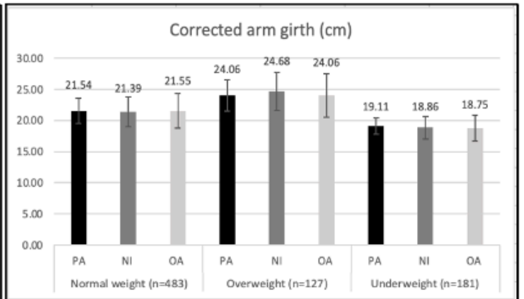
Normal weight	PA vs NI: Mean Diff: −2.000; p=1.000; 95% CI: −9.598; 5.598
	PA vs OA: Mean Diff: −4.018; p=0.661; 95% CI: −11.882; 3.845
	NI vs OA: Mean Diff: −2.019; p=0.921; 95% CI: −6.755; 2.718
Overweight	PA vs NI: Mean Diff: −5.305; p=1.000; 95% CI: −23.205; 12.594
	PA vs OA: Mean Diff: −12.458; p=0.322; 95% CI: −31.000; 6.084
	NI vs OA: Mean Diff: −7.152; p=0.230; 95% CI: −16.829; 2.524
Underweight	PA vs NI: Mean Diff: 2.691; p=1.000; 95% CI: −8.765; 14.147
	PA vs OA: Mean Diff: −0.223; p=1.000; 95% CI: −12.103; 11.658
	NI vs OA: Mean Diff: −2.913; p=1.000; 95% CI: −10.970; 5.143



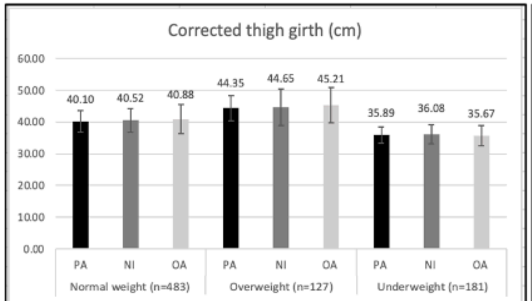
Normal weight	PA vs NI: Mean Diff: 1.044; p=0.749; 95% CI: -1.131; 3.218 PA vs OA: Mean Diff: 0.850; p=1.000; 95% CI: -1.400; 3.101 NI vs OA: Mean Diff: -0.193; p=1.000; 95% CI: -1.549; 1.162
Overweight	PA vs NI: Mean Diff: -3.358; p=0.348; 95% CI: -8.481; 1.764 PA vs OA: Mean Diff: -4.975; p=0.074; 95% CI: -10.282; 0.331 NI vs OA: Mean Diff: -1.617; p=0.485; 95% CI: -4.386; 1.152
Underweight	PA vs NI: Mean Diff: 0.913; p=1.000; 95% CI: -2.365; 4.191 PA vs OA: Mean Diff: 0.530; p=1.000; 95% CI: -2.870; 3.929 NI vs OA: Mean Diff: -0.383; p=1.000; 95% CI: -2.689; 1.922



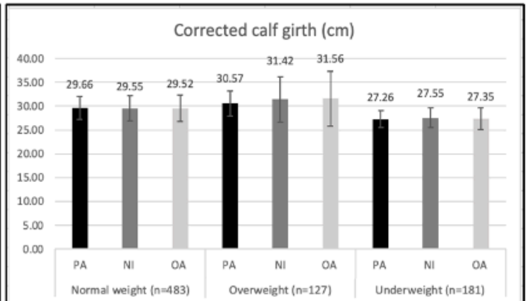
Normal weight	PA vs NI: Mean Diff: 0.197; p=1.000; 95% CI: -2.000; 2.394 PA vs OA: Mean Diff: -0.401; p=1.000; 95% CI: -2.675; 1.872 NI vs OA: Mean Diff: -0.599; p=0.884; 95% CI: -1.968; 0.771
Overweight	PA vs NI: Mean Diff: -2.105; p=0.989; 95% CI: -7.281; 3.072 PA vs OA: Mean Diff: -3.868; p=0.252; 95% CI: -9.230; 1.494 NI vs OA: Mean Diff: -1.763; p=0.393; 95% CI: -4.562; 1.035
Underweight	PA vs NI: Mean Diff: 0.351; p=1.000; 95% CI: -2.961; 3.664 PA vs OA: Mean Diff: -0.631; p=1.000; 95% CI: -4.066; 2.805 NI vs OA: Mean Diff: -0.982; p=0.936; 95% CI: -3.312; 1.348



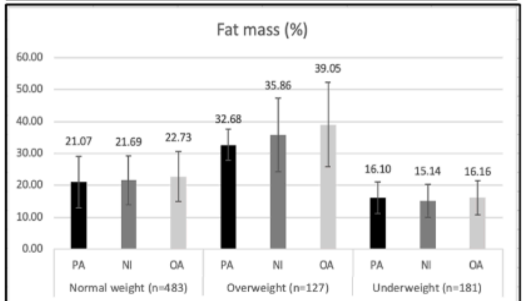
Normal weight	PA vs NI: Mean Diff: 0.150; p=1.000; 95% CI: -0.805; 1.106 PA vs OA: Mean Diff: -0.009; p=1.000; 95% CI: -0.998; 0.979 NI vs OA: Mean Diff: -0.160; p=1.000; 95% CI: -0.755; 0.436
Overweight	PA vs NI: Mean Diff: -0.621; p=1.000; 95% CI: -2.871; 1.630 PA vs OA: Mean Diff: -0.006; p=1.000; 95% CI: -2.337; 2.326 NI vs OA: Mean Diff: 0.615; p=0.676; 95% CI: -0.601; 1.832
Underweight	PA vs NI: Mean Diff: 0.255; p=1.000; 95% CI: -1.186; 1.695 PA vs OA: Mean Diff: 0.360; p=1.000; 95% CI: -1.134; 1.854 NI vs OA: Mean Diff: 0.105; p=1.000; 95% CI: -0.908; 1.118



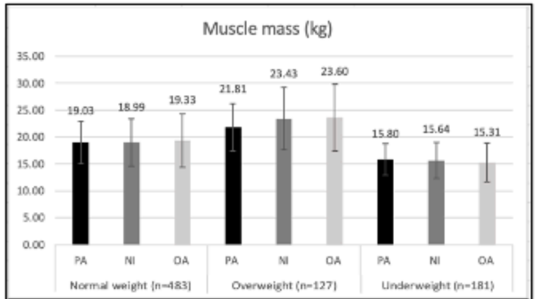
Normal weight	PA vs NI: Mean Diff: -0.414; p=1.000; 95% CI: -1.992; 1.164 PA vs OA: Mean Diff: -0.771; p=0.773; 95% CI: -2.404; 0.862 NI vs OA: Mean Diff: -0.357; p=1.000; 95% CI: -1.340; 0.627
Overweight	PA vs NI: Mean Diff: -0.301; p=1.000; 95% CI: -4.018; 3.417 PA vs OA: Mean Diff: -0.865; p=1.000; 95% CI: -4.716; 2.986 NI vs OA: Mean Diff: -0.564; p=1.000; 95% CI: -2.574; 1.445
Underweight	PA vs NI: Mean Diff: -0.185; p=1.000; 95% CI: -2.564; 2.194 PA vs OA: Mean Diff: 0.222; p=1.000; 95% CI: -2.245; 2.689 NI vs OA: Mean Diff: 0.407; p=1.000; 95% CI: -1.266; 2.080



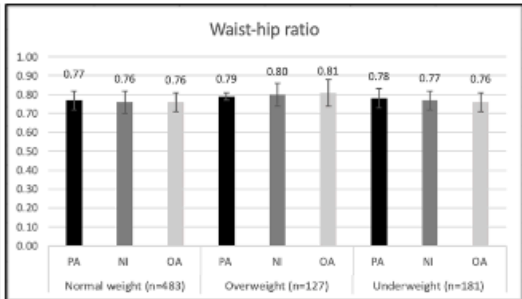
Normal weight	PA vs NI: Mean Diff: 0.119; p=1.000; 95% CI: -1.035; 1.274 PA vs OA: Mean Diff: 0.147; p=1.000; 95% CI: -1.048; 1.342 NI vs OA: Mean Diff: 0.028; p=1.000; 95% CI: -0.692; 0.747
Overweight	PA vs NI: Mean Diff: -0.854; p=1.000; 95% CI: -3.574; 1.865 PA vs OA: Mean Diff: -0.997; p=1.000; 95% CI: -3.814; 1.820 NI vs OA: Mean Diff: -0.143; p=1.000; 95% CI: -1.613; 1.327
Underweight	PA vs NI: Mean Diff: -0.285; p=1.000; 95% CI: -2.026; 1.455 PA vs OA: Mean Diff: -0.086; p=1.000; 95% CI: -1.891; 1.720 NI vs OA: Mean Diff: 0.200; p=1.000; 95% CI: -1.025; 1.424



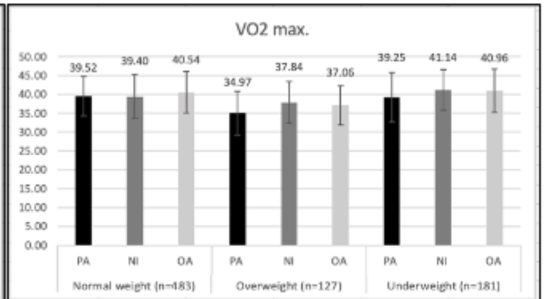
Normal weight	PA vs NI: Mean Diff: -0.615; p=1.000; 95% CI: -3.684; 2.454 PA vs OA: Mean Diff: -1.661; p=0.630; 95% CI: -4.837; 1.515 NI vs OA: Mean Diff: -1.046; p=0.570; 95% CI: -2.959; 0.867
Overweight	PA vs NI: Mean Diff: -3.178; p=0.876; 95% CI: -10.408; 4.052 PA vs OA: Mean Diff: -6.371; p=0.125; 95% CI: -13.861; 1.119 NI vs OA: Mean Diff: -3.193; p=0.151; 95% CI: -7.101; 0.716
Underweight	PA vs NI: Mean Diff: 0.962; p=1.000; 95% CI: -3.665; 5.590 PA vs OA: Mean Diff: -0.056; p=1.000; 95% CI: -4.855; 4.743 NI vs OA: Mean Diff: -1.019; p=1.000; 95% CI: -4.273; 2.236



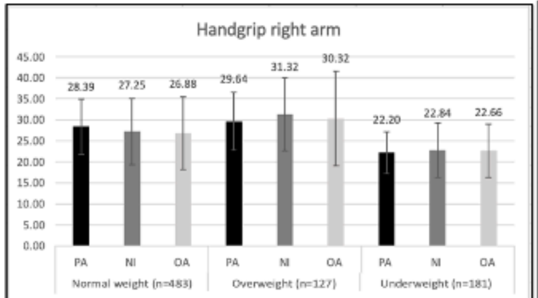
Normal weight	PA vs NI: Mean Diff: 0.042; p=1.000; 95% CI: –1.698; 1.782
	PA vs OA: Mean Diff: –0.297; p=1.000; 95% CI: –2.098; 1.503
	NI vs OA: Mean Diff: –0.339; p=1.000; 95% CI: –1.424; 0.745
Overweight	PA vs NI: Mean Diff: –1.623; p=1.000; 95% CI: –5.722; 2.476
	PA vs OA: Mean Diff: –1.796; p=0.931; 95% CI: –6.042; 2.450
	NI vs OA: Mean Diff: –0.173; p=1.000; 95% CI: –2.389; 2.043
Underweight	PA vs NI: Mean Diff: 0.160; p=1.000; 95% CI: –2.464; 2.783
	PA vs OA: Mean Diff: 0.492; p=1.000; 95% CI: –2.228; 3.213
	NI vs OA: Mean Diff: 0.333; p=1.000; 95% CI: –1.512; 2.178



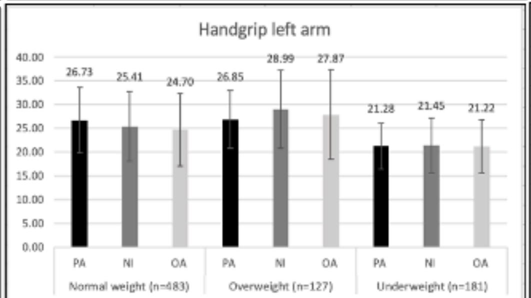
Normal weight	PA vs NI: Mean Diff: 0.009; p=0.815; 95% CI: –0.011; 0.030
	PA vs OA: Mean Diff: 0.013; p=0.414; 95% CI: –0.008; 0.034
	NI vs OA: Mean Diff: 0.004; p=1.000; 95% CI: –0.009; 0.017
Overweight	PA vs NI: Mean Diff: –0.017; p=1.000; 95% CI: –0.065; 0.032
	PA vs OA: Mean Diff: –0.019; p=1.000; 95% CI: –0.069; 0.031
	NI vs OA: Mean Diff: –0.002; p=1.000; 95% CI: –0.028; 0.024
Underweight	PA vs NI: Mean Diff: 0.008; p=1.000; 95% CI: –0.023; 0.039
	PA vs OA: Mean Diff: 0.013; p=0.972; 95% CI: –0.019; 0.045
	NI vs OA: Mean Diff: 0.006; p=1.000; 95% CI: –0.016; 0.028



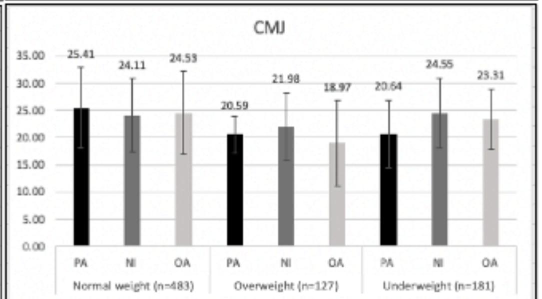
Normal weight	PA vs NI: Mean Diff: 0.119; p=1.000; 95% CI: –2.029; 2.266
	PA vs OA: Mean Diff: –1.018; p=0.816; 95% CI: –3.241; 1.204
	NI vs OA: Mean Diff: –1.137; p=0.126; 95% CI: –2.476; 0.202
Overweight	PA vs NI: Mean Diff: –2.874; p=0.520; 95% CI: –7.933; 2.185
	PA vs OA: Mean Diff: –2.089; p=1.000; 95% CI: –7.329; 3.151
	NI vs OA: Mean Diff: 0.785; p=1.000; 95% CI: –1.950; 3.520
Underweight	PA vs NI: Mean Diff: –1.896; p=0.481; 95% CI: –5.133; 1.342
	PA vs OA: Mean Diff: –1.714; p=0.663; 95% CI: –5.072; 1.643
	NI vs OA: Mean Diff: 0.181; p=1.000; 95% CI: –2.096; 2.458



Normal weight	PA vs NI: Mean Diff: 1.138; p=1.000; 95% CI: –1.892; 4.168
	PA vs OA: Mean Diff: 1.512; p=0.743; 95% CI: –1.624; 4.648
	NI vs OA: Mean Diff: 0.374; p=1.000; 95% CI: –1.515; 2.263
Overweight	PA vs NI: Mean Diff: –1.687; p=1.000; 95% CI: –8.826; 5.452
	PA vs OA: Mean Diff: –0.683; p=1.000; 95% CI: –8.078; 6.712
	NI vs OA: Mean Diff: 1.004; p=1.000; 95% CI: –2.855; 4.863
Underweight	PA vs NI: Mean Diff: –0.635; p=1.000; 95% CI: –5.204; 3.934
	PA vs OA: Mean Diff: –0.459; p=1.000; 95% CI: –5.198; 4.279
	NI vs OA: Mean Diff: 0.176; p=1.000; 95% CI: –3.037; 3.389



Normal weight	PA vs NI: Mean Diff: 1.319; p=0.760; 95% CI: –1.449; 4.087
	PA vs OA: Mean Diff: 2.038; p=0.265; 95% CI: –0.827; 4.903
	NI vs OA: Mean Diff: 0.718; p=0.955; 95% CI: –1.007; 2.444
Overweight	PA vs NI: Mean Diff: –2.142; p=1.000; 95% CI: –8.664; 4.380
	PA vs OA: Mean Diff: –1.022; p=1.000; 95% CI: –7.778; 5.734
	NI vs OA: Mean Diff: 1.121; p=1.000; 95% CI: –2.405; 4.646
Underweight	PA vs NI: Mean Diff: –0.170; p=1.000; 95% CI: –4.344; 4.004
	PA vs OA: Mean Diff: 0.056; p=1.000; 95% CI: –4.273; 4.385
	NI vs OA: Mean Diff: 0.226; p=1.000; 95% CI: –2.710; 3.161



Normal weight	PA vs NI: Mean Diff: 1.300; p=0.700; 95% CI: –1.316; 3.917
	PA vs OA: Mean Diff: 0.887; p=1.000; 95% CI: –1.821; 3.595
	NI vs OA: Mean Diff: –0.414; p=1.000; 95% CI: –2.045; 1.218
Overweight	PA vs NI: Mean Diff: –1.394; p=1.000; 95% CI: –7.558; 4.770
	PA vs OA: Mean Diff: –1.618; p=1.000; 95% CI: –4.767; 8.004
	NI vs OA: Mean Diff: 3.012; p=0.091; 95% CI: –0.320; 6.345
Underweight	PA vs NI: Mean Diff: –3.908; p=0.053; 95% CI: –7.853; 0.037
	PA vs OA: Mean Diff: –2.672; p=0.353; 95% CI: –6.764; 1.419
	NI vs OA: Mean Diff: 1.236; p=0.856; 95% CI: –1.538; 4.011

values in all these variables (Table 3). In the underweight group, males with optimal AMD showed higher scores in the level of physical activity ($p = 0.004$), and males with a need to improve their AMD showed higher values in the CMJ test ($p = 0.003$) as compared to males with a poor AMD. Also in this group, males with an optimal AMD showed higher values of hip girth ($p = 0.040$) as compared to males with a need to improve AMD (Table 4). Females in the overweight and underweight groups did not present significant differences in any variable.

5.5. Discussion

The main objectives of the present investigation were (a) to analyze the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in males and females with different AMD and (b) to determine the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in adolescents with different BMI and AMD. Based on these objectives and on previous scientific literature, the following research hypotheses were established: (H1) differences will be significant in physical fitness, physical activity level, and fat-mass-related variables in adolescents according to AMD level, although there will be differences according to gender; and (H2) adolescents with higher AMD will perform more physical activity, present better body composition, and have higher performance in physical fitness tests regardless of their weight status.

According to the first objective of the present investigation (to analyze the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in males and females with different AMD), the results showed only significant differences in the level of physical activity of the adolescents; adolescents with an optimal AMD practiced sports to a greater extent than those with a poor AMD. No differences were found in anthropometry and physical fitness variables. However, when considering the gender of the adolescents, both males and females with an optimal AMD presented a significantly higher level of physical activity. In addition, males with and optimal AMD showed greater muscle mass, especially in the thigh area, but also greater values in body mass, BMI, and fat mass, especially in the hip area, with respect to the poorer AMD group. Among females with optimal AMD, only differences were found in VO2 max with respect to the poorer AMD group. Previous research does

Table 2. Differences in physical activity, kinanthropometric measurements, and physical fitness variables among normal weight males with different levels of AMD and normal weight females with different levels of AMD.

		Normal Weight (n = 483)					
Variable	**Gender**	**Poor Adherence (A)**	**Need to Improve (B)**	**Optimal Adherence (C)**	**Diff A-B; p**	**Diff A-C; p**	**Diff. B-C; p**
Physical activity score	Males (n = 238)	2.52 ± 0.81	2.77 ± 0.63	3.02 ± 0.57	−0.246; 0.224	−0.499; p = 0.001	−0.253; p = 0.011
	Females (n = 245)	2.26 ± 0.85	2.35 ± 0.60	2.61 ± 0.57	−0.088; p = 1.000	−0.343; p = 0.054	−0.255; p = 0.009
Body mass (kg)	Males (n = 238)	58.69 ± 9.42	59.30 ± 8.45	60.03 ± 8.35	−0.608; p = 1.000	−1.341; p = 1.000	−0.733; p = 1.000
	Females (n = 245)	54.87 ± 6.80	53.54 ± 6.24	53.80 ± 7.18	1.330; p = 1.000	1.070; p = 1.000	−0.259; p = 1.000
BMI (kg/m^2)	Males (n = 238)	20.64 ± 1.65	21.11 ± 1.70	21.29 ± 1.78	−0.472; p = 0.811	−0.651; p = 0.421	−0.179; p = 1.000
	Females (n = 245)	21.06 ± 1.75	20.92 ± 1.71	21.00 ± 1.74	0.142; p = 1.000	0.061; p = 1.000	−0.081; p = 1.000
Height (cm)	Males (n = 238)	167.67 ± 8.66	167.45 ± 9.17	167.84 ± 9.06	0.216; p = 1.000	−0.175; p = 1.000	−0.391; p = 1.000
	Females (n = 245)	161.46 ± 7.16	160.01 ± 6.09	159.79 ± 6.38	1.449; p = 1.000	1.671; p = 1.000	0.222; p = 1.000
Sitting height (cm)	Males (n = 238)	85.92 ± 4.66	86.49 ± 7.72	86.86 ± 5.02	−0.562; p = 1.000	−0.935; p = 1.000	−0.373; p = 1.000
	Females (n = 245)	85.20 ± 2.94	84.20 ± 3.14	83.90 ± 3.43	0.999; p = 1.000	1.298; p = 0.787	0.299; p = 1.000
Sum three skinfolds (mm)	Males (n = 238)	37.84 ± 17.91	39.70 ± 18.25	43.98 ± 18.45	−1.857; p = 1.000	−6.137; p = 0.430	−4.280; p = 0.286
	Females (n = 245)	57.02 ± 18.50	57.95 ± 14.90	58.68 ± 17.71	−0.928; p = 1.000	−1.663; p = 1.000	−0.735; p = 1.000
Waist girth (cm)	Males (n = 238)	71.43 ± 5.42	71.31 ± 4.68	71.49 ± 4.58	0.126; p = 1.000	−0.056; p = 1.000	−0.182; p = 1.000
	Females (n = 245)	67.94 ± 4.71	66.27 ± 4.52	66.19 ± 4.83	1.664; p = 0.435	1.744; p = 0.425	0.079; p = 1.000
Hip girth (cm)	Males (n = 238)	89.50 ± 6.27	89.79 ± 5.91	90.97 ± 5.44	−0.299; p = 1.000	−1.473; p = 0.794	−1.175; p = 0.438
	Females (n = 245)	92.02 ± 5.31	91.21 ± 4.99	91.29 ± 5.18	0.809; p = 1.000	0.720; p = 1.000	−0.089; p = 1.000
Corrected arm girth (cm)	Males (n = 238)	22.65 ± 1.71	22.76 ± 2.29	22.85 ± 2.85	−0.128; p = 1.000	−0.201; p = 1.000	−0.073; p = 1.000
	Females (n = 245)	20.38 ± 1.64	20.11 ± 1.65	20.21 ± 2.02	0.263; p = 1.000	0.164; p = 1.000	−0.098; p = 1.000
Corrected thigh girth (cm)	Males (n = 238)	41.53 ± 3.61	42.36 ± 3.50	43.04 ± 4.98	−0.830; p = 0.966	−1.507; p = 0.244	−0.677; p = 0.601
	Females (n = 245)	38.61 ± 2.52	38.83 ± 3.11	38.66 ± 2.86	−0.216; p = 1.000	−0.046; p = 1.000	0.170; p = 1.000
Corrected calf girth (cm)	Males (n = 238)	30.61 ± 2.18	30.94 ± 2.47	30.62 ± 2.78	−0.330; p = 1.000	−0.014; p = 1.000	0.316; p = 1.000
	Females (n = 245)	28.68 ± 2.27	28.27 ± 1.97	28.39 ± 2.21	0.410; p = 1.000	0.293; p = 1.000	−0.117; p = 1.000

Fat mass (%)	Males (*n* = 238)	17.28 ± 7.62	17.97 ± 7.90	20.12 ± 8.07	−0.690; *p* = 1.000	−2.844; *p* = 0.295	−2.154; *p* = 0.123
	Females (*n* = 245)	25.02 ± 6.60	25.09 ± 5.61	25.40 ± 6.61	−0.061; *p* = 1.000	−0.375; *p* = 1.000	−0.313; *p* = 1.000
Muscle mass (kg)	Males (*n* = 238)	21.89 ± 3.13	22.36 ± 3.64	22.77 ± 4.38	−0.473; *p* = 1.000	−0.880; *p* = 0.743	−0.407; *p* = 1.000
	Females (*n* = 245)	16.05 ± 2.02	15.90 ± 2.27	15.81 ± 2.25	0.147; *p* = 1.000	0.242; *p* = 1.000	0.095; *p* = 1.000
Waist–hip ratio	Males (*n* = 238)	0.80 ± 0.04	0.80 ± 0.06	0.79 ± 0.03	0.003; *p* = 1.000	0.013; *p* = 0.602	0.010; *p* = 0.319
	Females (*n* = 245)	0.74 ± 0.03	0.73 ± 0.04	0.73 ± 0.04	0.012; *p* = 0.669	0.013; *p* = 0.551	0.002; *p* = 1.000
VO_2 max. (ml/kg/min)	Males (*n* = 238)	41.74 ± 5.62	42.74 ± 5.39	43.24 ± 5.38	−0.998; *p* = 1.000	−1.505; *p* = 0.548	−0.507; *p* = 1.000
	Females (*n* = 245)	37.20 ± 3.74	36.34 ± 4.40	37.76 ± 4.09	0.856; *p* = 1.000	−0.565; *p* = 1.000	−1.421; *p* = 0.113
Handgrip right arm (kg)	Males (*n* = 238)	31.87 ± 6.89	31.56 ± 8.32	31.20 ± 9.34	0.307; *p* = 1.000	0.667; *p* = 1.000	0.361; *p* = 1.000
	Females (*n* = 245)	24.76 ± 3.63	23.31 ± 4.80	22.45 ± 4.91	1.454; *p* = 1.000	2.307; *p* = 0.469	0.853; *p* = 1.000
Handgrip left arm (kg)	Males (*n* = 238)	30.25 ± 7.41	29.58 ± 7.72	28.83 ± 8.18	0.669; *p* = 1.000	1.420; *p* = 0.966	0.750; *p* = 1.000
	Females (*n* = 245)	23.06 ± 3.83	21.60 ± 4.36	20.46 ± 3.84	1.463; *p* = 0.895	2.600; *p* = 0.226	1.137; *p* = 0.570
CMJ (cm)	Males (*n* = 238)	29.53 ± 7.89	27.01 ± 7.15	27.97 ± 8.10	2.515; *p* = 0.209	1.560; *p* = 0.823	−0.955; *p* = 0.823
	Females (*n* = 245)	21.12 ± 3.56	21.46 ± 5.09	21.00 ± 5.18	−0.339; *p* = 1.000	0.115; *p* = 1.000	0.454; *p* = 1.000

BMI: body mass index; VO_2 max: maximum oxygen consumption; CMJ: countermovement jump.

Table 3. Differences in physical activity, kinanthropometric measurements, and physical fitness variables among overweight males with different levels of AMD and overweight females with different levels of AMD.

				Overweight (n = 127)			
Variable	**Gender**	**Poor Adherence (A)**	**Need to Improve (B)**	**Optimal Adherence (C)**	**Diff A-B; p**	**Diff A-C; p**	**Diff. B-C; p**
Physical activity score	Males (n = 76)	2.56 ± 0.80	2.76 ± 0.61	2.73 ± 0.58	−0.196; p = 1.000	−0.166; p = 1.000	0.030; p = 1.000
	Females (n = 51)	2.00 ± 0.40	2.48 ± 0.61	2.64 ± 0.57	−0.488; p = 0.422	−0.642; p = 0.198	−0.154; p = 1.000
Body mass (kg)	Males (n = 76)	74.12 ± 7.07	80.35 ± 14.56	83.72 ± 17.85	−6.227; p = 0.465	−9.595; p = 0.099	−3.369; p = 0.341
	Females (n = 51)	65.87 ± 8.91	70.33 ± 8.35	73.92 ± 6.56	−4.455; p = 0.965	−8.047; p = 0.268	−3.592; p = 0.592
BMI (kg/m^2)	Males (n = 76)	27.21 ± 2.15	28.06 ± 2.91	29.34 ± 4.24	−0.850; p = 1.000	−2.129; p = 0.117	−1.279; p = 0.027
	Females (n = 51)	27.44 ± 3.13	28.52 ± 3.36	28.61 ± 2.26	−1.080; p = 0.883	−1.170; p = 0.843	−0.089; p = 1.000
Height (cm)	Males (n = 76)	166.20 ± 3.35	169.01 ± 10.83	168.05 ± 11.18	−2.812; p = 1.000	−1.855; p = 1.000	−0.958; p = 1.000
	Females (n = 51)	155.15 ± 1.76	158.12 ± 5.48	160.80 ± 3.48	−2.970; p = 1.000	−5.650; p = 0.666	−2.680; p = 0.975
Sitting height (cm)	Males (n = 76)	86.35 ± 0.45	88.26 ± 5.51	87.64 ± 6.06	−1.911; p = 1.000	−1.288; p = 1.000	0.623; p = 1.000
	Females (n = 51)	82.97 ± 4.00	84.37 ± 2.75	85.31 ± 2.23	−1.393; p = 1.000	−2.336; p = 1.000	−0.943; p = 1.000
Sum three skinfolds (mm)	Males (n = 76)	72.97 ± 7.15	74.52 ± 26.80	85.85 ± 35.75	−1.542; p = 1.000	−12.872; p = 0.566	−11.330; p = 0.044
	Females (n = 51)	82.09 ± 10.80	96.15 ± 29.36	97.38 ± 19.19	−14.061; p = 0.453	−15.298; p = 0.413	−1.237; p = 1.000
Waist girth (cm)	Males (n = 76)	81.44 ± 4.21	86.97 ± 7.59	89.02 ± 7.98	−5.535; p = 0.110	−7.584; p = 0.016	−2.049; p = 0.334
	Females (n = 51)	79.76 ± 5.22	79.14 ± 8.33	79.42 ± 7.86	0.627; p = 1.000	0.341; p = 1.000	−0.286; p = 1.000
Hip girth (cm)	Males (n = 76)	102.95 ± 5.02	104.54 ± 8.27	106.49 ± 9.71	−1.589; p = 1.000	−3.541; p = 0.753	−1.952; p = 0.544
	Females (n = 51)	101.67 ± 4.00	104.22 ± 7.05	105.62 ± 4.44	−2.547; p = 1.000	−3.950; p = 0.671	−1.403; p = 1.000
Corrected arm girth (cm)	Males (n = 76)	25.52 ± 2.38	25.49 ± 2.88	25.36 ± 3.42	0.027; p = 1.000	0.156; p = 1.000	0.129; p = 1.000
	Females (n = 51)	22.59 ± 1.86	23.38 ± 3.03	21.74 ± 2.22	−0.782; p = 1.000	0.853; p = 1.000	1.635; p = 0.077
Corrected thigh girth (cm)	Males (n = 76)	45.66 ± 3.60	46.57 ± 5.40	45.90 ± 6.27	−0.910; p = 1.000	−0.236; p = 1.000	0.674; p = 1.000
	Females (n = 51)	43.03 ± 4.38	41.57 ± 5.26	43.98 ± 3.83	1.463; p = 1.000	−0.954; p = 1.000	−2.418; p = 0.161
Corrected calf girth (cm)	Males (n = 76)	31.43 ± 3.03	31.94 ± 3.72	31.85 ± 3.75	−0.509; p = 1.000	−0.412; p = 1.000	0.097; p = 1.000
	Females (n = 51)	29.70 ± 2.28	30.59 ± 6.20	31.06 ± 8.43	−0.886; p = 1.000	−1.360; p = 1.000	−0.474; p = 1.000

Fat mass (%)	Males (n = 76)	31.01 ± 4.24	34.12 ± 11.64	38.05 ± 15.80	−3.118; p = 1.000	−7.049; p = 0.239	−3.931; p = 0.117
	Females (n = 51)	34.36 ± 5.36	38.64 ± 11.00	40.83 ± 6.93	−4.280; p = 0.861	−6.477; p = 0.378	−2.197; p = 1.000
Muscle mass (kg)	Males (n = 76)	25.08 ± 2.97	26.31 ± 5.12	25.90 ± 6.33	−1.234; p = 1.000	−0.817; p = 1.000	0.416; p = 1.000
	Females (n = 51)	18.53 ± 2.73	18.82 ± 3.37	19.51 ± 3.38	−0.283; p = 1.000	−0.973; p = 1.000	−0.690; p = 1.000
Waist–hip ratio	Males (n = 76)	0.79 ± 0.02	0.83 ± 0.04	0.84 ± 0.05	−0.042; p = 0.185	−0.046; p = 0.129	−0.005; p = 1.000
	Females (n = 51)	0.78 ± 0.03	0.76 ± 0.05	0.75 ± 0.06	0.025; p = 0.808	0.033; p = 0.509	0.008; p = 1.000
VO_2 max. (ml/kg/min)	Males (n = 76)	37.51 ± 5.89	40.32 ± 4.99	39.04 ± 5.19	−2.812; p = 0.820	−1.529; p = 1.000	1.283; p = 0.912
	Females (n = 51)	32.43 ± 5.34	33.88 ± 3.59	33.52 ± 2.89	−1.448; p = 1.000	−1.092; p = 1.000	0.356; p = 1.000
Handgrip right arm (kg)	Males (n = 76)	35.13 ± 3.52	34.87 ± 8.38	33.54 ± 12.82	0.255; p = 1.000	1.581; p = 1.000	1.326; p = 1.000
	Females (n = 51)	24.15 ± 4.13	25.65 ± 5.77	24.56 ± 2.97	−1.502; p = 1.000	−0.414; p = 1.000	1.088; p = 1.000
Handgrip left arm (kg)	Males (n = 76)	29.98 ± 6.32	32.70 ± 7.85	30.67 ± 10.64	−2.728; p = 1.000	−0.697; p = 1.000	2.031; p = 0.601
	Females (n = 51)	23.73 ± 4.46	23.06 ± 4.60	22.87 ± 3.21	0.669; p = 1.000	0.854; p = 1.000	0.185; p = 1.000
CMJ (cm)	Males (n = 76)	20.93 ± 4.30	24.13 ± 5.41	20.55 ± 9.11	−3.208; p = 0.969	0.377; p = 1.000	3.585; p = 0.070
	Females (n = 51)	20.25 ± 2.70	18.54 ± 5.95	16.15 ± 3.66	1.710; p = 1.000	4.100; p = 0.728	2.390; p = 0.743

BMI: body mass index; VO_2 max: maximum oxygen consumption; CMJ: countermovement jump.

Table 4. Differences in physical activity, kinanthropometric measurements, and physical fitness variables among underweight males with different levels of AMD and underweight females with different levels of AMD.

		Underweight (n = 181)					
Variable	**Gender**	**Poor Adherence (A)**	**Need to Improve (B)**	**Optimal Adherence (C)**	**Diff A-B; p**	**Diff A-C; p**	**Diff. B-C; p**
Physical activity score	Males (n = 95)	2.48 ± 0.65	2.79 ± 0.69	3.13 ± 0.60	−0.313; p = 0.291	−0.646; p = 0.004	−0.333; p = 0.070
	Females (n = 86)	2.38 ± 0.42	2.47 ± 0.54	2.75 ± 0.53	−0.092; p = 1.000	−0.372; p = 0.378	−0.280; p = 0.174
Body mass (kg)	Males (n = 95)	45.90 ± 6.45	45.23 ± 7.11	47.85 ± 6.24	0.674; p = 1.000	−1.952; p = 1.000	−2.625; p = 0.560
	Females (n = 86)	44.60 ± 1.96	44.03 ± 4.41	42.23 ± 4.63	0.573; p = 1.000	2.372; p = 1.000	1.799; p = 1.000
BMI (kg/m^2)	Males (n = 95)	17.29 ± 1.12	16.93 ± 1.03	17.38 ± 0.94	0.352; p = 1.000	−0.092; p = 1.000	−0.444; p = 0.989
	Females (n = 86)	17.37 ± 0.52	17.34 ± 0.87	16.93 ± 1.02	0.024; p = 1.000	0.442; p = 1.000	0.418; p = 1.000
Height (cm)	Males (n = 95)	162.01 ± 9.94	162.97 ± 10.38	165.89 ± 9.07	−0.961; p = 1.000	−3.888; p = 0.430	−2.927; p = 0.396
	Females (n = 86)	160.52 ± 3.99	159.15 ± 6.49	157.87 ± 7.71	1.375; p = 1.000	2.657; p = 1.000	1.282; p = 1.000
Sitting height (cm)	Males (n = 95)	83.34 ± 4.41	83.61 ± 5.23	84.34 ± 5.18	−0.275; p = 1.000	−1.007; p = 1.000	−0.732; p = 1.000
	Females (n = 86)	83.97 ± 1.82	82.96 ± 3.81	82.45 ± 3.42	1.016; p = 1.000	1.520; p = 1.000	0.505; p = 1.000
Sum three skinfolds (mm)	Males (n = 95)	30.94 ± 11.02	25.09 ± 6.37	29.98 ± 14.17	5.851; p = 0.878	0.960; p = 1.000	−4.891; p = 0.775
	Females (n = 86)	44.21 ± 7.35	42.53 ± 10.78	41.43 ± 10.36	1.677; p = 1.000	2.776; p = 1.000	1.098; p = 1.000
Waist girth (cm)	Males (n = 95)	64.10 ± 3.56	63.36 ± 3.88	65.28 ± 5.10	0.744; p = 1.000	−1.182; p = 1.000	−1.926; p = 0.327
	Females (n = 86)	60.77 ± 2.77	60.35 ± 2.50	59.71 ± 2.13	0.429; p = 1.000	1.061; p = 1.000	0.632; p = 1.000
Hip girth (cm)	Males (n = 95)	80.02 ± 4.89	78.97 ± 5.27	82.34 ± 5.47	1.051; p = 1.000	−2.325; p = 0.637	−3.376; p = 0.040
	Females (n = 86)	82.99 ± 2.14	82.86 ± 4.13	81.17 ± 4.59	0.135; p = 1.000	1.817; p = 1.000	1.683; p = 0.662
Corrected arm girth (cm)	Males (n = 95)	19.64 ± 1.08	19.52 ± 1.97	19.87 ± 2.24	0.113; p = 1.000	−0.236; p = 1.000	−0.349; p = 1.000
	Females (n = 86)	18.19 ± 1.26	18.06 ± 1.20	17.73 ± 1.25	0.124; p = 1.000	0.454; p = 1.000	0.331; p = 1.000
Corrected thigh girth (cm)	Males (n = 95)	36.87 ± 2.50	37.07 ± 3.17	37.18 ± 3.17	−0.200; p = 1.000	−0.306; p = 1.000	−0.105; p = 1.000
	Females (n = 86)	34.18 ± 2.03	34.90 ± 2.26	34.31 ± 2.52	−0.721; p = 1.000	−0.125; p = 1.000	0.596; p = 1.000
	Males (n = 95)	27.91 ± 1.70	28.25 ± 2.09	28.44 ± 2.43	−0.347; p = 1.000	−0.535; p = 1.000	−0.188; p = 1.000

Corrected calf girth (cm)	Females (n = 86)	26.14 ± 1.34	26.72 ± 1.59	26.36 ± 1.63	−0.576; p = 1.000	−0.220; p = 1.000	0.355; p = 1.000
Fat mass (%)	Males (n = 95)	14.05 ± 4.86	11.55 ± 2.69	13.80 ± 5.88	2.495; p = 0.824	0.247; p = 1.000	−2.249; p = 0.617
	Females (n = 86)	19.70 ± 2.52	19.39 ± 3.81	18.30 ± 3.54	0.311; p = 1.000	1.405; p = 1.000	1.094; p = 1.000
Muscle mass (kg)	Males (n = 95)	17.45 ± 2.21	17.75 ± 2.95	18.22 ± 2.94	−0.296; p = 1.000	−0.773; p = 1.000	−0.477; p = 1.000
	Females (n = 86)	12.92 ± 1.31	13.15 ± 1.41	12.67 ± 1.56	−0.233; p = 1.000	0.249; p = 1.000	0.482; p = 1.000
Waist–hip ratio	Males (n = 95)	0.80 ± 0.04	0.80 ± 0.04	0.79 ± 0.04	−0.002; p = 1.000	0.009; p = 1.000	0.011; p = 0.882
	Females (n = 86)	0.73 ± 0.05	0.73 ± 0.02	0.74 ± 0.04	0.004; p = 1.000	−0.004; p = 1.000	−0.008; p = 1.000
VO_2 max. (ml/kg/min)	Males (n = 95)	40.81 ± 7.40	43.76 ± 5.14	42.33 ± 6.28	−2.942; p = 0.149	−1.513; p = 1.000	1.429; p = 0.661
	Females (n = 86)	36.51 ± 3.68	38.05 ± 3.69	39.72 ± 4.96	−1.543; p = 1.000	−3.219; p = 0.289	−1.676; p = 0.461
Handgrip right arm (kg)	Males (n = 95)	22.15 ± 5.70	25.07 ± 7.36	26.34 ± 6.01	−2.919; p = 0.505	−4.188; p = 0.190	−1.269; p = 1.000
	Females (n = 86)	22.30 ± 3.88	20.20 ± 3.86	19.33 ± 4.51	2.100; p = 1.000	2.966; p = 0.836	0.866; p = 1.000
Handgrip left arm (kg)	Males (n = 95)	21.63 ± 5.64	23.51 ± 6.51	24.57 ± 5.71	−1.880; p = 0.969	−2.937; p = 0.440	−1.057; p = 1.000
	Females (n = 86)	20.66 ± 3.14	19.01 ± 3.57	18.19 ± 3.44	1.657; p = 1.000	2.472; p = 0.944	0.815; p = 1.000
CMJ (cm)	Males (n = 95)	21.55 ± 7.15	27.76 ± 6.15	25.43 ± 5.20	−6.208; p = 0.003	−3.881; p = 0.163	2.327; p = 0.344
	Females (n = 86)	19.05 ± 3.84	20.75 ± 4.27	21.39 ± 4.98	−1.699; p = 1.000	−2.344; p = 1.000	−0.644; p = 1.000

BMI: body mass index; VO_2 max: maximum oxygen consumption; CMJ: countermovement jump.

not provide conclusive results in this regard, as some studies showed that there was no relationship between AMD, physical activity level, and kinanthropometric variables (Santana et al., 2018), while other studies showed that adolescents with better AMD performed more physical activity (Moral García et al., 2019) and presented a higher VO2 max (Galan-Lopez et al., 2019; Manzano-Carrasco, Felipe, Sánchez-Sánchez, Hernández-Martín, Gallardo, et al., 2020). More specifically, the higher fat percentage of males with higher adherence to the Mediterranean diet may be because previous studies have suggested that high-fat diets such as the Mediterranean diet may promote obesity and fat accumulation when there is a positive energy balance (Panagiotakos et al., 2006). Indeed, males with optimal AMD showed a greater increase in fat mass compared to muscle mass, which could be the origin of the changes in body mass and BMI (Freedman et al., 2005). In addition, this would explain why no differences were found in the fitness tests related to strength (Fogelholm et al., 2008; Nikolaidis, 2013). On the other hand, the isolated improvement in VO2 max in females could be due to the fact that adolescents with a better diet are those who are more aware of the importance of healthy habits (González-Gross et al., 2008; Malheiros et al., 2021), thus leading them to practice more physical activity. Therefore, it could be the greater practice of physical activity that is responsible for the higher VO2 max compared to the rest of the AMD groups (D'Alleva et al., 2022; Kim & Park, 2021). Therefore, differences obtained in the present study could indicate that AMD as an isolated factor is not a determinant in the changes in kinanthropometric variables or in the fitness of adolescents. Despite these results, questions remain for future studies.

The results obtained in the present study partially confirm the first research hypothesis (H1) since adolescents with better AMD had a higher level of physical activity. However, the differences were not significant in the kinanthropometric or physical condition variables. When analyzing the results according to the gender of the adolescents, the differences were significant in males and females with optimal AMD compared to those with worse AMD. In this regard, males and females with optimal AMD showed a higher level of physical activity, but only males showed differences in body composition (increasing fat mass to a greater extent than muscle mass), and only females showed differences in physical fitness (increasing VO2 max) but not being able to claim that this was due to better AMD.

The second objective of the present study was to determine the existing differences in physical fitness, level of physical activity, and kinanthropometric variables of adolescents with different BMI and AMD, which could be termed the "fat but healthy diet" paradigm. Following the line of the "fat but fit" paradigm (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022; Torres-Costoso et al., 2021), it was hypothesized that adolescents with a better AMD would show a higher level of physical activity, better kinanthropometric variables, as well as a higher performance in the fitness variables compared to adolescents presenting worse AMD within the same weight status. Thus, the obtained results showed higher levels of physical activity in the optimal AMD group of normal weight and underweight adolescents. However, this was not the case in the overweight group, where a higher body mass was also found in the optimal AMD group. Previous research that considered adolescent AMD showed a higher level of physical activity in the group of adolescents with a higher AMD (Moral García et al., 2019). It is important to note that adolescent BMI and AMD have not been previously considered together, so the results obtained in this regard are novel. The fact that the overweight group was the only one that did not show significant differences in the level of physical activity among adolescents with different AMD could be explained by the frequent alterations in body image suffered by overweight and obese adolescents. This has very negative consequences during adolescence, mainly related to dietary alterations and avoidance of sports participation (Voelker et al., 2015). Regarding the greater body mass in adolescents with an optimal AMD in the overweight group, a possible explanation would be that the type of food ingested was not as decisive as the quantity ingested (Feinglos & Totten, 2008). Thus, the lack of physical activity in this population, linked to excessive intake, would favor the increase in body mass, although future research that analyzes the specific daily intake of adolescents is necessary to corroborate this conclusion.

When analyzing the results considering the BMI and gender of the adolescents, it should be noted that the differences in physical fitness were significant in males and females, while kinanthropometric variables only showed differences in the group of males. Regarding physical fitness, the CMJ of underweight males with a poor AMD was significantly lower than the rest of the males with a better AMD. Previous research analyzing CMJ performance found no significant differences in either males or females based on AMD (Manzano-

Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Clavel, et al., 2020). These results suggest that AMD may not be particularly relevant in this variable, so the observed differences could be due to the fact that males in the underweight group have less muscle mass and corrected thigh and calf girth than males in the normal weight and overweight groups. This could be a determining factor in the relationship between the amount of muscle mass and CMJ performance (Leão et al., 2022).

In the group of overweight males with an optimal AMD, regarding the kinanthropometric variables measured, the sum of three folds and waist girth were significantly higher as compared to the males with poor AMD. These results are in line with previous research, which showed that adolescent males and females with better AMD had a higher body fat than those with worse AMD, although the differences were not statistically significant in this case (Manzano-Carrasco, Felipe, Sánchez-Sánchez, Hernández-Martín, Gallardo, et al., 2020). These results could be explained by the fact that, although the adolescents have an optimal AMD, the level of physical activity in the overweight group is very low (≤2.75). Thus, most of the adolescents in this group are considered physically inactive, which would make it difficult to achieve the caloric deficit necessary to reduce body fat (Strasser et al., 2007). However, the results obtained should be taken with caution, as the sample size of the overweight groups of males and females was very small, which makes it difficult to extrapolate the results. It should also be noted that, together with the results obtained in the group of overweight males, the absence of significant differences in the females and in the group of normal weight males is relevant. This could indicate that AMD alone is not so important in producing modifications in the kinanthropometric variables of adolescents, which would grant greater relevance to other elements of the diet (e.g., quantity or caloric deficit) and to other healthy lifestyle habits, such as the practice of physical activity at this age. Nevertheless, this should be confirmed in future research in which the contribution of dietary variables and physical activity to the kinanthropometric variables of adolescents is analyzed.

Regarding the second research hypothesis (H2), the results obtained allow us to partially accept it since the differences when considering BMI and AMD were significant in adolescents with optimal AMD compared to those with worse AMD. Thus, the level of physical activity practiced in males and females of the normal weight group with optimal AMD was higher. The level of physical activity and CMJ performance was higher in the males of the underweight group with optimal AMD. However, in the overweight group, the differences were significant in the kinanthropometric variables, with the males with optimal AMD showing greater body fat. Furthermore, in the females, there were only differences in the level of physical activity in the normal weight group, so future research is needed to explore the "fat but healthy diet" paradigm.

It should be noted that the findings of the present research regarding differences in physical fitness could be also influenced by the biological maturation of adolescents (Albaladejo-Saura et al., 2021). Adolescence is a stage in which physical and anthropometric changes occur that are determinant in the development of physical capacities. Thus, previous research has found that adolescents who mature earlier present better performance in physical condition tests, independently of the physical activity performed (Albaladejo-Saura et al., 2021; Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a). Therefore, it would be necessary that future research studying the differences in the level of physical activity practiced, kinanthropometric variables, and physical fitness variables of adolescents according to their AMD, BMI, and gender also analyze the effect of biological maturation on the changes found.

The present investigation is not free of limitations. The sample was selected by convenience in the educational centers to which we had access. It should be noted that this is a cross-sectional study in which the data were measured at a single point in time. In addition, the use of questionnaires to assess the AMD and the level of physical activity always involves a risk that adolescents will not complete the questionnaire with complete accuracy, so this is a factor to be highlighted. The classification provided by the KIDMED questionnaire makes it possible to obtain a score on the AMD, but it has gaps in terms of knowing the food intake and the quantities ingested by adolescents. Changes in physical fitness, mainly in strength, power, and cardiorespiratory fitness, could be influenced by the biological maturation of adolescents. Finally, when analyzing the results according to BMI, AMD, and gender of the adolescents, the sample sizes of some groups were too small.

Regarding the practical applications derived from the present investigation, although AMD does not seem to exert great influence on kinanthropometric variables and physical fitness in adolescents, it does seem to be related to the adoption of other healthy lifestyle habits in adolescent males and females, including a higher level of physical activity. However, the novelty of the present article with respect to previous scientific literature is that it shows the need to consider gender and BMI in the study of AMD since needs change between groups. The results obtained show that in overweight males, the optimal AMD seemed not to be so relevant for the practice of physical activity and kinanthropometric variables, and other healthy habits may be more determinant in this population, but future research is required to corroborate this. Furthermore, AMD does not seem to be a relevant variable in the improvement of the physical condition and body composition of females since the only differences were found in the group of normal weight females in the level of physical activity, but not in body composition or physical condition, independently of weight status.

The second major novelty of the present study is that the "fat but healthy diet" paradigm cannot be confirmed since differences in the level of physical activity, anthropometric variables, and physical condition according to AMD were observed only in the underweight and normal weight males. In addition, the results showed that in the overweight group, males with optimal AMD had worse body composition, and no differences were found in kinanthropometrics and physical fitness variables in any weight status group in females with different AMD. Therefore, future research is needed to determine whether AMD is a sufficient determining factor to compensate for inadequate weight status. In this sense, more scientific literature is needed to determine whether adolescents with better AMD show better body composition and physical condition, independently of their weight status, as occurs in the fat but fit paradigm (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022). Furthermore, future studies should also consider monitoring the degree of AMD during adolescence with a longitudinal and observational design mainly from pre-adolescence. This is because adolescence is a stage in which changes occur in the factors that are most determinant for the acquisition of healthy behaviors, with the influence exerted by peers increasing considerably and lessening the influence of their parents and teachers (Mateo-Orcajada et al., 2021); moreover, they obtain more information from other sources such as the internet or social networks (Pilař et al., 2021; Serenko et al., 2020), which is not always correct and can influence AMD.

5.6. Conclusions

Based on the results obtained, it can be concluded that greater AMD does not seem to produce beneficial effects in the adolescent population. Thus, only the level of physical activity showed significant differences as a function of the adolescents' AMD, while there were no significant differences in the kinanthropometrics variables and the physical condition variables of the adolescents according to their AMD when considering the whole sample. Considering the gender of the adolescents, it was observed that the males with better AMD had a higher level of physical activity and a greater muscle mass, but also showed a greater fat mass, body mass, and BMI. As for the females with better AMD, they presented only a higher level of physical activity and higher VO2 max. In addition, when considering BMI and gender together, the view of the "fat but healthy diet" paradigm could not be confirmed. This is because overweight and obese males with optimal AMD showed greater body mass, sum of three skinfolds, and waist circumference, and they did not practice more physical activity than overweight males with worse AMD. In addition, no differences were found in the kinanthropometric and physical condition variables in the females in any of the weight status groups. Therefore, the fat but healthy diet paradigm cannot be confirmed in the present research.

Vc – ESTUDIO 3: The role of basic psychological needs in the adoption of healthy habits by adolescents

ESTUDIO 3 – THE ROLE OF BASIC PSYCHOLOGICAL NEEDS IN THE ADOPTION OF HEALTHY HABITS BY ADOLESCENTS

5.1. Abstract

Previous research in this field has not examined the significance of each of the basic psychological needs (BPNs) on changes in the physical activity level, adherence to the Mediterranean diet (AMD), kinanthropometric and derived variables, and the physical fitness of adolescents. Therefore, the purpose of this study was (a) to examine the variances in physical activity, AMD, and kinanthropometric and derived variables, as well as fitness levels, among adolescents with varying degrees of satisfaction regarding each of the BPNs and (b) to assess the differences in the study variables among adolescents based on whether the BPNs are satisfied individually or jointly. The sample consisted of 791 adolescents (404 males and 387 females; average age: 14.39 ± 1.26 years old). The findings indicated that adolescents in the highest percentiles (75–100) of competence, autonomy, or relatedness showed higher scores in physical activity and AMD and better kinanthropometric and physical fitness variables than adolescents in the lowest percentiles (0–25). Adolescents who showed joint satisfaction of all BPNs showed the best results on all variables analyzed. In addition, it should be noted that competence played the most relevant role.

5.2. Introduction

Self-determination theory (SDT) defines autonomy, competence, and relatedness as the three basic psychological needs (BPNs) (Ryan & Deci, 2000). Satisfaction of BPNs in adolescents is necessary to achieve well-being and decrease vulnerability to the development of any psychopathology (Gnambs & Hanfstingl, 2016). Adolescents who have all BPNs satisfied together seem to show adequate health status, although individual satisfaction of each BPN has also been shown to influence psychological and behavioral development (Wang et al., 2019). Thus, the results found in previous research showed that the joint satisfaction of the BPNs was related to autonomous motivation, favoring enjoyment and less pressure, with relatedness being the most determinant BPN in this relationship; competence predicted controlled motivation positively, while autonomy and relatedness predicted it negatively; in addition, competence was negatively related to the feeling of pressure (Wang et al., 2019).

In addition, it should be noted that in previous cross-sectional research the authors showed the relationship between BPN and certain healthy lifestyle habits, such as the practice of physical activity (Gil-Píriz et al., 2021), or adherence to an optimal nutritional pattern (Lirola et al., 2021). Thus, with respect to the practice of physical activity, adolescents who had more barriers to physical activity practice showed higher BPNs frustration (Gil-Píriz et al., 2021). Similarly, the BPNs were significantly related to adherence to an optimal nutritional pattern, specifically Adherence to the Mediterranean Diet (AMD), with the AMD score being higher in adolescents who had a greater satisfaction of the BPNs, although it is unknown whether the differences were in competence, autonomy, or relatedness, since the authors calculated a final score for the satisfaction of the BPNs, without specifying in which of these needs the differences were found (Lirola et al., 2021).

Furthermore, the preliminary findings from pilot studies conducted by the researchers have identified additional personal factors that play a crucial role in maintaining good health and the prevention of chronic diseases in adolescents, such as kinanthropometric and derived variables (Markland & Ingledew, 2007), and the maintenance of a high level of physical fitness (Erturan-Ilker et al., 2018). The latter also showed a positive relationship with BPNs, thus becoming a fundamental aspect for the integral health of the adolescent population. Regarding kinanthropometric and derived variables, in previous studies the researchers demonstrated that autonomy was highest in males when body mass index (BMI) was around 18.50. For females, the study findings revealed that autonomy exhibited an upward trend as body size discrepancies became less negative. Autonomy reached its peak and stabilized when the discrepancy reached +1 (Markland & Ingledew, 2007). Regarding fitness variables, only one previous study analyzed this relationship, showing that fitness improvements in adolescents could be increased in environments where the satisfaction of BPNs was favored, mainly competence and relatedness (Erturan-Ilker et al., 2018). However, it is important to note that these studies had limitations, for example, Markland and Ingledew (2007) only included BMI as a variable to assess body composition; while in the research by Erturan-Ilker et al. (2018) the measurement of specific physical fitness tests was not provided as a fitness score was calculated, preventing the analysis of the association of the specific performance in these tests to the satisfaction of BPNs. These reasons call for further research to address anthropometric and fitness variables in relation to BPN satisfaction.

In the psychological field, the importance of joint or individual satisfaction with the BPNs has been analyzed (Wang et al., 2019). However, no previous studies have analyzed whether differences in the level of physical activity, AMD, kinanthropometric and derived variables, and fitness depended on the degree of satisfaction with each of the BPNs. Likewise, it has not been analyzed whether one of the BPNs in particular played a more important role than the rest in the changes that occurred in these variables (Wang et al., 2019). Therefore, the purpose of this study were a) to examine the variances in physical activity, AMD, kinanthropometric and derived variables, and fitness among adolescents with different degree levels of satisfaction of each of the BPNs; and b) to assess the differences in the level of physical activity, AMD, kinanthropometric and derived variables, and physical fitness of the adolescents according to whether the BPNs are satisfied individually or jointly.

Based on the objectives of the present research, as well as previous scientific literature, the following research hypotheses (H) are proposed: H1) adolescents who experience higher levels of satisfaction with BPNs are expected to exhibit increased levels of physical activity, greater AMD, better physical performance and better kinanthropometric and derived variables; and H2) in the absence of previous research that would allow us to establish an accurate hypothesis as to which BPN is more relevant to the study variables, we hypothesize that adolescents who have all BPNs satisfied collectively will demonstrate elevated levels of physical activity, AMD, physical performance and improved kinanthropometric and derived variables.

5.3. Materials and Methods

5.3.1. Design

The current study employed a cross-sectional design and utilized non-probability convenience sampling. Four compulsory secondary schools in various regions of the Region of Murcia, Spain, were involved in the study. The research adhered to the STROBE statement (Vandenbroucke et al., 2014), guiding its design and manuscript development. Furthermore, the study received prior approval from the institutional ethics committee of the Catholic University of Murcia (code: CE022102). The research protocol and design adhered to the guidelines set forth by the World Medical Association and the Helsinki declaration. According to the psychologists' code of conduct, the ethical principles of beneficence and non-maleficence, fidelity and responsibility, integrity, justice and respect for the rights and dignity of people were followed during all the research (American Psychological Association, 2017).

5.3.2. Participants

The final sample consisted of 791 adolescents (404 males and 387 females) aged 12-16 years old (mean age: 14.39±1.26 years old). These adolescents willingly participated in the research after providing informed consent forms signed by both themselves, and their parents. The sample size was determined using the methodology employed in previous studies (Bhalerao & Kadam, 2010) and the statistical software Rstudio 3.15.0 (Rstudio Inc., Boston, MA, USA). This calculation was based on the standard deviations (SD) obtained from earlier research conducted on BPNs in the adolescent population (Fraguela-Vale et al., 2020). Thus, for an SD=0.77 for autonomy, SD=0.82 for competence, and SD=0.85 for relatedness, and an estimated error (d) of 0.07 for autonomy and 0.08 for competence and relatedness, the minimum sample size required to extrapolate the results with a 99% confidence interval was 764 adolescents.

The participants included in the study satisfied the following inclusion criteria a) completion of all questionnaires, kinanthropometric measurements and physical tests in their entirety; b) not presenting any disease or surgical operation that prevented participation in any of the tests; c) age range between twelve and sixteen years old; and d) attending compulsory secondary education.

5.3.3. Instruments

*5.3.3.1. **Measurement of BPNs***

To assess competence, autonomy, and relatedness (BPNs), the Spanish version of the Basic Psychological Needs Scale (BPNS) (Wilson et al., 2006) was employed. This scale consists of 18 items, with 6 items dedicated to each dimension. Participants rated each item on a Likert scale ranging from 1 to 6 points (1 totally false; 6 totally true). Consequently, a score between 6 and 36 points was obtained for each dimension.

Based on previous research (Marcos-Pardo et al., 2021), the analysis of the degree of satisfaction of each of the BPNs was determined by establishing the 0-25, 25-50, 50-75 and 75-100 percentiles. Thus, the score for each dimension was as follows: competence (percentile 0-25: <22; percentile 25-50: <28; percentile 50-75: <32; percentile 75-100: ≥32), autonomy (percentile 0-25: <22; percentile 25-50: <26; percentile 50-75: <30; percentile 75-100: ≥30), and relatedness (percentile 0-25: <21; percentile 25-50: <25; percentile 50-75: <29; percentile 75-100: ≥29).

In addition, BPNs were considered as satisfied when the score was above the 50th percentile resulting in the following classification: none (no BPN satisfied), competence (competence satisfied only), autonomy (autonomy satisfied only), relatedness (relatedness satisfied only), competence and autonomy satisfied, competence and relatedness satisfied, autonomy and relatedness satisfied, and all BPNs satisfied.

5.3.3.2. Physical activity level and AMD measurement

To evaluate the participants' physical activity level, the Spanish version of the "Physical Activity Questionnaire for Adolescents" (PAQ-A) was employed (Kowalski et al., 1997; Martínez-Gómez et al., 2009). This questionnaire consists of nine items, and the final score is calculated as the average of the scores from the first eight items, resulting in a value between 1 and 5 points (Martínez-Gómez et al., 2009).

The assessment of the participants' adherence to the Mediterranean diet was conducted using the "Mediterranean Diet Quality Index for children and adolescents" (KIDMED) questionnaire (Serra-Majem et al., 2004). This questionnaire comprises 16 items, with 12 items reflecting positive aspects (+1) and four items reflecting negative aspects (-1). The scoring range for this questionnaire is from 0 to 12 points.

5.3.3.3. Kinanthropometric and derived variables measurement

In accordance with the protocol established by the International Society for the Advancement of Kinanthropometry (ISAK) (Esparza-Ros et al., 2019), three anthropometrists (level 2 to 4) conducted measurements using standardized techniques. The measurements included three basic parameters: body mass, height, and sitting height. Additionally, three skinfold measurements were taken (triceps, thigh, and calf), along with five girth measurements (relaxed arm, waist, hips, thigh, and calf).

The instruments utilized for the measurements were as follows: a TANITA BC 418-MA Segmental (TANITA, Tokyo, Japan) (body mass); a SECA stadiometer 213 (SECA, Hamburg, Germany) (height and sitting height); a Harpenden skinfold caliper (Burgess Hill, UK) (skinfolds); and an inextensible tape, Lufkin W606PM (Lufkin, Missouri City, TX, USA) (girths).

The derived variables calculated with the final values of the kinanthropometric measurement were: BMI, waist-to-hip ratio (waist girth/hip girth) (Yan et al., 2007), corrected arm girth [arm relaxed girth − ($\pi \times$ triceps skinfold)], corrected thigh girth [thigh girth − ($\pi \times$ thigh skinfold)], corrected calf girth [calf girth − ($\pi \times$ calf skinfold)], $\Sigma 3$ skinfolds (triceps, thigh, and calf), fat mass (%) (Slaughter et al., 1988), and muscle mass (Poortmans et al., 2005).

5.3.3.4. *Physical fitness measurement*

In accordance with the methodology employed in prior studies (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022), the following physical fitness tests were performed: 20-m shuttle run test to measure cardiorespiratory capacity and prediction of maximal oxygen consumption (VO2 max.) (Léger et al., 1988; Tomkinson et al., 2019); handgrip strength for the measurement of upper limb strength using a Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo, Japan) (Matsudo et al., 2014); sit-and-reach to assess hamstring flexibility using an Acuflex Tester III box (Novel Products, Rockton, IL, USA); countermovement jump (CMJ) to assess lower limb explosive strength by means of a force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) with which jump height was measured (Barker et al., 2018); and the 20-m sprint to measure running speed using single-beamed photocells (Polifemo Light, Microgate, Italy) placed at hip height (Altmann et al., 2017).

5.3.4. Procedure

Data collection for this research took place in each of the high schools, specifically during the physical education classes. The tests were conducted in a covered sports pavilion to minimize the potential interference of confounding variables. It is important to note that all tests were performed on the same day to maintain consistency in data collection.

The protocol, based on previous research (Mateo-Orcajada, Abenza-Cano, et al., 2022), consisted of: 1) completion of the BPNS, PAQ-A, and KIDMED questionnaires; 2) kinanthropometric measurements taken by anthropometrists; 3) a single attempt of the sit-and-reach test was conducted before the warm-up to mitigate the potential influence of warm-up activities on test performance; 4) warm-up session was conducted, consisting of 5 minutes of progressive running and 10 minutes of joint mobility exercises; 5) familiarization and explanation of the handgrip, CMJ and 20-m sprint tests to adolescents; 6) the handgrip strength, CMJ, and 20-m sprint tests were performed. The order of execution of these tests was randomized for each adolescent. Each test was repeated twice, with the best value recorded. The rest period between each attempt of the same test was two minutes, while five minutes were provided between different tests, in line with the recommendations of the National Strength and Conditioning Association (NSCA) regarding fatigue management (Coburn & Malek, 2014); 7) a single attempt of the 20-m shuttle run test was conducted. Four experienced researchers were assigned to oversee the execution of the tests. Each researcher was responsible for conducting the same test throughout all measurements.

5.3.5. Data analysis

Initially, the normality of the data was evaluated using the Kolmogorov-Smirnov test, as well as an analysis of skewness and kurtosis. As the data demonstrated a normal distribution, parametric tests were employed for subsequent analysis. Descriptive statistics, including mean (M) and standard deviation (SD), were utilized to summarize the analyzed variables. The internal consistencies of self-reported measures were evaluated using Cronbach's Alpha. Subsequently, four one-way ANOVA tests were conducted. The first ANOVA aimed to identify differences in the study variables among different percentiles in the competence variable. The second ANOVA focused on the autonomy variable, while the third ANOVA examined the relatedness variable. Lastly, the fourth ANOVA was conducted to determine differences in the study variables based on the BPNs satisfied by the adolescents. For statistically significant variables, Bonferroni's pairwise comparison was employed. The effect size (ES) was calculated using partial eta squared ($\eta 2$), with values classified as small ($ES \geq 0.10$), moderate ($ES \geq 0.30$), large ($ES \geq 1.2$), or very large ($ES \geq 2.0$). The significance level was set at $p < 0.05$ (Hopkins et al., 2009). All tests performed were evaluated for statistical significance at this level. The SPSS statistical package (v.25.0; SPSS Inc., Chicago, IL, USA) was utilized for the statistical analysis.

5.4. Results

Prior to the analysis, the internal consistencies of the self-reported measures were calculated. Thus, the BPNs survey reported a Cronbach's alpha between 0.768 and 0.820 (competence: 0.768; autonomy: 0.820; and relatedness: 0.776), the PAQ-A reported 0.840, and the AMD reported 0.756. A scale has an acceptable internal consistency when the Cronbach’s Alpha value is greater than 0.70 (Gliem & Gliem, 2003), which indicates a high internal consistency for the present study.

Table 1 shows the differences in the studied variables according to the percentile of satisfaction of the competence variable. The results show significant differences in physical activity score, AMD, height, individual corrected girths, sum of 3 skinfolds, fat mass, muscle mass, VO2 max, handgrip strength, CMJ, and 20-m sprint.

The post-hoc analysis of the differences between the satisfaction percentiles of the competence variable is shown in Supplementary Figure 1. Thus, with respect to the level of physical activity practiced, the lowest percentiles (0-25 and 25-50) showed lower scores as compared to the highest percentiles. For AMD, the 0-25 percentile showed significantly lower scores as compared to the rest of the percentiles. Similarly, in the kinanthropometric and derived variables, the 75-100 percentile showed significant differences as compared to the 0-25 and 25-50 percentiles, with the 75-100 percentile score being higher in height, sitting height, corrected girths, and muscle mass, but lower in the sum of 3 skinfolds and fat mass. Regarding the physical fitness tests, performance was higher in adolescents in the 75-100 percentile as compared to the rest of the percentiles, in VO2 max, handgrip strength, CMJ, and 20-m sprint, except for adolescents in the 50-75 percentile.

The differences in the studied variables, according to the percentile of satisfaction of the autonomy variable, are found in Table 2. The results showed significant differences in physical activity level, AMD, height, corrected girths, muscle mass, VO2 max, handgrip strength, CMJ, and the 20-m sprint.

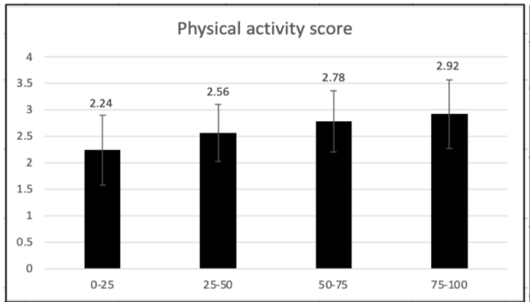
Supplementary Figure 2 shows the post-hoc analysis of the differences between the percentiles of satisfaction of the autonomy variable. The level of physical activity practiced was significantly lower in the 0-25 percentile as compared to the rest of the percentiles, as well as in the 25-50 percentile as compared to the 75-100. Regarding AMD, the score of adolescents in the 75-100 percentile was significantly higher than that of adolescents in the 0-25 percentile. According to the kinanthropometric and derived variables, it noteworthy to find that adolescents in the 0-25 percentile showed significantly lower scores as compared to the rest of the percentiles in height, corrected girths and in muscle mass. In physical fitness variables, adolescents in the 0-25 percentile showed a significantly lower performance in VO2 max, handgrip strength, CMJ, and 20-m sprint, as compared to the 50-75 and 75-100 percentiles, as well as in CMJ and 20-m sprint, as compared to the 25-50 percentile.

Table 1. Differences in the physical activity score, AMD, kinanthropometric and derived variables, and physical fitness variables according to the degree of satisfaction of the competence variable.

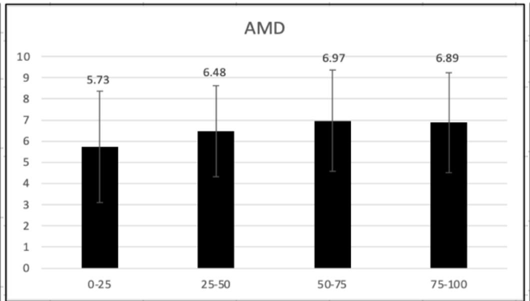
Variable	Descriptors (M ± SD)				F	*p*	Effect Size (η^2)
	Competence (0–25) (*n* = 158)	Competence (25–50) (*n* = 225)	Competence (50–75) (*n* = 167)	Competence (75–100) (*n* = 241)			
Physical activity score	2.24 ± 0.66	2.56 ± 0.54	2.78 ± 0.58	2.92 ± 0.65	41.003	<0.001	0.142
AMD	5.73 ± 2.64	6.48 ± 2.16	6.97 ± 2.38	6.89 ± 2.36	9.100	<0.001	0.035
Body mass (kg)	56.27 ± 14.20	56.66 ± 13.57	57.36 ± 12.18	57.81 ± 12.77	0.513	0.673	0.002
Height (cm)	161.78 ± 8.50	162.30 ± 9.21	164.48 ± 8.59	164.75 ± 9.04	5.252	0.001	0.021
BMI (kg/m^2)	21.44 ± 4.29	21.41 ± 4.14	21.10 ± 3.50	21.20 ± 3.69	0.293	0.830	0.001
Sitting height (cm)	84.45 ± 4.32	84.39 ± 6.33	85.81 ± 4.45	85.71 ± 4.63	4.276	0.005	0.017
Waist girth (cm)	69.23 ± 9.30	69.88 ± 9.19	69.48 ± 7.90	69.96 ± 8.67	0.271	0.847	0.001
Hip girth (cm)	91.04 ± 9.67	90.68 ± 9.41	90.56 ± 8.41	90.73 ± 9.07	0.073	0.974	0.001
Waist-to-hip ratio	0.76 ± 0.05	0.77 ± 0.05	0.77 ± 0.05	0.77 ± 0.06	1.433	0.232	0.006
Corrected arm girth (cm)	20.76 ± 2.97	21.01 ± 2.93	21.57 ± 2.94	21.80 ± 3.06	4.868	0.002	0.019
Corrected thigh girth (cm)	39.03 ± 4.49	39.58 ± 4.96	40.47 ± 4.70	41.31 ± 5.12	8.124	<0.001	0.032
Corrected calf girth (cm)	28.79 ± 2.67	29.14 ± 3.90	29.52 ± 2.98	29.81 ± 3.02	3.496	0.015	0.014
Sum of 3 skinfolds (cm)	57.38 ± 27.27	54.07 ± 26.27	49.56 ± 23.76	47.15 ± 22.42	6.173	<0.001	0.024
Fat mass (%)	25.15 ± 11.37	23.85 ± 10.70	21.82 ± 9.67	21.00 ± 9.14	6.276	<0.001	0.025
Muscle mass (kg)	17.60 ± 4.64	18.38 ± 4.95	19.33 ± 5.10	20.11 ± 5.30	8.773	<0.001	0.034
VO2 max. (mL/kg/min)	36.87 ± 4.91	38.77 ± 5.06	40.71 ± 6.08	41.62 ± 5.67	26.596	<0.001	0.097
Handgrip right arm (kg)	24.15 ± 6.83	25.41 ± 7.63	28.16 ± 8.32	28.72 ± 9.07	13.125	<0.001	0.050
Handgrip left arm (kg)	22.30 ± 6.10	23.65 ± 6.84	26.20 ± 7.88	26.75 ± 8.16	14.614	<0.001	0.056
Sit-and-reach (cm)	15.87 ± 8.93	15.26 ± 8.57	16.48 ± 8.53	16.05 ± 8.98	0.622	0.601	0.003
CMJ (cm)	20.92 ± 5.71	22.62 ± 6.61	24.58 ± 7.17	25.79 ± 7.19	18.399	<0.001	0.069
20 m sprint (s)	4.16 ± 0.39	4.00 ± 0.58	3.83 ± 0.61	3.78 ± 0.45	19.469	<0.001	0.073

AMD: adherence to Mediterranean diet; BMI: body mass index; VO2 max: maximum oxygen consumption; CMJ: countermovement jump.

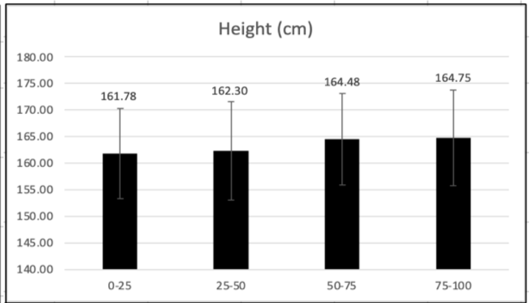
Supplementary Figure 1. Bonferroni post-hoc analysis of the variables that showed significant differences in competence



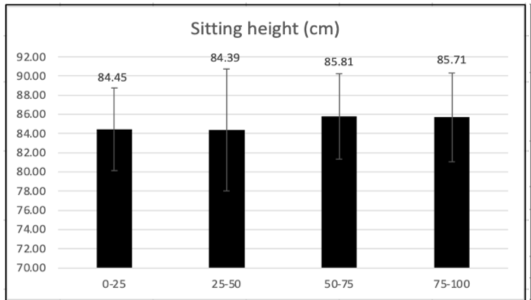
0-25 vs 25-50: Mean Diff: -0.319; p<0.001; 95% CI: -0.49; -0.15
0-25 vs 50-75: Mean Diff: -0.540; p<0.001; 95% CI: -0.72; -0.36
0-25 vs 75-100: Mean Diff: -0.675; p<0.001; 95% CI: -0.85; -0.51
25-50 vs 50-75: Mean Diff: -0.221; p=0.004; 95% CI: -0.39; -0.05
25-50 vs 75-100: Mean Diff: -0.356; p<0.001; 95% CI: -0.51; -0.20
50-75 vs 75-100: Mean Diff: -0.136; p=0.188; 95% CI: -0.30; 0.03



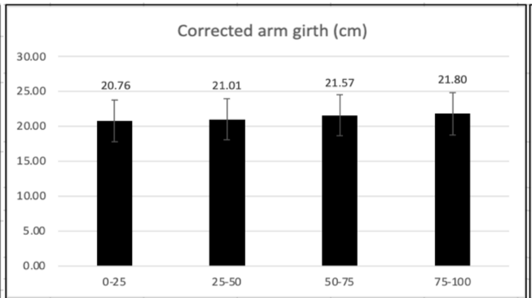
0-25 vs 25-50: Mean Diff: -0.75; p=0.020; 95% CI: -1.42; -0.08
0-25 vs 50-75: Mean Diff: -1.24; p<0.001; 95% CI: -1.96; -0.52
0-25 vs 75-100: Mean Diff: -1.15; p<0.001; 95% CI: -1.81; -0.49
25-50 vs 50-75: Mean Diff: -0.49; p=0.289; 95% CI: -1.15; 0.17
25-50 vs 75-100: Mean Diff: -0.41; p=0.429; 95% CI: -1.00; 0.19
50-75 vs 75-100: Mean Diff: 0.09; p=1.000; 95% CI: -0.56; 0.74



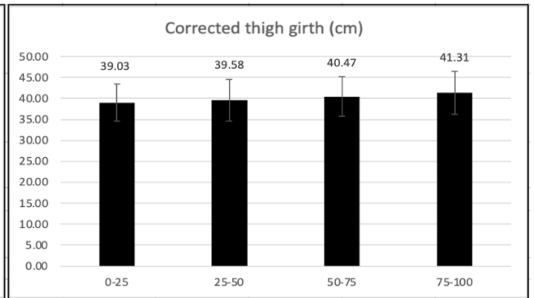
0-25 vs 25-50: Mean Diff: -0.527; p=1.000; 95% CI: -3.05; 1.99
0-25 vs 50-75: Mean Diff: -2.705; p=0.050; 95% CI: -5.41; -0.01
0-25 vs 75-100: Mean Diff: -2.974; p=0.010; 95% CI: -5.46; -0.49
25-50 vs 50-75: Mean Diff: -2.178; p=0.122; 95% CI: -4.65; 0.30
25-50 vs 75-100: Mean Diff: -2.447; p=0.023; 95% CI: -4.68; -0.21
50-75 vs 75-100: Mean Diff: -0.269; p=1.000; 95% CI: -2.71; 2.17



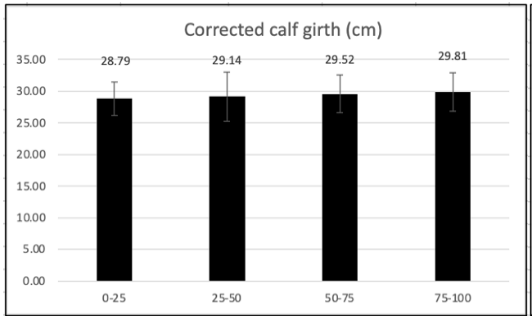
0-25 vs 25-50: Mean Diff: -0.056; p=1.000; 95% CI: -1.39; 1.50
0-25 vs 50-75: Mean Diff: -1.359; p=0.122; 95% CI: -2.91; -0.19
0-25 vs 75-100: Mean Diff: -1.257; p=0.117; 95% CI: -2.68; 0.16
25-50 vs 50-75: Mean Diff: -1.415; p=0.051; 95% CI: -2.83; 0.01
25-50 vs 75-100: Mean Diff: -1.313; p=0.040; 95% CI: -2.59; -0.03
50-75 vs 75-100: Mean Diff: 0.102; p=1.000; 95% CI: -1.29; 1.50



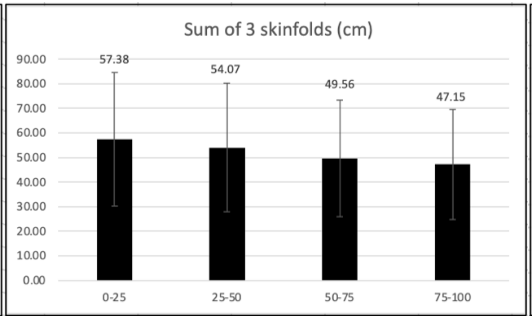
0-25 vs 25-50: Mean Diff: -0.254; p=1.000; 95% CI: -1.10; 0.59
0-25 vs 50-75: Mean Diff: -0.809; p=0.111; 95% CI: -1.72; 0.10
0-25 vs 75-100: Mean Diff: -1.045; p=0.006; 95% CI: -1.88; -0.21
25-50 vs 50-75: Mean Diff: -0.555; p=0.464; 95% CI: -1.39; 0.28
25-50 vs 75-100: Mean Diff: -0.791; p=0.032; 95% CI: -1.54; -0.04
50-75 vs 75-100: Mean Diff: -0.236; p=1.000; 95% CI: -1.05; 0.58



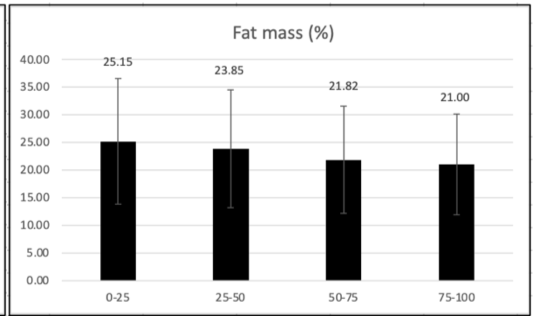
0-25 vs 25-50: Mean Diff: -0.555; p=1.000; 95% CI: -1.93; 0.82
0-25 vs 50-75: Mean Diff: -1.439; p=0.062; 95% CI: -2.92; 0.04
0-25 vs 75-100: Mean Diff: -2.281; p<0.001; 95% CI: -3.64; -0.92
25-50 vs 50-75: Mean Diff: -0.884; p=0.510; 95% CI: -2.24; 0.47
25-50 vs 75-100: Mean Diff: -1.726; p=0.001; 95% CI: -2.95; -0.50
50-75 vs 75-100: Mean Diff: -0.843; p=0.573; 95% CI: -2.18; 0.49



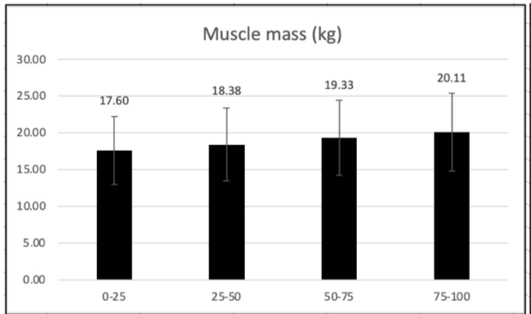
0-25 vs 25-50: Mean Diff: -0.354; p=1.000; 95% CI: -1.27; 0.56
0-25 vs 50-75: Mean Diff: -0.733; p=0.291; 95% CI: -1.72; 0.25
0-25 vs 75-100: Mean Diff: -1.024; p=0.017; 95% CI: -1.93; -0.12
25-50 vs 50-75: Mean Diff: -0.379; p=1.000; 95% CI: -1.28; 0.52
25-50 vs 75-100: Mean Diff: -0.670; p=0.175; 95% CI: -1.48; 0.14
50-75 vs 75-100: Mean Diff: -0.291; p=1.000; 95% CI: -1.18; 0.59



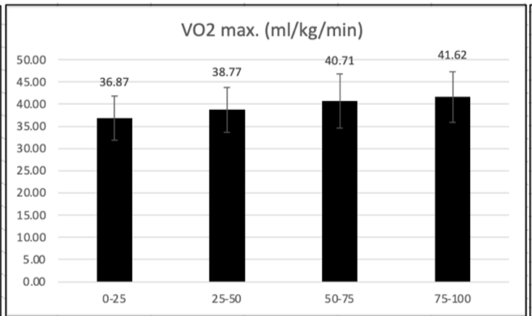
0-25 vs 25-50: Mean Diff: 3.317; p=1.000; 95% CI: -3.72; 10.35
0-25 vs 50-75: Mean Diff: 7.822; p=0.038; 95% CI: 0.27; 15.37
0-25 vs 75-100: Mean Diff: 10.234; p=0.001; 95% CI: 3.30; 17.17
25-50 vs 50-75: Mean Diff: 4.505; p=0.512; 95% CI: -2.41; 11.42
25-50 vs 75-100: Mean Diff: 6.917; p=0.021; 95% CI: 0.68; 13.16
50-75 vs 75-100: Mean Diff: 2.412; p=1.000; 95% CI: -4.40; 9.23



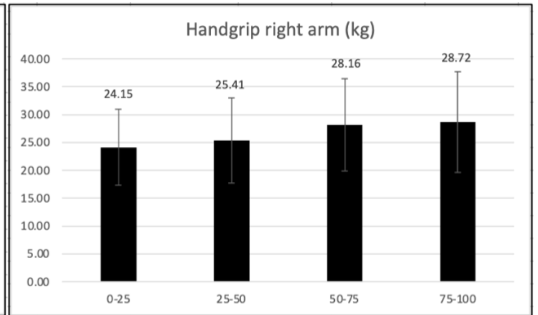
0-25 vs 25-50: Mean Diff: 1.303; p=1.000; 95% CI: -1.58; 4.19
0-25 vs 50-75: Mean Diff: 3.334; p=0.027; 95% CI: 0.24; 6.43
0-25 vs 75-100: Mean Diff: 4.157; p=0.001; 95% CI: 1.32; 7.00
25-50 vs 50-75: Mean Diff: 2.030; p=0.350; 95% CI: -0.80; 4.86
25-50 vs 75-100: Mean Diff: 2.854; p=0.019; 95% CI: 0.30; 5.41
50-75 vs 75-100: Mean Diff: 0.824; p=1.000; 95% CI: -1.97; 3.61



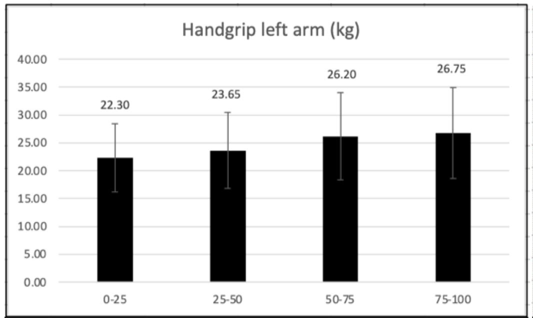
0-25 vs 25-50: Mean Diff: -0.785; p=0.874; 95% CI: -2.21; 0.64
0-25 vs 50-75: Mean Diff: -1.735; p=0.017; 95% CI: -3.27; -0.20
0-25 vs 75-100: Mean Diff: -2.507; p<0.001; 95% CI: -3.91; -1.10
25-50 vs 50-75: Mean Diff: -0.949; p=0.442; 95% CI: -2.35; 0.45
25-50 vs 75-100: Mean Diff: -1.721; p=0.002; 95% CI: -2.99; -0.46
50-75 vs 75-100: Mean Diff: -0.772; p=0.838; 95% CI: -2.15; 0.61



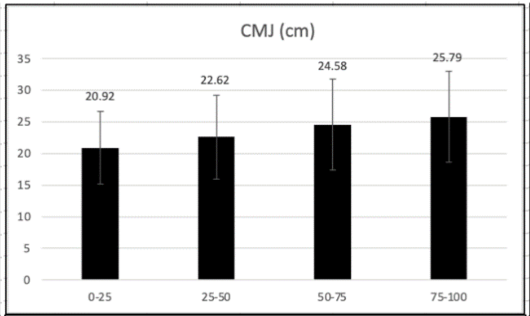
0-25 vs 25-50: Mean Diff: -1.906; p=0.007; 95% CI: -3.45; -0.36
0-25 vs 50-75: Mean Diff: -3.837; p<0.001; 95% CI: -5.49; -2.18
0-25 vs 75-100: Mean Diff: -4.753; p<0.001; 95% CI: -6.27; -3.23
25-50 vs 50-75: Mean Diff: -1.932; p=0.005; 95% CI: -3.45; -0.41
25-50 vs 75-100: Mean Diff: -2.847; p<0.001; 95% CI: -4.22; -1.48
50-75 vs 75-100: Mean Diff: -0.916; p=0.633; 95% CI: -2.41; 0.58



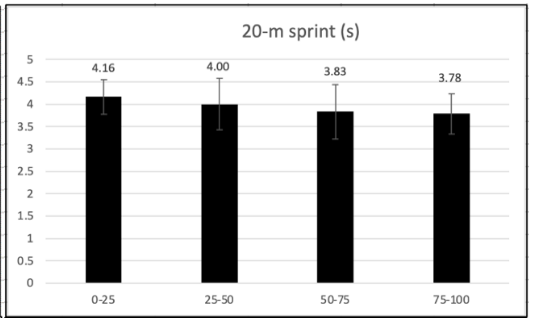
0-25 vs 25-50: Mean Diff: -1.262; p=0.878; 95% CI: -3.56; 1.03
0-25 vs 50-75: Mean Diff: -4.014; p<0.001; 95% CI: -6.48; -1.55
0-25 vs 75-100: Mean Diff: -4.575; p<0.001; 95% CI: -6.84; -2.31
25-50 vs 50-75: Mean Diff: -2.752; p=0.008; 95% CI: -5.01; -0.50
25-50 vs 75-100: Mean Diff: -3.312; p<0.001; 95% CI: -5.35; -1.28
50-75 vs 75-100: Mean Diff: -0.560; p=1.000; 95% CI: -2.78; 1.66



0-25 vs 25-50: Mean Diff: -1.352; p=0.521; 95% CI: -3.44; 0.73
0-25 vs 50-75: Mean Diff: -3.902; p<0.001; 95% CI: -6.14; -1.66
0-25 vs 75-100: Mean Diff: -4.448; p<0.001; 95% CI: -6.50; -2.39
25-50 vs 50-75: Mean Diff: -2.550; p=0.006; 95% CI: -4.60; -0.50
25-50 vs 75-100: Mean Diff: -3.096; p<0.001; 95% CI: -4.95; -1.25
50-75 vs 75-100: Mean Diff: -0.546; p=1.000; 95% CI: -2.57; 1.47



0-25 vs 25-50: Mean Diff: -1.698; p=0.115; 95% CI: -3.61; 0.22
0-25 vs 50-75: Mean Diff: -3.662; p<0.001; 95% CI: -5.72; -1.61
0-25 vs 75-100: Mean Diff: -4.875; p<0.001; 95% CI: -6.76; -2.99
25-50 vs 50-75: Mean Diff: -1.964; p=0.035; 95% CI: -3.84; -0.08
25-50 vs 75-100: Mean Diff: -3.177; p<0.001; 95% CI: -4.87; -1.48
50-75 vs 75-100: Mean Diff: -1.214; p=0.502; 95% CI: -3.07; 0.64



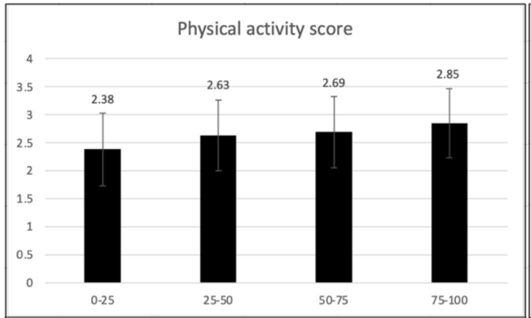
0-25 vs 25-50: Mean Diff: 0.158; p=0.026; 95% CI: 0.01; 0.30
0-25 vs 50-75: Mean Diff: 0.331; p<0.001; 95% CI: 0.17; 0.49
0-25 vs 75-100: Mean Diff: 0.378; p<0.001; 95% CI: 0.23; 0.52
25-50 vs 50-75: Mean Diff: 0.173; p=0.009; 95% CI: 0.03; 0.32
25-50 vs 75-100: Mean Diff: 0.220; p<0.001; 95% CI: 0.09; 0.35
50-75 vs 75-100: Mean Diff: 0.047; p=1.000; 95% CI: -0.09; 0.19

Table 2. Differences in the physical activity score, AMD, kinanthropometric and derived variables, and physical fitness variables according to the degree of satisfaction of the autonomy variable.

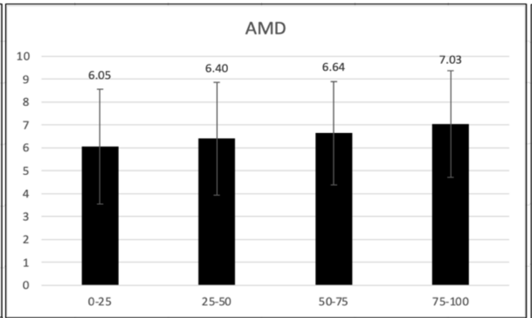
Variable	Descriptors (M ± SD)				F	*p*	Effect Size (η^2)
	Autonomy (0–25) (*n* = 189)	**Autonomy (25–50) (*n* = 167)**	**Autonomy (50–75) (*n* = 208)**	**Autonomy (75–100) (*n* = 227)**			
Physical activity score	2.38 ± 0.65	2.63 ± 0.63	2.69 ± 0.64	2.85 ± 0.62	18.200	<0.001	0.068
AMD	6.05 ± 2.51	6.40 ± 2.46	6.64 ± 2.25	7.03 ± 2.33	5.866	0.001	0.023
Body mass (kg)	55.21 ± 15.07	56.85 ± 11.11	58.60 ± 13.71	57.41 ± 12.19	2.140	0.094	0.009
Height (cm)	161.05 ± 9.06	163.70 ± 8.72	164.14 ± 9.12	164.48 ± 8.64	5.746	0.001	0.023
BMI (kg/m²)	21.17 ± 4.46	21.19 ± 3.58	21.63 ± 3.99	21.15 ± 3.54	0.689	0.559	0.003
Sitting height (cm)	84.23 ± 4.51	85.35 ± 4.85	85.46 ± 4.69	85.33 ± 6.03	2.312	0.075	0.009
Waist girth (cm)	68.58 ± 9.59	69.54 ± 7.90	70.78 ± 9.07	69.73 ± 8.36	1.993	0.114	0.008
Hip girth (cm)	89.76 ± 10.32	90.25 ± 7.88	91.74 ± 9.29	90.99 ± 8.76	1.667	0.173	0.007
Waist-to-hip ratio	0.76 ± 0.05	0.77 ± 0.05	0.77 ± 0.05	0.77 ± 0.06	0.651	0.582	0.003
Corrected arm girth (cm)	20.59 ± 2.91	21.45 ± 2.99	21.66 ± 2.98	21.51 ± 3.04	4.759	0.003	0.019
Corrected thigh girth (cm)	38.94 ± 4.86	40.39 ± 5.23	40.59 ± 4.88	40.71 ± 4.68	5.181	0.002	0.020
Corrected calf girth (cm)	28.63 ± 3.57	29.56 ± 3.51	29.67 ± 2.93	29.52 ± 2.96	4.084	0.007	0.016
Sum of 3 skinfolds (cm)	55.30 ± 27.51	49.80 ± 24.87	52.39 ± 25.98	49.30 ± 21.92	2.238	0.083	0.009
Fat mass (%)	24.19 ± 11.47	22.45 ± 10.55	22.93 ± 10.31	21.81 ± 8.86	1.822	0.142	0.007
Muscle mass (kg)	17.54 ± 4.92	19.22 ± 4.91	19.43 ± 5.22	19.51 ± 5.13	6.207	<0.001	0.024
VO2 max. (mL/kg/min)	38.30 ± 5.66	39.27 ± 5.21	40.02 ± 5.78	40.80 ± 5.85	6.812	<0.001	0.027
Handgrip right arm (kg)	24.40 ± 7.36	26.48 ± 7.60	27.63 ± 8.56	28.10 ± 8.88	7.634	<0.001	0.030
Handgrip left arm (kg)	22.55 ± 6.96	24.60 ± 6.99	25.88 ± 7.48	26.06 ± 8.09	8.886	<0.001	0.035
Sit-and-reach (cm)	15.38 ± 8.45	15.36 ± 9.26	16.14 ± 7.92	16.43 ± 9.35	0.719	0.541	0.003
CMJ (cm)	21.40 ± 6.59	23.91 ± 7.51	23.68 ± 6.63	25.36 ± 6.76	10.970	<0.001	0.042
20 m sprint (s)	4.12 ± 0.42	3.95 ± 0.44	3.86 ± 0.64	3.81 ± 0.53	12.995	<0.001	0.050

AMD: adherence to Mediterranean diet; BMI: body mass index; VO2 max: maximum oxygen consumption; CMJ: countermovement jump.

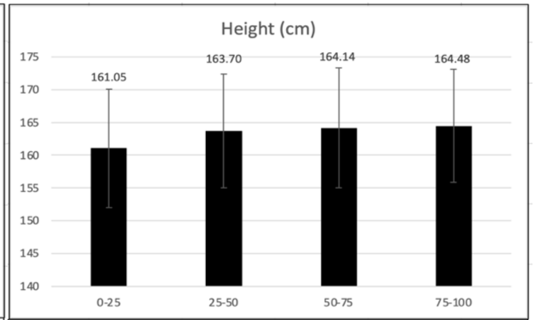
Supplementary Figure 2. Bonferroni post-hoc analysis of the variables that showed significant differences in autonomy.



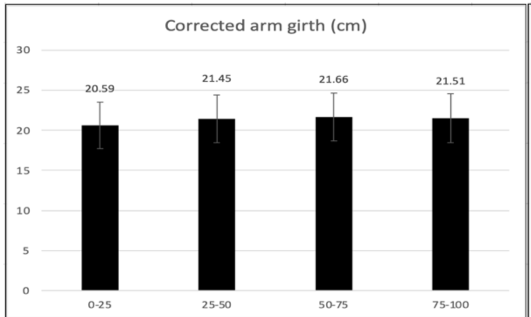
0-25 vs 25-50: Mean Diff: -0.251; p=0.002; 95% CI: -0.43; -0.07
0-25 vs 50-75: Mean Diff: -0.308; p<0.001; 95% CI: -0.48; -0.13
0-25 vs 75-100: Mean Diff: -0.469; p<0.001; 95% CI: -0.64; -0.30
25-50 vs 50-75: Mean Diff: -0.057; p=1.000; 95% CI: -0.24; 0.12
25-50 vs 75-100: Mean Diff: -0.218; p=0.006; 95% CI: -0.39; -0.04
50-75 vs 75-100: Mean Diff: -0.161; p=0.060; 95% CI: -0.33; 0.01



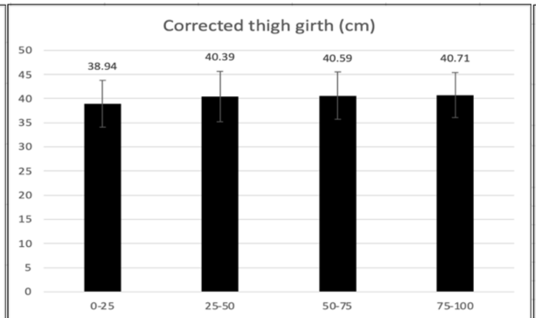
0-25 vs 25-50: Mean Diff: -0.35; p=1.000; 95% CI: -1.04; 0.34
0-25 vs 50-75: Mean Diff: -0.59; p=0.102; 95% CI: -1.24; 0.06
0-25 vs 75-100: Mean Diff: -0.98; p<0.001; 95% CI: -1.62; -0.34
25-50 vs 50-75: Mean Diff: -0.24; p=1.000; 95% CI: -0.92; 0.43
25-50 vs 75-100: Mean Diff: -0.63; p=0.068; 95% CI: -1.30; 0.03
50-75 vs 75-100: Mean Diff: -0.39; p=0.567; 95% CI: -1.01; 0.23



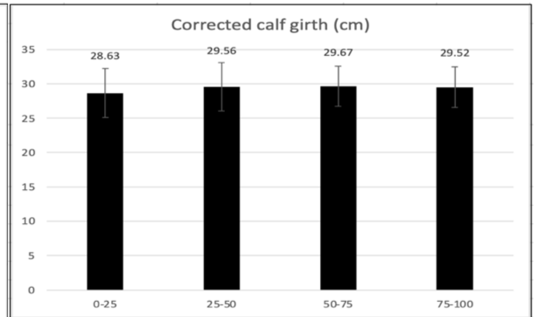
0-25 vs 25-50: Mean Diff: -2.654; p=0.040; 95% CI: -5.23; -0.08
0-25 vs 50-75: Mean Diff: -3.095; p=0.005; 95% CI: -5.53; -0.66
0-25 vs 75-100: Mean Diff: -3.435; p=0.001; 95% CI: -5.81; -1.06
25-50 vs 50-75: Mean Diff: -0.441; p=1.000; 95% CI: -2.96; 2.08
25-50 vs 75-100: Mean Diff: -0.782; p=1.000; 95% CI: -3.25; 1.69
50-75 vs 75-100: Mean Diff: -0.341; p=1.000; 95% CI: -2.66; 1.98



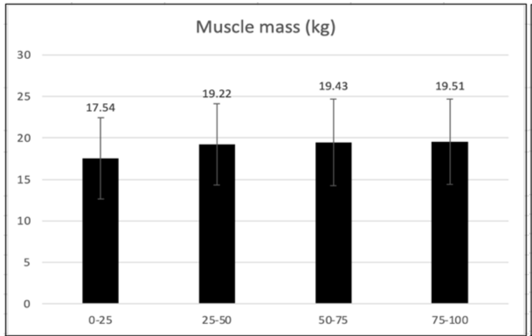
0-25 vs 25-50: Mean Diff: -0.858; p=0.053; 95% CI: -1.72; 0.01
0-25 vs 50-75: Mean Diff: -1.064; p=0.004; 95% CI: -1.88; -0.25
0-25 vs 75-100: Mean Diff: -0.919; p=0.015; 95% CI: -1.72; -0.12
25-50 vs 50-75: Mean Diff: -0.206; p=1.000; 95% CI: -1.05; 0.64
25-50 vs 75-100: Mean Diff: -0.061; p=1.000; 95% CI: -0.89; 0.77
50-75 vs 75-100: Mean Diff: 0.145; p=1.000; 95% CI: -0.63; 0.92



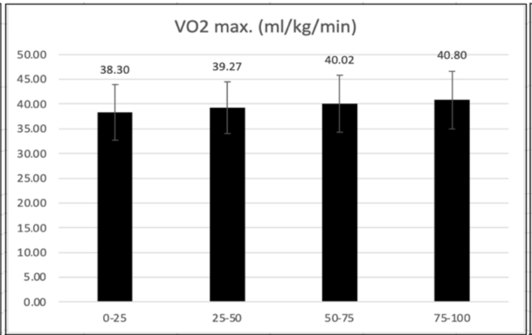
0-25 vs 25-50: Mean Diff: -1.450; p=0.042; 95% CI: -2.87; -0.03
0-25 vs 50-75: Mean Diff: -1.650; p=0.007; 95% CI: -2.99; -0.31
0-25 vs 75-100: Mean Diff: -1.762; p=0.002; 95% CI: -3.07; -0.45
25-50 vs 50-75: Mean Diff: -0.200; p=1.000; 95% CI: -1.59; 1.19
25-50 vs 75-100: Mean Diff: -0.312; p=1.000; 95% CI: -1.67; 1.05
50-75 vs 75-100: Mean Diff: -0.112; p=1.000; 95% CI: -1.39; 1.16



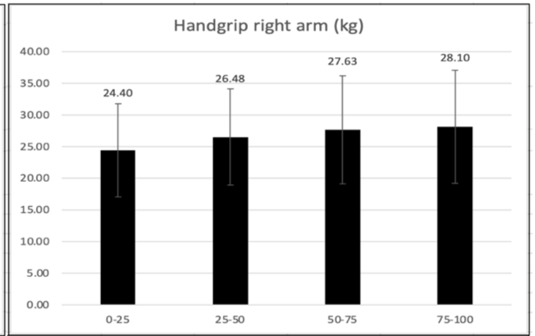
0-25 vs 25-50: Mean Diff: -0.936; p=0.050; 95% CI: -1.87; 0.01
0-25 vs 50-75: Mean Diff: -1.050; p=0.010; 95% CI: -1.93; -0.17
0-25 vs 75-100: Mean Diff: -0.894; p=0.038; 95% CI: -1.76; -0.03
25-50 vs 50-75: Mean Diff: -0.114; p=1.000; 95% CI: -1.03; 0.80
25-50 vs 75-100: Mean Diff: 0.041; p=1.000; 95% CI: -0.86; 0.94
50-75 vs 75-100: Mean Diff: 0.156; p=1.000; 95% CI: -0.68; 1.00



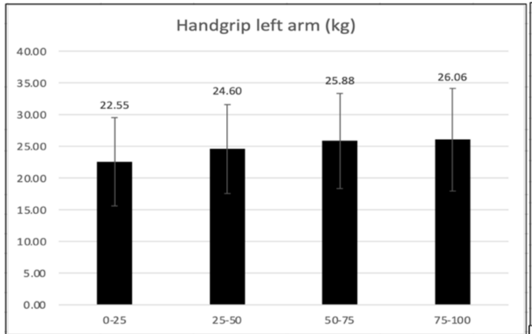
0-25 vs 25-50: Mean Diff: -1.682; p=0.015; 95% CI: -3.15; -0.21
0-25 vs 50-75: Mean Diff: -1.884; p=0.002; 95% CI: -3.27; -0.50
0-25 vs 75-100: Mean Diff: -1.967; p=0.001; 95% CI: -3.32; -0.61
25-50 vs 50-75: Mean Diff: -0.202; p=1.000; 95% CI: -1.64; 1.23
25-50 vs 75-100: Mean Diff: -0.285; p=1.000; 95% CI: -1.69; 1.12
50-75 vs 75-100: Mean Diff: -0.082; p=1.000; 95% CI: -1.40; 1.24



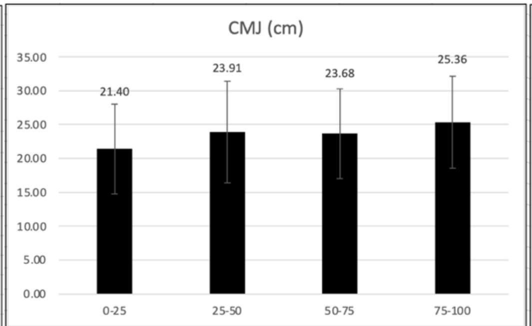
0-25 vs 25-50: Mean Diff: -0.970; p=0.711; 95% CI: -2.61; 0.67
0-25 vs 50-75: Mean Diff: -1.713; p=0.021; 95% CI: -3.26; -0.17
0-25 vs 75-100: Mean Diff: -2.492; p<0.001; 95% CI: -4.01; -0.98
25-50 vs 50-75: Mean Diff: -0.743; p=1.000; 95% CI: -2.35; 0.86
25-50 vs 75-100: Mean Diff: -1.522; p=0.064; 95% CI: -3.09; 0.05
50-75 vs 75-100: Mean Diff: -0.779; p=0.975; 95% CI: -2.25; 0.70



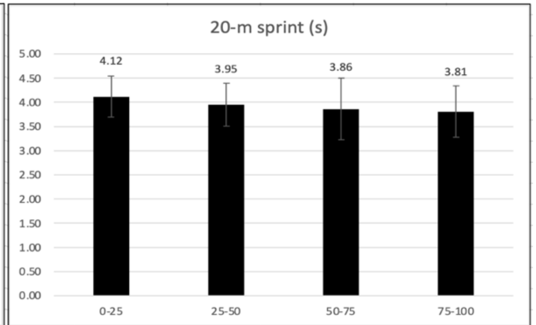
0-25 vs 25-50: Mean Diff: -2.076; p=0.127; 95% CI: -4.45; 0.30
0-25 vs 50-75: Mean Diff: -3.228; p=0.001; 95% CI: -5.47; -0.99
0-25 vs 75-100: Mean Diff: -3.693; p<0.001; 95% CI: -5.89; -1.50
25-50 vs 50-75: Mean Diff: -1.152; p=1.000; 95% CI: -3.47; 1.17
25-50 vs 75-100: Mean Diff: -1.617; p=0.364; 95% CI: -3.89; 0.66
50-75 vs 75-100: Mean Diff: -0.465; p=1.000; 95% CI: -2.60; 1.67



0-25 vs 25-50: Mean Diff: -2.052; p=0.073; 95% CI: -4.21; 0.11
0-25 vs 50-75: Mean Diff: -3.327; p<0.001; 95% CI: -5.36; -1.29
0-25 vs 75-100: Mean Diff: -3.515; p<0.001; 95% CI: -5.51; -1.52
25-50 vs 50-75: Mean Diff: -1.274; p=0.664; 95% CI: -3.38; 0.84
25-50 vs 75-100: Mean Diff: -1.462; p=0.372; 95% CI: -3.53; 0.61
50-75 vs 75-100: Mean Diff: -0.188; p=1.000; 95% CI: -2.13; 1.75



0-25 vs 25-50: Mean Diff: -2.513; p=0.005; 95% CI: -4.50; -0.53
0-25 vs 50-75: Mean Diff: -2.288; p=0.008; 95% CI: -4.16; -0.41
0-25 vs 75-100: Mean Diff: -3.961; p<0.001; 95% CI: -5.79; -2.13
25-50 vs 50-75: Mean Diff: 0.225; p=1.000; 95% CI: -1.72; 2.17
25-50 vs 75-100: Mean Diff: -1.448; p=0.268; 95% CI: -3.35; 0.46
50-75 vs 75-100: Mean Diff: -1.673; p=0.080; 95% CI: -3.46; 0.11



0-25 vs 25-50: Mean Diff: 0.175; p=0.014; 95% CI: 0.02; 0.33
0-25 vs 50-75: Mean Diff: 0.266; p<0.001; 95% CI: 0.12; 0.41
0-25 vs 75-100: Mean Diff: 0.309; p<0.001; 95% CI: 0.17; 0.45
25-50 vs 50-75: Mean Diff: 0.091; p=0.617; 95% CI: -0.06; 0.24
25-50 vs 75-100: Mean Diff: 0.134; p=0.089; 95% CI: -0.01; 0.28
50-75 vs 75-100: Mean Diff: 0.042; p=1.000; 95% CI: -0.09; 0.18

Table 3 shows the differences in the studied variables according to the percentile of satisfaction of the relatedness variable. The results showed significant differences in the level of physical activity practiced, AMD, height, muscle mass, VO2 max, handgrip, CMJ, and the 20-m sprint.

The subsequent post-hoc analysis (Supplementary Figure 3) showed that adolescents in the 75-100 percentile had a higher level of physical activity as compared to the rest of the percentiles, as well as adolescents in the 50-75 percentile as compared to the 0-25 percentile. In AMD, the score was significantly lower in the 0-25 percentile compared to the 50-75 and 75-100. Regarding the kinanthropometric and derived variables, the adolescents in the 0-25 percentile showed lower scores in height than the rest of the percentiles, as well as in muscle mass as compared to the 50-75 and 75-100 percentiles. According to the physical fitness variables, performance was significantly lower in adolescents in the 0-25 percentile as compared to those in the 50-75 and 75-100 percentiles for VO2 max, handgrip, CMJ and 20-m sprint. Furthermore, in VO2 max and CMJ the differences were also significant between the 25-50 and 75-100 percentiles, with the score of adolescents in the 75-100 percentile being higher in both tests.

The differences in the studied variables according to the BPNs satisfied in the adolescents are shown in Table 4. The results showed significant differences between the groups analyzed, in the level of physical activity practiced, AMD, height, corrected arm girth, corrected thigh girth, sum of 3 skinfolds, fat mass, muscle mass, VO2 max, handgrip strength, CMJ, and the 20-m sprint

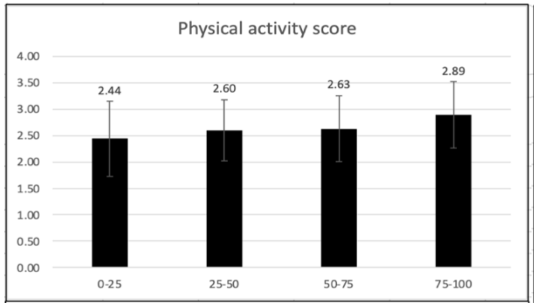
It is worth noting that the level of physical activity was significantly lower in adolescents with no basic psychological needs satisfied, as compared to those with satisfied competence, competence and autonomy, competence, and relatedness, or all BPNs. In addition, adolescents with a satisfied competence showed higher scores than those with satisfied relatedness, while those with satisfied competence and relatedness showed higher scores than those with satisfied autonomy and relatedness. On the other hand, adolescents who had all BPNs satisfied showed higher scores than those who only had autonomy, relatedness, or autonomy and relatedness satisfied. Regarding the AMD, adolescents with no BPNs satisfied showed lower scores than those with competence and relatedness satisfied, or those with all BPNs satisfied (Supplementary Figure 4).

Table 3. Differences in the physical activity score, AMD, kinanthropometric and derived variables, and physical fitness variables according to the degree of satisfaction of the relatedness variable.

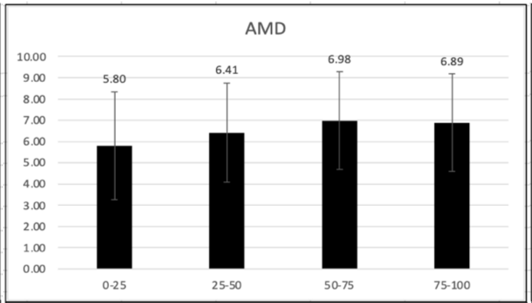
Variable	Descriptors (M ± SD)				F	p	Effect Size (η^2)
	Relatedness (0–25) (n = 178)	**Relatedness (25–50) (n = 178)**	**Relatedness (50–75) (n = 217)**	**Relatedness (75–100) (n = 218)**			
Physical activity score	2.44 ± 0.71	2.60 ± 0.58	2.63 ± 0.62	2.89 ± 0.63	15.993	<0.001	0.061
AMD	5.80 ± 2.54	6.41 ± 2.34	6.98 ± 2.30	6.89 ± 2.30	9.480	<0.001	0.037
Body mass (kg)	55.71 ± 12.64	58.03 ± 14.67	57.13 ± 12.57	57.38 ± 12.87	0.930	0.426	0.004
Height (cm)	161.22 ± 8.06	163.87 ± 9.68	164.18 ± 9.05	164.03 ± 8.77	4.373	0.005	0.017
BMI (kg/m^2)	21.44 ± 4.30	21.43 ± 4.04	21.08 ± 3.67	21.25 ± 3.69	0.362	0.780	0.001
Sitting height (cm)	84.32 ± 4.24	85.12 ± 6.74	85.57 ± 4.63	85.27 ± 4.67	1.965	0.118	0.008
Waist girth (cm)	69.26 ± 8.99	70.30 ± 9.50	69.53 ± 8.04	69.72 ± 8.76	0.424	0.736	0.002
Hip girth (cm)	90.61 ± 8.99	90.98 ± 9.72	90.50 ± 9.02	90.89 ± 8.95	0.113	0.952	0.001
Waist-to-hip ratio	0.76 ± 0.06	0.77 ± 0.05	0.77 ± 0.05	0.77 ± 0.06	0.573	0.633	0.002
Corrected arm girth (cm)	20.89 ± 2.84	21.49 ± 3.21	21.45 ± 2.99	21.40 ± 2.97	1.472	0.221	0.006
Corrected thigh girth (cm)	39.04 ± 4.39	40.15 ± 4.91	40.85 ± 5.41	40.49 ± 4.74	4.569	0.054	0.018
Corrected calf girth (cm)	28.99 ± 4.19	29.25 ± 2.94	29.57 ± 2.83	29.53 ± 2.97	1.259	0.287	0.005
Sum of 3 skinfolds (cm)	55.78 ± 27.33	52.62 ± 25.29	48.14 ± 23.74	51.03 ± 23.96	3.002	0.060	0.012
Fat mass (%)	24.35 ± 11.46	23.14 ± 10.50	21.54 ± 9.77	22.54 ± 9.45	2.421	0.065	0.010
Muscle mass (kg)	17.80 ± 4.50	19.14 ± 5.34	19.47 ± 5.22	19.23 ± 5.18	3.879	0.009	0.015
VO2 max. (mL/kg/min)	38.43 ± 6.09	39.01 ± 5.55	40.32 ± 5.74	40.58 ± 5.31	6.102	<0.001	0.024
Handgrip right arm (kg)	24.97 ± 7.46	26.78 ± 8.14	27.62 ± 8.78	27.32 ± 8.42	3.661	0.012	0.015
Handgrip left arm (kg)	23.18 ± 6.71	24.95 ± 7.63	25.72 ± 8.13	25.32 ± 7.40	3.957	0.008	0.016
Sit-and-reach (cm)	15.75 ± 8.56	15.70 ± 8.51	15.98 ± 8.98	16.02 ± 8.94	0.062	0.980	0.001
CMJ (cm)	22.08 ± 6.86	23.01 ± 6.74	24.12 ± 7.22	25.03 ± 6.77	6.418	<0.001	0.025
20 m sprint (s)	4.08 ± 0.55	3.96 ± 0.42	3.87 ± 0.65	3.83 ± 0.44	8.141	<0.001	0.032

AMD: adherence to Mediterranean diet; BMI: body mass index; VO2 max: maximum oxygen consumption; CMJ: countermovement jump.

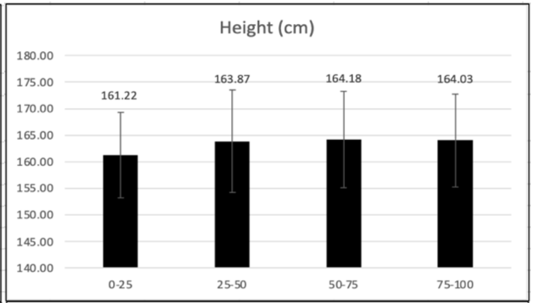
Supplementary Figure 3. Bonferroni post-hoc analysis of the variables that showed significant differences in relatedness.



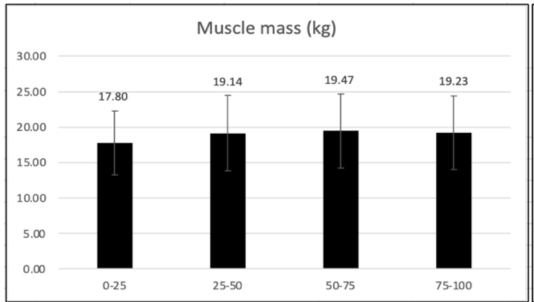
0-25 vs 25-50: Mean Diff: -0.155; p=0.154; 95% CI: -0.34; 0.03
0-25 vs 50-75: Mean Diff: -0.189; p=0.026; 95% CI: -0.36; -0.01
0-25 vs 75-100: Mean Diff: -0.445; p<0.001; 95% CI: -0.62; -0.27
25-50 vs 50-75: Mean Diff: -0.034; p=1.000; 95% CI: -0.21; 0.14
25-50 vs 75-100: Mean Diff: -0.289; p<0.001; 95% CI: -0.46; -0.11
50-75 vs 75-100: Mean Diff: -0.255; p<0.001; 95% CI: -0.42; -0.09



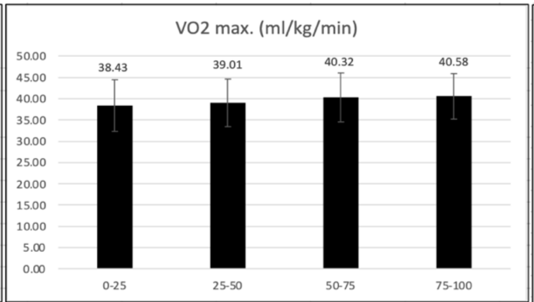
0-25 vs 25-50: Mean Diff: -0.62; p=0.104; 95% CI: -1.30; 0.07
0-25 vs 50-75: Mean Diff: -1.18; p<0.001; 95% CI: -1.83; -0.53
0-25 vs 75-100: Mean Diff: -1.09; p<0.001; 95% CI: -1.74; -0.44
25-50 vs 50-75: Mean Diff: -0.56; p=0.135; 95% CI: -1.21; 0.09
25-50 vs 75-100: Mean Diff: -0.48; p=0.321; 95% CI: -1.13; 0.17
50-75 vs 75-100: Mean Diff: 0.09; p=1.000; 95% CI: -0.53; 0.70



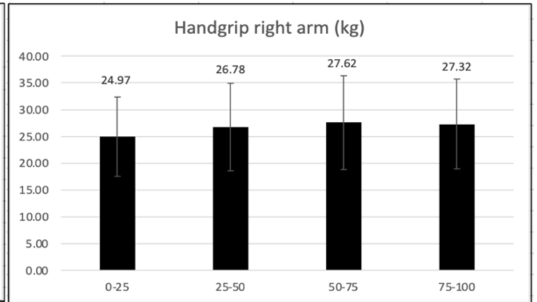
0-25 vs 25-50: Mean Diff: -2.651; p=0.040; 95% CI: -5.23; -0.07
0-25 vs 50-75: Mean Diff: -2.965; p=0.009; 95% CI: -5.42; -0.51
0-25 vs 75-100: Mean Diff: -2.816; p=0.015; 95% CI: -5.27; -0.36
25-50 vs 50-75: Mean Diff: -0.315; p=1.000; 95% CI: -2.77; 2.14
25-50 vs 75-100: Mean Diff: -0.166; p=1.000; 95% CI: -2.62; 2.29
50-75 vs 75-100: Mean Diff: 0.149; p=1.000; 95% CI: -2.17; 2.47



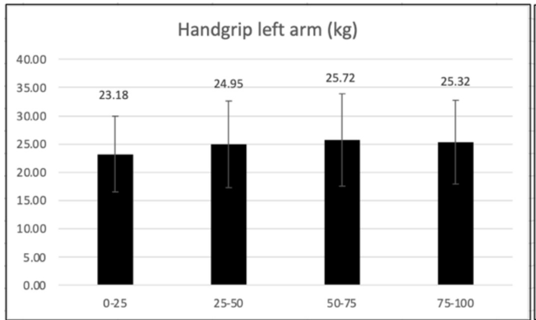
0-25 vs 25-50: Mean Diff: -1.345; p=0.095; 95% CI: -2.82; 0.13
0-25 vs 50-75: Mean Diff: -1.675; p=0.010; 95% CI: -3.08; -0.27
0-25 vs 75-100: Mean Diff: -1.434; p=0.041; 95% CI: -2.83; -0.04
25-50 vs 50-75: Mean Diff: -0.330; p=1.000; 95% CI: -1.73; 1.07
25-50 vs 75-100: Mean Diff: -0.088; p=1.000; 95% CI: -1.49; 1.31
50-75 vs 75-100: Mean Diff: 0.241; p=1.000; 95% CI: -1.08; 1.56



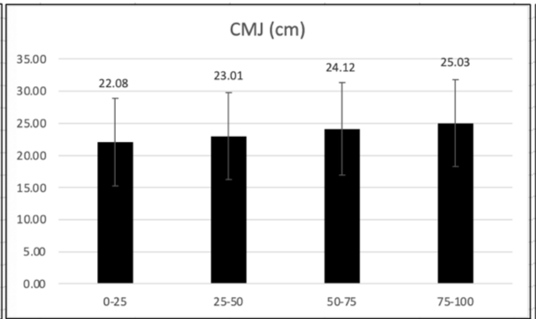
0-25 vs 25-50: Mean Diff: -0.578; p=1.000; 95% CI: -2.22; 1.06
0-25 vs 50-75: Mean Diff: -1.890; p=0.008; 95% CI: -3.45; -0.33
0-25 vs 75-100: Mean Diff: -2.148; p=0.002; 95% CI: -3.71; -0.59
25-50 vs 50-75: Mean Diff: -1.311; p=0.159; 95% CI: -2.87; 0.25
25-50 vs 75-100: Mean Diff: -1.569; p=0.047; 95% CI: -3.13; -0.01
50-75 vs 75-100: Mean Diff: -0.258; p=1.000; 95% CI: -1.73; 1.22



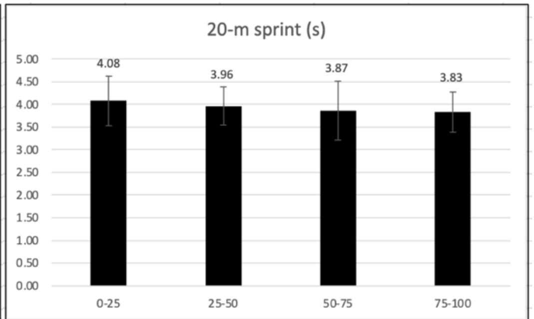
0-25 vs 25-50: Mean Diff: -1.803; p=0.278; 95% CI: -4.19; 0.59
0-25 vs 50-75: Mean Diff: -2.644; p=0.013; 95% CI: -4.92; -0.37
0-25 vs 75-100: Mean Diff: -2.342; p=0.039; 95% CI: -4.61; -0.07
25-50 vs 50-75: Mean Diff: -0.841; p=1.000; 95% CI: -3.11; 1.43
25-50 vs 75-100: Mean Diff: -0.538; p=1.000; 95% CI: -2.81; 1.73
50-75 vs 75-100: Mean Diff: 0.303; p=1.000; 95% CI: -1.85; 2.45



0-25 vs 25-50: Mean Diff: -1.771; p=0.190; 95% CI: -3.95; 0.41
0-25 vs 50-75: Mean Diff: -2.542; p=0.007; 95% CI: -4.61; -0.47
0-25 vs 75-100: Mean Diff: -2.146; p=0.037; 95% CI: -4.21; -0.07
25-50 vs 50-75: Mean Diff: -0.772; p=1.000; 95% CI: -2.84; 1.30
25-50 vs 75-100: Mean Diff: -0.375; p=1.000; 95% CI: -2.44; 1.69
50-75 vs 75-100: Mean Diff: 0.397; p=1.000; 95% CI: -1.56; 2.35



0-25 vs 25-50: Mean Diff: -0.926; p=1.000; 95% CI: -2.93; 1.07
0-25 vs 50-75: Mean Diff: -2.037; p=0.029; 95% CI: -3.94; -0.13
0-25 vs 75-100: Mean Diff: -2.949; p<0.001; 95% CI: -4.85; -1.05
25-50 vs 50-75: Mean Diff: -1.111; p=0.739; 95% CI: -3.01; 0.79
25-50 vs 75-100: Mean Diff: -2.023; p=0.030; 95% CI: -3.92; -0.12
50-75 vs 75-100: Mean Diff: -0.912; p=1.000; 95% CI: -2.71; 0.89



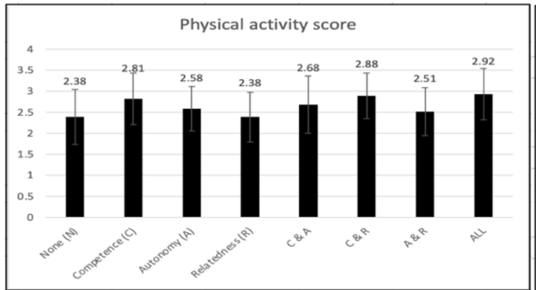
0-25 vs 25-50: Mean Diff: 0.117; p=0.258; 95% CI: -0.04; 0.27
0-25 vs 50-75: Mean Diff: 0.206; p=0.001; 95% CI: 0.06; 0.35
0-25 vs 75-100: Mean Diff: 0.253; p<0.001; 95% CI: 0.11; 0.40
25-50 vs 50-75: Mean Diff: 0.089; p=0.634; 95% CI: -0.06; 0.23
25-50 vs 75-100: Mean Diff: 0.136; p=0.078; 95% CI: -0.01; 0.28
50-75 vs 75-100: Mean Diff: 0.047; p=1.000; 95% CI: -0.09; 0.18

Table 4. Differences in the physical activity score, AMD, kinanthropometric and derived variables, and physical fitness variables according to the psychological needs satisfied by the adolescents.

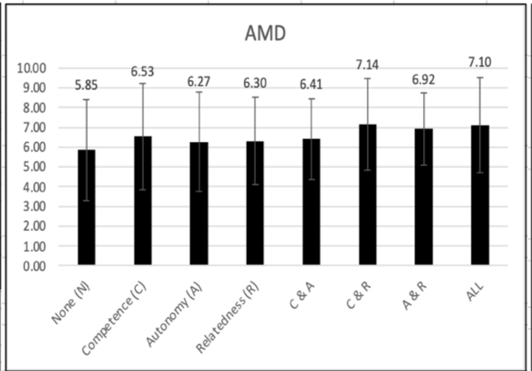
Variable	Descriptors (M ± SD)								p	Effect Size (η^2)
	Basic Psychological Needs Met									
	None	Competence	Autonomy	Relatedness	Competence and Autonomy	Competence and Relatedness	Autonomy and Relatedness	All of Them		
Physical activity score	2.38 ± 0.65	2.81 ± 0.61	2.58 ± 0.53	2.38 ± 0.59	2.68 ± 0.68	2.88 ± 0.54	2.51 ± 0.57	2.92 ± 0.61	<0.001	0.126
AMD	5.85 ± 2.55	6.53 ± 2.67	6.27 ± 2.52	6.30 ± 2.22	6.41 ± 2.03	7.14 ± 2.32	6.92 ± 1.82	7.10 ± 2.41	<0.001	0.044
Body mass (kg)	56.13 ± 14.22	55.69 ± 8.61	57.98 ± 14.44	55.00 ± 13.22	58.42 ± 13.95	57.09 ± 13.43	58.18 ± 12.76	57.78 ± 12.36	0.635	0.007
Height (cm)	161.46 ± 8.71	162.60 ± 8.60	162.14 ± 9.01	162.46 ± 9.42	165.41 ± 9.39	164.67 ± 9.33	163.44 ± 8.87	164.70 ± 8.62	0.006	0.027
BMI (kg/m²)	21.46 ± 4.50	21.11 ± 3.08	21.85 ± 4.13	20.79 ± 3.56	21.25 ± 3.83	20.82 ± 3.78	21.72 ± 4.06	21.22 ± 3.59	0.750	0.006
Sitting height (cm)	84.55 ± 4.57	84.78 ± 4.33	83.26 ± 9.38	84.64 ± 4.86	86.13 ± 4.67	85.59 ± 5.15	84.76 ± 4.73	85.81 ± 4.41	0.054	0.023
Waist girth (cm)	69.40 ± 9.66	69.44 ± 6.32	70.74 ± 9.82	68.11 ± 8.51	70.17 ± 9.08	68.79 ± 7.84	71.12 ± 8.04	69.91 ± 8.53	0.560	0.008
Hip girth (cm)	90.59 ± 9.81	89.54 ± 7.36	91.79 ± 9.32	89.58 ± 8.69	91.18 ± 9.16	88.84 ± 9.31	92.23 ± 9.70	91.07 ± 8.75	0.455	0.009
Waist-to-hip ratio	0.77 ± 0.05	0.78 ± 0.05	0.77 ± 0.06	0.76 ± 0.05	0.77 ± 0.05	0.76 ± 0.05	0.77 ± 0.06	0.77 ± 0.06	0.760	0.006
Corrected arm girth (cm)	20.76 ± 2.94	21.36 ± 2.33	21.23 ± 3.01	20.85 ± 2.92	22.11 ± 3.42	21.76 ± 3.45	21.12 ± 2.98	21.61 ± 2.87	0.020	0.022
Corrected thigh girth (cm)	38.84 ± 4.68	40.68 ± 3.60	39.93 ± 4.79	39.45 ± 4.76	40.68 ± 4.82	41.86 ± 6.81	40.27 ± 4.98	40.91 ± 4.70	<0.001	0.036
Corrected calf girth (cm)	28.87 ± 4.06	28.79 ± 3.04	29.13 ± 2.86	28.95 ± 2.80	29.87 ± 3.17	30.06 ± 2.94	29.30 ± 2.69	29.69 ± 2.95	0.072	0.017
Sum of 3 skinfolds (cm)	56.73 ± 27.40	51.11 ± 27.82	56.47 ± 27.24	51.10 ± 25.09	47.95 ± 21.23	42.45 ± 20.86	56.00 ± 26.14	49.01 ± 23.12	0.002	0.029
Fat mass (%)	24.86 ± 11.60	22.94 ± 11.98	24.74 ± 10.93	22.92 ± 10.21	20.74 ± 8.36	19.22 ± 8.68	24.47 ± 10.17	21.75 ± 9.33	0.002	0.030
Muscle mass (kg)	17.69 ± 4.69	19.01 ± 3.50	18.44 ± 5.10	18.02 ± 5.04	20.11 ± 5.74	20.50 ± 6.05	18.89 ± 4.76	19.65 ± 5.08	<0.001	0.035
VO2 max. (mL/kg/min)	37.44 ± 5.35	40.81 ± 5.87	38.79 ± 4.97	38.83 ± 4.75	40.78 ± 6.64	41.81 ± 5.00	37.92 ± 4.62	41.34 ± 5.77	<0.001	0.088
Handgrip right arm (kg)	24.30 ± 6.86	26.51 ± 8.09	26.02 ± 7.93	25.27 ± 6.99	29.26 ± 8.87	28.44 ± 9.23	25.20 ± 8.50	28.56 ± 8.74	<0.001	0.053
Handgrip left arm (kg)	22.56 ± 6.41	25.19 ± 8.12	24.14 ± 6.55	23.21 ± 6.91	27.10 ± 8.15	26.08 ± 7.86	23.65 ± 6.65	26.64 ± 8.06	<0.001	0.057
Sit-and-reach (cm)	15.67 ± 8.54	17.31 ± 8.59	16.45 ± 8.71	13.75 ± 9.06	14.60 ± 8.31	15.38 ± 9.45	16.40 ± 8.69	16.76 ± 8.80	0.196	0.013
CMJ (cm)	20.91 ± 6.22	24.32 ± 9.23	22.41 ± 6.06	23.27 ± 6.34	25.74 ± 6.10	26.08 ± 8.01	22.80 ± 6.38	25.13 ± 7.01	<0.001	0.071
20 m sprint (s)	4.14 ± 0.40	3.91 ± 0.55	3.98 ± 0.74	4.03 ± 0.39	3.82 ± 0.37	3.80 ± 0.46	3.95 ± 0.66	3.78 ± 0.57	<0.001	0.075

AMD: adherence to Mediterranean diet; BMI: body mass index; VO2 max: maximum oxygen consumption; CMJ: countermovement jump.

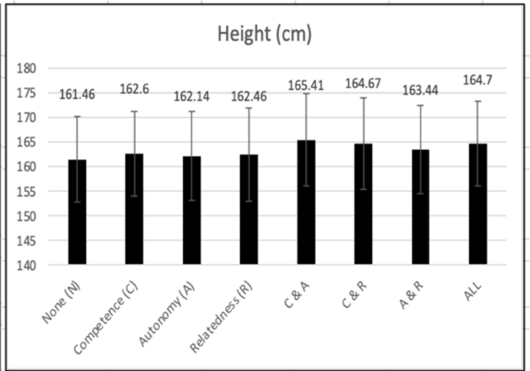
Supplementary Figure 4. Bonferroni post hoc of the variables that showed differences according to the psychological needs satisfied by the adolescents.



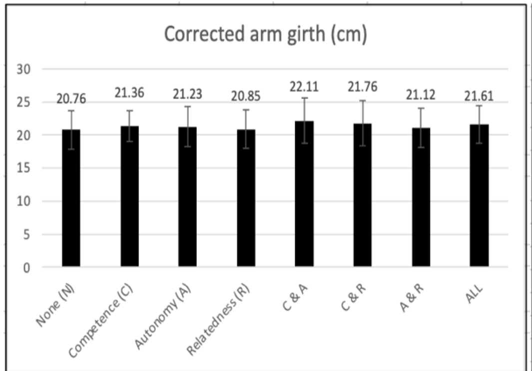
N vs C: Mean Diff: -0.433; p=0.005; 95% CI: -0.79; -0.07
N vs C & A: Mean Diff: -0.306; p=0.010; 95% CI: -0.57; -0.04
N vs C & R: Mean Diff: -0.505; p<0.001; 95% CI: -0.81; -0.20
N vs ALL: Mean Diff: -0.542; p<0.001; 95% CI: -0.74; -0.35
C vs R: Mean Diff: 0.427; p=0.023; 95% CI: 0.03; 0.83
C & R vs A & R: Mean Diff: 0.375; p=0.039; 95% CI: 0.01; 0.74
ALL vs A: Mean Diff: 0.342; p=0.009; 95% CI: 0.05; 0.64
ALL vs R: Mean Diff: 0.536; p<0.001; 95% CI: 0.28; 0.79
ALL vs A & R: Mean Diff: 0.413; p<0.001; 95% CI: 0.13; 0.69



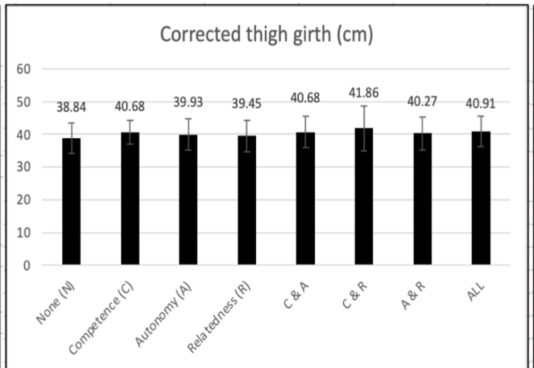
N vs C & R: Mean Diff: -1.29; p=0.017; 95% CI: -2.47; -0.11
N vs ALL: Mean Diff: -1.25; p<0.001; 95% CI: -1.99; -0.51



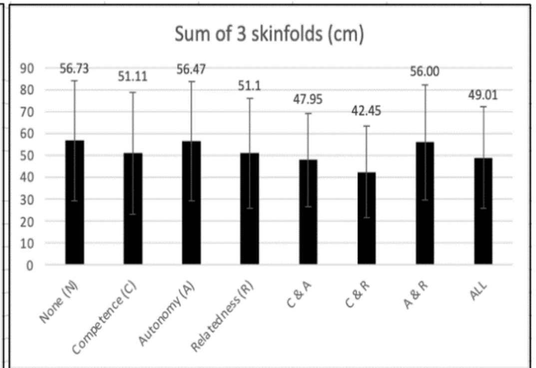
N vs C & A: Mean Diff: -3.954; p=0.041; 95% CI: -7.84; -0.07
N vs ALL: Mean Diff: -3.239; p=0.009; 95% CI: -6.04; -0.44



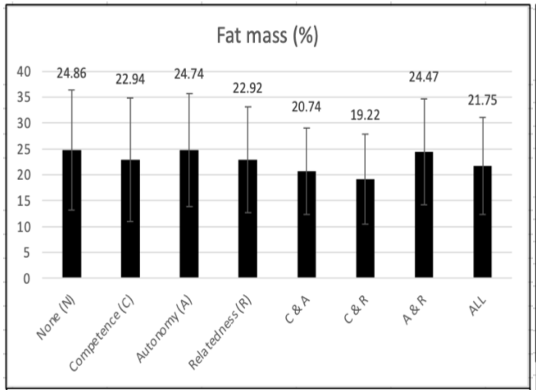
N vs C & A: Mean Diff: -1.350; p=0.034; 95% CI: -2.65; -0.05



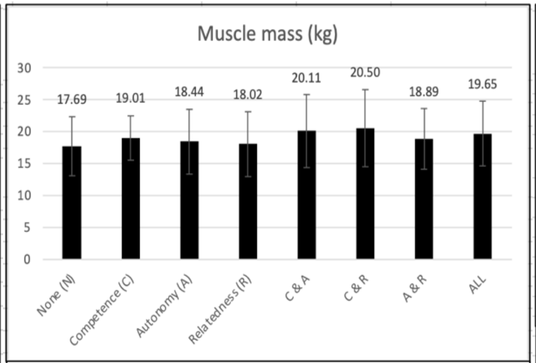
N vs C & R: Mean Diff: -3.02; p=0.003; 95% CI: -5.45; -0.59
N vs ALL: Mean Diff: -2.070; p=0.001; 95% CI: -3.60; -0.54



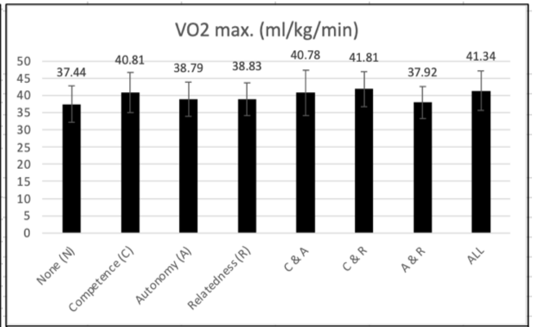
N vs C & R: Mean Diff: 14.284; p=0.009; 95% CI: 1.89; 26.67



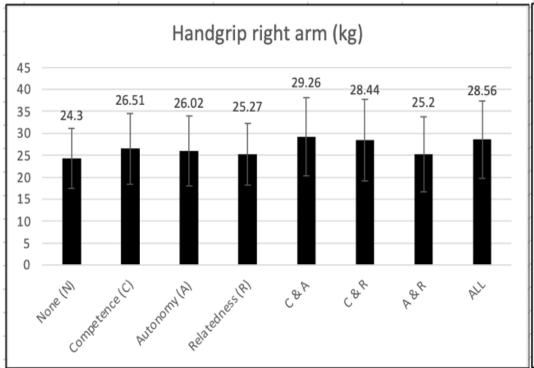
N vs C & R: Mean Diff: 5.646; p=0.014; 95% CI: 0.57; 10.72



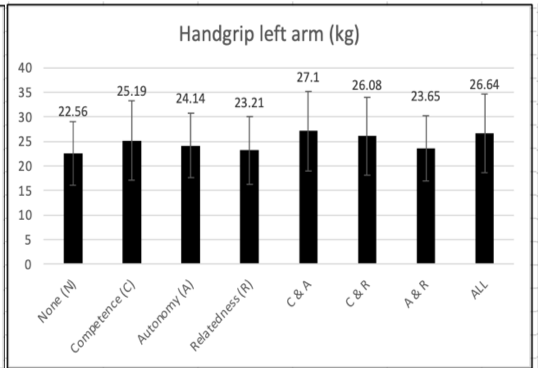
N vs C & A: Mean Diff: -2.418; p=0.017; 95% CI: -4.62; -0.21
N vs C & R: Mean Diff: -2.813; p=0.014; 95% CI: -5.33; -0.30
N vs ALL: Mean Diff: -1.960; p=0.003; 95% CI: -3.55; -0.37



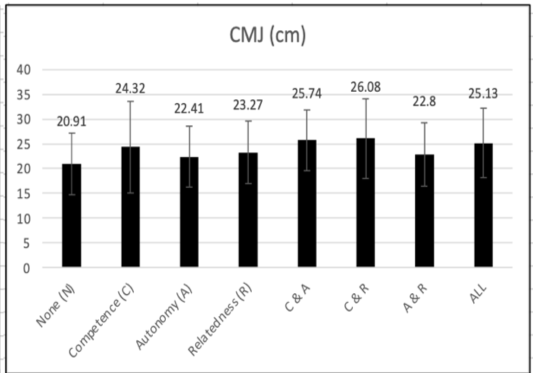
N vs C: Mean Diff: -3.372; p=0.031; 95% CI: -6.60; -0.15
N vs C & A: Mean Diff: -3.345; p<0.001; 95% CI: -5.74; -0.95
N vs C & R: Mean Diff: -4.371; p<0.001; 95% CI: -7.11; -1.63
N vs ALL: Mean Diff: -3.904; p<0.001; 95% CI: -5.63; -2.17
C & R vs A & R: Mean Diff: 3.890; p=0.006; 95% CI: 0.61; 7.17
A & R vs ALL: Mean Diff: -3.422; p=0.001; 95% CI: -5.92; -0.92



N vs C & A: Mean Diff: -4.956; p<0.001; 95% CI: -8.50; -1.41
N vs C & R: Mean Diff: -4.143; p=0.039; 95% CI: -8.19; -0.10
N vs ALL: Mean Diff: -4.259; p<0.001; 95% CI: -6.81; -1.70



N vs C & A: Mean Diff: -4.543; p<0.001; 95% CI: -7.77; -1.32
N vs ALL: Mean Diff: -4.085; p<0.001; 95% CI: -6.41; -1.76



N vs C & A: Mean Diff: -4.832; p<0.001; 95% CI: -7.79; -1.88
N vs C & R: Mean Diff: -5.167; p<0.001; 95% CI: -8.54; -1.79
N vs ALL: Mean Diff: -4.223; p<0.001; 95% CI: -6.35; -2.09

The results from the kinanthropometric and derived variables showed that adolescents who did not have any BPNs satisfied had lower scores than adolescents who had competence and autonomy satisfied, in height, corrected arm girth and muscle mass; lower scores than adolescents who had competence and relatedness satisfied, in corrected thigh girth and muscle mass, but higher scores in the sum of 3 skinfolds and fat mass; as well as lower scores than adolescents who had all BPNs satisfied, in height, corrected thigh girth, and muscle mass (Supplementary Figure 4).

As for the physical condition variables, performance was significantly lower in VO2 max, handgrip, CMJ, and 20-m sprint in adolescents who had no BPNs satisfied, as compared to those who had competence together with autonomy or relatedness, as well as compared to those who had all BPNs satisfied. In addition, it is worth noting that in VO2 max, adolescents who had a satisfied competence showed higher scores than those who did not have any BPNs satisfied; in addition adolescents who had satisfied autonomy and relatedness showed a lower performance than those who had competence and relatedness or all BPNs satisfied (Supplementary Figure 4).

5.5. Discussion

The objectives established for the present research were a) to determine the differences in the level of physical activity, AMD, kinanthropometric and derived variables, and fitness among adolescents with different degree levels of satisfaction of each of the BPNs, and b) to establish the differences in the level of physical activity, AMD, kinanthropometric and derived variables, and physical fitness of the adolescents according to whether the BPNs are satisfied individually or jointly. The results indicate that adolescents who practice more physical activity have a greater satisfaction of the BPNs, which is similar to the results of previous research (de Juan et al., 2021). However, what is particularly noteworthy is that significant differences in the level of physical activity were observed specifically between the highest percentiles of the relatedness variable (50-75 and 75-100). Thus, the group of adolescents in the 75-100 percentile showed the highest score. However, this did not occur in the competence and autonomy variables, as there were no significant differences between the 50-75 and 75-100 percentiles in the level of physical activity. A possible explanation for these results is that during adolescence, peers have a great influence on the behaviors and habits acquired (Madtha et al., 2022), with the presence of friends or parents who practice sports and with whom they can practice being one of the main factors that influence the sports practice of the adolescent population (Mateo-Orcajada et al., 2021). This is one of the main incentives for the practice and permanence of sports at this age and could also explain why adolescents with a higher satisfaction in the relatedness variable have a higher level of physical activity.

In addition, another novelty found in the present investigation is the determinant role played by the satisfaction of the need for competence in the practice of physical activity during adolescence. Thus, adolescents who had all the BPNs satisfied jointly, or those who had a satisfied competence individually, or together with autonomy or relatedness, practiced more physical activity as compared to those who did not have any satisfied BPNs or satisfied autonomy or relatedness individually. This could be due to the fact that a greater perception of competence would lead adolescents to seek optimal challenges to maintain or improve their skills (Guinoubi et al., 2022), with sports practice being an ideal setting in which, if the demands are adapted to the level of the participant, it would allow this need to be satisfied (Almagro et al., 2015). Another possible explanation would be that competence has been shown to be the most relevant BPN in dropping out of sports practice in the adolescent population, due to its influence on the sense of sport accomplishment (Morano et al., 2020). Therefore, it is logical to think that adolescents who drop out of sports practice have a lower satisfaction of this BPN. These results point to the importance of proposing challenging, stimulating, and individualized activities in the sports environment and in physical education classes, which are also very achievable by adolescents, to favor the satisfaction of the need for competence and, with it, the practice of physical activity.

Regarding AMD, the lowest percentile (0-25) of satisfaction of the competence, autonomy or relatedness variables showed a significantly lower adherence to this nutritional guidelines compared to the other percentiles. However, no significant differences were found in the level of AMD in any of the BPNS when comparing the other BPNS satisfaction percentiles (25-50 with 50-75; 50-75 with 75-100; nor 25-50 with 75-100). In previous research, the authors showed a significant and positive relationship between BPNs satisfaction and AMD (Lirola et al., 2021), as well as the importance of satisfying BPNs to facilitate the adoption of healthy lifestyle habits (Leyton et al., 2020). The present research goes further, and shows the differences in the level of AMD considering the degree of satisfaction of each of the BPNs, establishing that adolescents with a reduced level of satisfaction of competence, autonomy, or relatedness are at risk of having a low level of AMD, with the negative effects on physical and psychological health that this could entail (Romero-Robles et al., 2022). This information is crucial and highly relevant for the well-being of the adolescent population. It highlights that a minimum level of satisfaction with BPNs is necessary to promote the adoption of healthy lifestyle habits, including AMD.

Similar to the practice of physical activity, differences were also found in AMD according to individual or joint satisfaction of BPNs. Adolescents who did not have any satisfied BPNs scored lower in AMD as compared to adolescents who had satisfied all the BPNs, and those who had competence and relatedness jointly satisfied. A possible explanation for these results would be that the acquisition of a certain healthy lifestyle habit favors the acquisition of other healthy habits (García-Hermoso et al., 2020), with the BPNs being of great importance in the adoption of these habits (Leyton et al., 2020) so that adolescents with a satisfied competence and who had a high level of physical activity practice are also likely to have a high AMD. And, with respect to relatedness, the satisfaction of this BPN in adolescents who had a greater AMD could be due to the fact that healthy behaviors in adolescents are influenced by the social network to which they belong, with many of the changes in these behaviors being promoted by changes in social status or the popularity that they entail (Montgomery et al., 2020); or also by the fundamental role played by parents in the adoption of eating habits, with adolescents living at home with their parents having the highest AMD (Papadaki & Mavrikaki, 2015). Therefore, the results obtained show that competence and relatedness jointly satisfied seem to exert an important influence on AMD, but this will need to be corroborated in future studies.

According to the kinanthropometric and derived variables, adolescents in the lower percentiles of satisfaction (0-25) of the BPNs showed a lower height and sitting height, greater body fat accumulation, and less muscle development, than adolescents in the higher percentiles (50-75 and 75-100). Authors of previous research have shown that autonomy was related to body mass and body size discrepancies (Markland & Ingledew, 2007), but these same authors did not analyze differences in kinanthropometric and derived variables in terms of BPNs satisfaction. The results found could be explained by the fact that in the present society, body image is a determining factor in the psychological satisfaction of individuals (Vaquero-Cristóbal et al., 2013), and is especially relevant during adolescence, given the rise of insecurities related to the one's physique (Marques et al., 2014), as well as critical judgments by peers that are granted special importance (Pryor et al., 2016). Furthermore, it should be added that the maturation process is different in each adolescent, with those who mature earlier being taller, with greater muscle mass, and higher testosterone production (Albaladejo-Saura et al., 2021), which is especially relevant, as physical dimension is one of the most important in the configuration of the general self-concept (Fernández et al., 2010), and is strongly related to the satisfaction of BPNs (Valero-Valenzuela et al., 2021).

In fact, adolescents who had satisfied all the BPNs, or competence individually or together with autonomy or relatedness, were those who showed better kinanthropometric and derived variables, as compared to adolescents who did not have any satisfied BPNs. This could be due to the fact that a good physical self-concept improves the perception of competence, and is related to the measurement of subjective psychological well-being in the adolescent population (Fraguela-Vale et al., 2020). Another possible explanation could be that a higher self-concept is also related to increased physical activity in adolescents (Gasparotto et al., 2019), with less fat mass accumulation in adolescents who are more physically active (Mateo-Orcajada, González-Gálvez, et al., 2022). However, further research is warranted to elucidate the relationship between BPNs and kinanthropometric and derived variables, as self-concept is greatly modified during adolescence, especially in girls (Fernández Bustos et al., 2011).

Regarding physical fitness, adolescents in the lowest percentile (0-25) of BPNs satisfaction showed worse performances in VO2 max, handgrip strength, CMJ, and 20-m sprint tests, as compared to the highest satisfaction percentiles (50-75 and 75-100). In addition, competence seemed the most important BPN for physical fitness, as adolescents who had all BPNs satisfied, or those with satisfied competence independently, or together with autonomy or relatedness, showed better performances. Only one previous research study is known in which the authors analyzed the relationship between BPNs and the physical fitness of adolescents, and although it showed that environments that satisfied BPNs may favor increased fitness, it did not include differences in specific physical fitness tests, as it only calculated a total fitness score (Erturan-Ilker et al., 2018). The results of this study are groundbreaking as they reveal significant differences in physical tests such as 20-m shuttle run test, handgrip strength, CMJ, or 20-m sprint, there were differences according to the degree of satisfaction of BPNs, and that the satisfaction of competence seemed to be the most important for performance in the physical fitness test. A possible explanation for these results would be that a better performance in physical fitness tests is related to higher motor competence and performance in certain sports modalities (Utesch et al., 2019). In previous research the authors concluded that the athletes who performed better were those who scored higher on the BPNs (ranked in the highest percentiles of satisfaction for each BPN) (Lourenço et al., 2022), mainly those with the highest satisfaction of the need for competence, because they perceived that they could overcome their challenges to a greater extent (Mertens et al., 2018).

The findings from this investigation provide support for the first research hypothesis (H1), as they indicate that adolescents who experience higher levels of satisfaction with BPNs demonstrate a higher level of physical activity, greater AMD, better physical performance and better kinanthropometric and derived variables, and it was the adolescents in the highest percentiles of each of the BPNs who showed higher scores in each of the study variables. The results of this study confirm the acceptance of the second research hypothesis (H2). The findings demonstrate that adolescents who have all the BPNs collectively satisfied exhibit a higher level of physical activity, AMD, physical performance, and improved kinanthropometric and derived variables. In addition, the results obtained allow us to give greater relevance to the need for competence, since when not all the BPNs were satisfied, the satisfaction of competence alone or together with relatedness or autonomy showed significant differences.

This research is similar to those previously carried out in the adolescent population (Mateo-Orcajada, Abenza-Cano, et al., 2022; Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022, 2023) but has a particularly relevant novelty. Thus, the analysis of the satisfaction of BPNs individually or jointly is something that had not previously been done in adolescents. This finding holds significant relevance due to the demonstrated importance of BPNs in adolescent development. BPNs play a crucial role in acquiring healthy habits and enhancing body composition and physical fitness. However, prior to this study, it remained unclear whether individual satisfaction with a specific BPN was associated with these improvements or if the collective satisfaction of all BPNs was the key factor. The results highlight the importance of joint satisfaction with all BPNs for the observed enhancements, providing valuable insights into the interplay between BPN satisfaction and various aspects of adolescent well-being. This study provides evidence in this regard and adds to previous studies on the importance of physical activity and adherence to the Mediterranean diet for adolescent development, focusing especially on the psychological field and, more specifically, on the BPNs.

Regarding the limitations of the present study, it should be noted that, unlike other psychological scales, the BPNS (Basic Psychological Needs Scale) does not have a classification scale to determine the degree of satisfaction of each of the BPNs, so that percentiles had to be established according to the scores of the adolescents in the sample. The single use of questionnaires is an aspect to be considered in future research, since more information on the satisfaction of the BPNs would be obtained through the combined use of the questionnaire and interviews or focus groups on the adolescent population. Since this was a cross-sectional study, causality cannot be established in the results found, so longitudinal studies are required to establish the indicated relationships between the BPNs and other psychological variables, as well as between BPNs and changes in the level of physical activity, AMD, kinanthropometric and derived variables, and physical fitness.

5.6. Conclusions

To conclude, the present study shows that adolescents in the highest percentiles (50-75 and 75-100) of BPNs satisfaction had better levels of physical activity, AMD, kinanthropometric and derived variables, and physical fitness. Furthermore, it is noteworthy that adolescents who had all BPNs satisfied showed higher levels of physical activity, AMD, better kinanthropometric and derived variables, and better physical fitness, with competence being the most relevant; when not all BPNs were satisfied, satisfaction of competence alone or together with autonomy or relatedness reported the greatest benefits.

The relevance of the present research lies in the fact that it establishes the importance that BPNs can have in the healthy development of the adolescent population, beyond the sports field in which this relationship had been widely studied. Thus, the results show the relevance of the satisfaction of the BPNs in the adoption of healthy lifestyle habits, which is fundamental in a society in which the adolescent population has considerably reduced its practice of physical activity and its adherence to adequate nutritional patterns. Therefore, this research may be of relevance to all those professionals working with adolescents (coaches, teachers, medical staff, and even parents).

Vd – ESTUDIO 4: The degree of problematic technology use negatively affects physical activity level, adherence to Mediterranean diet and psychological state of adolescents

ESTUDIO 4 – THE DEGREE OF PROBLEMATIC TECHNOLOGY USE NEGATIVELY AFFECTS PHYSICAL ACTIVITY LEVEL, ADHERENCE TO MEDITERRANEAN DIET AND PSYCHOLOGICAL STATE OF ADOLESCENTS

5.1. Abstract

The previous scientific literature has shown how detrimental addictive internet and mobile phone use can be for the adolescent population. However, little is known about their influence on the physical activity, kinanthropometry and body composition, nutrition patterns, psychological state, and physical fitness of this population. For this reason, the objectives of this research were (a) to determine the differences in the physical activity level, kinanthropometric and body composition variables, adherence to Mediterranean diet (AMD), psychological state, and physical fitness according to gender and different levels of problematic use of the internet and mobile phones; and (b) to establish the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness among adolescents when considering problematic use of the internet and mobile phones in combination. The sample consisted of 791 adolescent males and females between 12 and 16 years of age (1st to 4th course) from four compulsory secondary schools (404 males and 387 females; mean age: 14.39 ± 1.26 years-old). The physical activity level (baseline score: 2.64 ± 0.67), kinanthropometric variables and body composition, AMD (baseline score: 6.48 ± 2.48), psychological state (baseline life satisfaction: 17.73 ± 4.83; competence: 26.48 ± 7.54; autonomy: 25.37 ± 6.73; relatedness: 24.45 ± 6.54), and physical condition variables were measured. The results showed that adolescent males and females with problematic internet and/or mobile phone use presented a worse psychological state, but it is especially relevant to highlight that females also had a lower level of physical activity and AMD, with problematic mobile phone use being especially relevant, mainly in the psychological state of adolescents. In conclusion, problematic use of the internet and mobile phones can have detrimental effects on the level of physical activity, AMD, and psychological state of adolescents, with the differences found in females being particularly relevant.

5.2. Introduction

The COVID-19 pandemic exacerbated the excessive use of mobile phones in the adolescent population (Humer et al., 2022). Scientific research conducted during and after the pandemic found that a percentage of nearly 90% of adolescents used mobile phones on a regular basis. Along with the increase in the use of these devices, problematic use of the internet and mobile phones also increased, understood as a pattern of interaction with the mobile phone and the internet that is characterized by repetitive use of the mobile phone and internet to engage in negative health behaviors (Bianchi & Phillips, 2005; Billieux, 2012). This includes the inability to regulate mobile phone and internet use, leading to associated negative consequences in daily life, including technological dependence, as well as social, behavioral, and affective problems (Bianchi & Phillips, 2005; Billieux, 2012). This problematic use reaches rates close to 35% of adolescents (Bhanderi et al., 2021). In addition, it should be noted that this problematic use of mobile phones and internet does not affect adolescent males and females equally, and significant differences have been found depending on gender (Jamir et al., 2019; Kamran et al., 2018; Nagata et al., 2022).

The problematic use of these technologies affects the possibilities of the healthy development of adolescents (Gómez-Baya et al., 2022), with the excessive use of the internet on weekdays, excessive time spent playing online games, and not being able to use social networks being factors that exert a negative impact on this population (Gómez-Baya et al., 2022). Thus, there are numerous adolescents who use the internet and mobile phones daily, and they do so in a problematic way, characterized by excessive or maladaptive use that disrupts the individual's social functions and involves withdrawal, compulsive behavior, and functional impairment (Panova & Carbonell, 2018), which could be affecting their health status (Solera-Gómez et al., 2022).

Numerous aspects of adolescent health are affected by problematic internet and mobile phone use, with a special emphasis on physical activity practice (Alaca, 2020; Kamran et al., 2018), body composition and kinanthropometric variables (Bilgrami et al., 2017; Shen et al., 2021), nutritional habits (Kamran et al., 2018; Ying et al., 2021), psychological state (Alaca, 2020; Columb et al., 2021), and physical fitness (Bravo-Sánchez et al., 2021; Wacks & Weinstein, 2021).

Regarding the practice of physical activity, previous results are contradictory, as some research showed that adolescents with problematic internet use performed a significantly lower level of sports practice (Alaca, 2020; Kamran et al., 2018), while other research found no significant differences between adolescents with and without problematic use (Dang et al., 2018). According to kinanthropometric and derived variables, a higher body mass index and a higher probability of being overweight were found in adolescents who used their mobile phones for more than three hours a day (Bilgrami et al., 2017; Shen et al., 2021). However, no study has attempted to investigate differences in variables related to adiposity, muscle mass development, or body composition in adolescents who present problematic internet and mobile use. In addition, no previous research has analyzed whether internet use, mobile use, or both in combination are equally detrimental to physical activity level and body composition in this population.

Similarly, young people with problematic internet use showed irregular dietary behaviors characterized by a reduced consumption of fruits and vegetables, skipping meals, snacking abuse, consumption of carbonated soft drinks, and consumption of fast food, resulting in a poor-quality diet (Kamran et al., 2018; Ying et al., 2021). However, no previous research has analyzed the differences in a nutritional dietary pattern, which is much more representative of the daily diet, such as adherence to the Mediterranean diet (AMD), according to the level of problematic use of the internet and mobile phones. This dietary pattern has been widely used in the adolescent population because it has been shown to be one of the best nutritional structured recommendations and includes numerous health-related nutritional lifestyle habits (Iaccarino Idelson et al., 2017; Serra-Majem et al., 2004). In addition, previous research has shown that this index is related to other healthy and fundamental variables for the development of the adolescent population, such as body composition (Mistretta et al., 2017), physical condition (Galan-Lopez et al., 2019), and level of physical activity (Jiménez Boraita et al., 2020). Therefore, it is necessary to analyze the differences in adherence to this nutritional pattern according to the level of problematic internet and mobile phone use, as it is unknown in the previous scientific literature and may be an aspect of great relevance for adolescent development.

Regarding psychological state, numerous previous studies have analyzed its relationship with the problematic use of technology, obtaining similar conclusions in which they highlighted that adolescents who showed problematic use of these technologies saw their psychological state negatively affected, increasing the likelihood of suffering depression and anxiety (Alaca, 2020; Columb et al., 2021). However, previous research has not analyzed existing differences in the satisfaction of basic psychological needs and life satisfaction of adolescents according to their level of problematic internet and mobile phone use. This is especially relevant given the relationship between these psychological variables and healthy behaviors such as nutrition or physical activity (López-Gil & García-Hermoso, 2022; Rubio et al., 2019). In addition, it is not known whether problematic use of the internet and mobile phones together is more detrimental to the psychological state of adolescents than problematic use of one of these technologies.

With respect to physical fitness, adolescents with problematic use of mobile phones showed reduced physical fitness, which considerably affected their health (Wacks & Weinstein, 2021). Little is known about the relationship between internet and mobile phone use and differences in the physical fitness of adolescents, as only one study, by Bravo-Sánchez et al. (2021), provided specific results on physical fitness tests (abdominal test, medicine ball throw, broad jump, 50 m sprint, deep trunk flexion, and agility test). However, this research only recorded the level of mobile phone use, so it is unknown whether internet use is also detrimental to adolescents' physical fitness, and whether the two combined (mobile and internet) may have even more detrimental effects.

Based on previous scientific research, there is a gap in the previous scientific literature in which it is unknown whether the degree of problematic internet or mobile phone use by adolescents is related to a worse level of physical activity, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness. Lastly, to all of the above, it should be added that these previous studies did not analyze the influence of gender in the relationship between the problematic use of technology and the variables mentioned above, and that no previous research has analyzed the combination of problematic internet and mobile phone use in the adolescent population; therefore, it is unknown whether one or the other is more relevant in the existence of differences in the level of physical activity, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness.

For this reason, the aims of the present investigation were (a) to determine the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness according to gender and different levels of problematic use of the internet and mobile phones; and (b) to establish the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness among adolescents when considering problematic use of the internet and mobile phone in combination.

5.3. Materials and Methods

5.3.1. Design

A cross-sectional design was followed, in accordance with the STROBE guidelines (Vandenbroucke et al., 2014). A non-probabilistic convenience sampling was used, selecting those adolescents to whom access was available from the educational centers contacted. The Institutional Ethics Committee of the Catholic University of Murcia reviewed and authorized the protocol designed for data collection in accordance with the World Medical Association (code: CE022102). The Declaration of Helsinki statements were followed throughout the entire process.

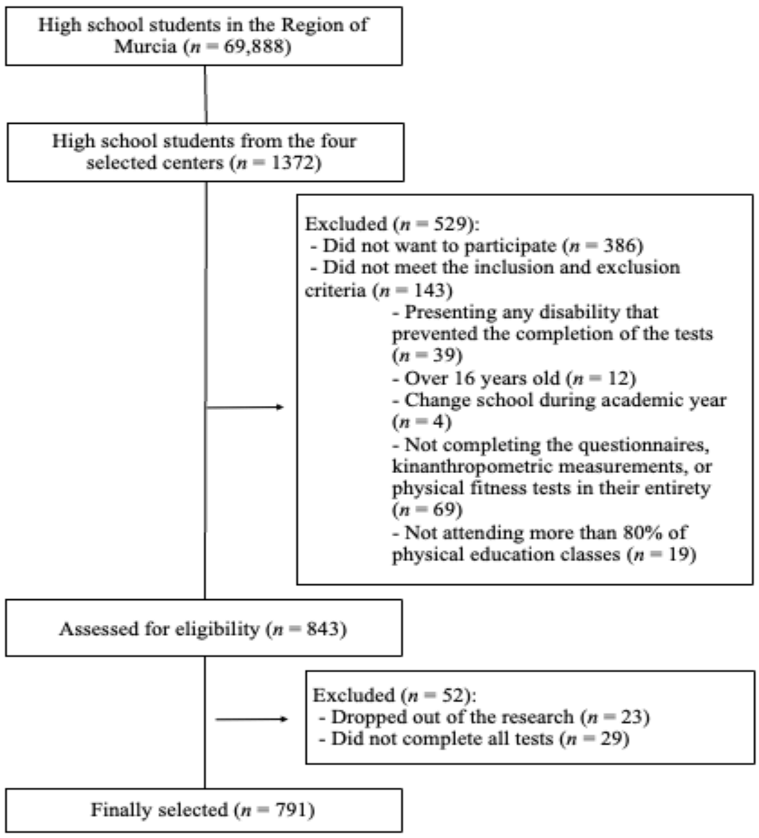
All measurements took place on the same day, utilizing the dedicated time slot of the physical education class and the enclosed sports pavilion at the education centers as the designated location. This approach aimed to minimize the presence of confounding variables that could potentially affect the results.

5.3.2. Participants

A total of 791 adolescents aged 12 to 16 years old participated in the study (404 males; 387 females; mean age: 14.39 ± 1.26 years-old). The adolescents belonged to four compulsory secondary schools in different areas of the Region of Murcia, all of them public schools located in developed areas. The level of sports practice was low (mean physical activity level: 2.64 ± 0.67). The students belonged to the four academic years of compulsory secondary education (1st to 4th course), distributed as follows: 1st (n = 206), 2nd (n = 133), 3rd (n = 238), and 4th (n = 214). The inclusion criteria were a) attending compulsory secondary education; b) not presenting any disability that prevented the completion of the tests; and c) age between 12 and 16 years old; participants were excluded in case of a) a change of school during the academic year; and b) not completing the questionnaires, kinanthropometric measurements, or physical fitness tests in their entirety.

The sample selection flowchart is shown in Figure 1. The sample size was calculated using the Rstudio statistical software (v. 3.15.0; Rstudio Inc., Boston, MA, USA) and setting the statistical significance at α = 0.05. Standard deviations (SD) from previous research that had analyzed problematic internet (SD = 4.50) and mobile phone use in young people (SD = 3.50) (Carbonell et al., 2018) were used. This technique for sample size calculation is based on the use of the SD, a constant, and the estimated effect size, and has been used in previous research (Bhalerao & Kadam, 2010). With an estimated error (d) of 0.32 for the internet score and 0.25 for the mobile phone score, for a 95% confidence interval (CI), the minimum sample needed was 756 adolescents.

Figure 1. Sample selection flowchart.



A non-probabilistic convenience sampling was carried out by contacting the schools in the different areas of the Region of Murcia (north, west, east, and south) that had the largest number of students in compulsory secondary education. The four high schools contacted decided to participate voluntarily in the study. The adolescents who were willing to participate voluntarily completed the informed consent form, after which it was signed by them and their parents.

5.3.3. Instruments

5.3.3.1. ***Questionnaires***

The Questionnaire of Experiences Related to Internet use (CERI) and the Questionnaire of Experiences Related to Mobile phones (CERM) were used to analyze the adolescents' problematic use of the internet and mobile phones (Beranuy et al., 2009). Both questionnaires had been previously validated, and had a Cronbach's alpha of 0.77 for the CERI and 0.80 for the CERM (Beranuy et al., 2009). Both instruments are composed of 10 items that are completed with a Likert scale of 1 to 4 points (1: never; 4: almost always), with the sum of the 10 items being the final score of the questionnaire. Both questionnaires measure problematic use (PU), when the score is higher than 26 in CERI and 24 in CERM; occasional problems (OP), when the score is between 18 and 25 in CERI and 16 and 23 in CERM; and the absence of problems (NP), when the score is lower than 18 in CERI and 16 in CERM (Beranuy et al., 2009).

The level of physical activity performed was measured using the Physical Activity Questionnaire for Adolescents (PAQ-A), an instrument that was previously validated, and which obtained an intraclass correlation coefficient of 0.71 (Martínez-Gómez et al., 2009). This questionnaire is composed of nine items that measure physical activity in the previous week using a Likert scale of 1 to 5 points (1: no physical activity; 5: a lot of physical activity). The final score is obtained from the arithmetic mean of the scores from the first eight items, with 1 being the minimum score and 5 the maximum.

The "Mediterranean Diet Quality Index for Children and Adolescents" (KIDMED) was used to assess the adherence of adolescents to the Mediterranean nutritional pattern, providing the final AMD score (Serra-Majem et al., 2004). This questionnaire has a good agreement in its general score (kappa = 0.73) for use in the adolescent population (Atencio-Osorio et al., 2020). To complete the 16 items that shaped the questionnaire, adolescents had to indicate whether they complied with the statement indicated. The score of the responses varied between +1 (positive connotation, 12 items) and −1 (negative connotation, 4 items), resulting in a final score between 0 and 12 points (Serra-Majem et al., 2004).

The psychological state of the adolescents was assessed by means of the Satisfaction with Life Scale (SWLS) (Diener et al., 1985) and the Basic Psychological Needs Scale (BPNS) (Wilson et al., 2006). The SWLS is composed of 5 items that are answered with a Likert scale from 1 to 5, where the final score is obtained by adding all the items, with a minimum score of 5 and a maximum of 25; the BPNS is composed of 18 items (6 per dimension: competence, autonomy, and relatedness) completed with a Likert scale from 1 to 6 points, where the final score is obtained by adding all the items, with a minimum score of 6 and a maximum of 36. Both scales have adequate external validity and internal consistency for use with adolescents (life satisfaction: $\alpha = 0.84$; competence: $\alpha = 0.80$; autonomy: $\alpha = 0.69$; and relatedness: $\alpha = 0.73$) (Atienza et al., 2000; Moreno-Murcia et al., 2011).

5.3.3.2. ***Kinanthropometric and body composition measurement***

The kinanthropometric measurements were carried out by three accredited anthropometrists from the International Society for the Advancement of Kinanthropometry (ISAK), ranging from levels 2 to 4. The measurements encompassed two fundamental variables: body mass and height. Body mass was determined using a TANITA BC-418-MA Segmental scale (TANITA, Tokyo, Japan) with a precision of 100 g, while height was measured using a SECA stadiometer 213 (SECA, Hamburg, Germany) with a precision of 0.1 cm. Additionally, three skinfold measurements were taken on the triceps, thigh, and calf using a skinfold caliper (Harpenden, Burgess Hill, UK) with an accuracy of 0.2 mm. Furthermore, five girth measurements were recorded, including relaxed arm, waist, hips, thigh, and calf, employing an inextensible Lufkin W606PM tape (Lufkin, Missouri City, TX, USA) with a precision of 0.1 cm. Before conducting the measurements, all instruments were properly calibrated, and the entire process adhered to the standardized protocol established by the ISAK (Esparza-Ros et al., 2019).

It is important to highlight that each subject's measurements were conducted consistently by the same anthropometrist. A minimum of two measurements were obtained for each variable, and a third measurement was taken if the difference between the initial two measurements exceeded 5% for the skinfolds or 1% for the remaining measurements. The final value utilized for the analysis was determined based on the mean of the measurements when two were taken, or the median when three measurements were recorded. This approach ensured reliable and accurate data for each variable (Esparza-Ros et al., 2019).

The intra- and inter-evaluator technical error of measurements (TEM) were calculated for a subsample. These were 0.02% and 0.03% for the basic measurements, 1.21% and 1.98% for the skinfolds, and 0.04% and 0.06% for the girths, respectively, and their correlation coefficients with an expert, level 4 anthropometrist were 0.96 for the basic measurements, 0.84 for the skinfolds, and 0.87 for the girths.

In addition, the following variables, derived from the kinanthropometric measurements, were calculated: BMI, fat mass (%) (Slaughter et al., 1988), muscle mass (Poortmans et al., 2005), Σ3 skinfolds (triceps, thigh, and calf), waist-to-hip ratio (waist girth/hip girth), and corrected girths (arm, thigh, and calf). Corrected girths were calculated using the following formulas: arm [arm relaxed girth-(π × triceps skinfold)], thigh [thigh girth-(π × thigh skinfold)], and calf [calf girth-(π × calf skinfold)].

5.3.3.3. ***Physical fitness measurement***

According to the methodology of previous research, the following physical fitness tests were carried out (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022).

The 20 m shuttle run test, an incremental test with high validity and reliability for use with adolescents, was used to assess the cardiorespiratory capacity of the adolescents (Léger et al., 1988). Using the formula by Léger et al. (1988) and the speed at which the subject left the test, the maximum oxygen consumption (VO2 max.) was predicted.

Upper and lower limb strength were assessed using the handgrip strength test (Matsudo et al., 2014) and the countermovement jump test (CMJ) (Barker et al., 2018), respectively. To assess upper limb strength, participants were instructed to utilize a Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo, Japan) and squeeze it with their elbow fully extended. This position was chosen, as it allows for maximum force production (España-Romero et al., 2010). For the CMJ, a force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) was employed. During the CMJ test, participants were directed to execute a maximal vertical jump while keeping their hands on their waists and ensuring full extension of the trunk throughout the flight phase (Barker et al., 2018).

To measure hamstring and lower back flexibility, the sit-and-reach test was used (Mayorga-Vega et al., 2014). Following the protocol from previous research (López-Miñarro et al., 2015), adolescents had to perform a maximum trunk flexion, keeping their hands and knees fully extended, to reach the maximum distance possible by sliding the palms of their hands, one on top of the other, across the box.

To measure speed, the 20 m sprint was used, in which the adolescents, starting from a standing position behind a line, and initiating the race at a time of their choice, had to cover 20 m in the shortest possible time (García-Manso et al., 1996). For the measurement, single-beamed photocells (Polifemo Light; Microgate, Italy) placed at hip height were used (Altmann et al., 2017; Cronin & Templeton, 2008).

For each of the physical tests, except for the sit-and-reach and the 20 m shuttle run test, two attempts were made, leaving two minutes of recovery time between each attempt, and five minutes between each physical condition test. The best value obtained in the two attempts was considered for analysis. The physical fitness tests were overseen by four researchers with experience in the field.

5.3.4. Procedure

First, the participants completed the CERI, CERM, PAQ-A, KIDMED, SWLS, and BPNS questionnaires. Second, the kinanthropometric measurements were taken. Third, the sit-and-reach test was performed, prior to the warm-up, because this could influence test performance (Díaz-Soler et al., 2015). Fourth, the handgrip strength, CMJ, and 20 m sprint tests were explained to the adolescents, and once they were familiar with the protocol, a general warm-up was performed that included 5 min of progressive running and 10 min of mobility of the main joints involved in the physical fitness tests. A researcher oversaw the warm-up and randomly indicated the physical test to be performed to each adolescent. Fifth, and once the handgrip strength, CMJ, and 20 m sprint tests had been completed, the 20 m shuttle run test was performed. The order of the physical fitness tests was chosen according to the recommendations of the fatigue generated and metabolic demand for each test established by the National Strength and Conditioning Association (NSCA) (Coburn & Malek, 2014).

5.3.5. Data analysis

The normality of the data was assessed using the Kolmogorov–Smirnov test, skewness, and kurtosis, and since all the variables had a normal distribution, parametric tests were used for their analysis. Descriptive statistics were used to determine the mean and standard deviation. Two one-factor ANOVAs were performed: the first to analyze the differences between males with different degrees of problematic use, and females with different problematic internet and mobile phone use in the study variables; and the second to establish the differences between adolescents when considering the combination of the different degrees of problematic internet and mobile phone use. To determine the significant differences between groups for each variable, Bonferroni's pairwise comparison was employed. The effect size (ES) was calculated using partial eta squared (η^2), where ES values were categorized as small (ES ≥ 0.10), moderate (ES ≥ 0.30), large (ES ≥ 1.2), or very large (ES ≥ 2.0), with the significance level set at $p < 0.05$ (Hopkins et al., 2009). Statistical significance for the conducted tests was defined as $p < 0.05$. The statistical analysis was carried out using the SPSS statistical package (v.25.0; SPSS Inc., Chicago, IL, USA).

5.4. Results

The differences between males with different levels of problematic internet and mobile phone use and females with different levels of problematic internet and mobile phone use are shown in Table 1. The results show significant differences with problematic internet use in the level of physical activity ($p = 0.013$), AMD ($p = 0.001$), life satisfaction ($p = 0.009$) and competence ($p = 0.009$) in females; meanwhile, in males, the differences were found in right arm handgrip ($p = 0.001$), left arm handgrip ($p = 0.019$), and CMJ ($p = 0.014$). Regarding problematic mobile phone use, differences were significant in AMD ($p < 0.001$-0.047) and life satisfaction ($p < 0.001$–0.001) in both males and females, as well as in relatedness ($p = 0.010$) and CMJ ($p = 0.003$) in males.

Table 1. Differences between males and females with different levels of problematic internet and mobile phone use in their physical activity level, kinanthropometric variables, AMD, psychological state, and physical condition.

		Internet Related Experiences (M ± SD)					Mobile Related Experiences (M ± SD)				
	Gender	NP (M:142) (F:150)	OP (M:181) (F:149)	PU (M:86) (F:83)	**F, *p***	η^2	NP (M:204) (F:164)	OP (M:144) (F:156)	PU (M:62) (F:61)	**F, *p***	η^2
Physical activity score	M	2.85 ± 0.64	2.78 ± 0.63	2.89 ± 0.73	1.000; *p* = 0.368	0.003	2.81 ± 0.65	2.84 ± 0.59	2.83 ± 0.84	0.122; *p* = 0.885	0.001
	F	2.53 ± 0.62	2.50 ± 0.55	2.25 ± 0.66	4.377; *p* = 0.013	0.012	2.54 ± 0.63	2.41 ± 0.57	2.42 ± 0.64	1.995; *p* = 0.137	0.005
Body mass (kg)	M	59.09 ± 15.52	60.54 ± 15.04	62.68 ± 12.19	1.744; *p* = 0.176	0.005	59.93 ± 14.77	60.85 ± 15.02	60.76 ± 14.62	0.243; *p* = 0.784	0.001
	F	53.56 ± 10.67	53.07 ± 9.81	55.43 ± 9.60	0.732; *p* = 0.481	0.002	52.70 ± 9.90	54.45 ± 10.36	54.53 ± 10.26	0.844; *p* = 0.430	0.002
Height (cm)	M	165.56 ± 9.99	166.96 ± 9.63	169.82 ± 8.39	5.884; *p* = 0.053	0.016	166.48 ± 9.91	167.16 ± 9.44	168.24 ± 9.23	0.851; *p* = 0.427	0.002
	F	159.33 ± 6.08	159.71 ± 6.48	160.34 ± 6.31	0.335; *p* = 0.716	0.001	158.98 ± 6.16	160.08 ± 6.34	160.76 ± 6.38	1.110; *p* = 0.330	0.003
BMI (kg/m2)	M	21.38 ± 4.78	21.60 ± 4.17	21.66 ± 3.26	0.167; *p* = 0.846	0.001	21.52 ± 4.19	21.62 ± 4.25	21.27 ± 3.59	0.120; *p* = 0.887	0.001
	F	21.13 ± 4.01	20.79 ± 3.14	21.58 ± 3.81	0.897; *p* = 0.408	0.002	20.85 ± 3.63	21.27 ± 3.66	21.09 ± 3.62	0.450; *p* = 0.638	0.001
Fat mass (%)	M	20.17 ± 11.46	20.27 ± 11.43	20.77 ± 10.68	0.083; *p* = 0.920	0.001	20.17 ± 10.78	20.74 ± 12.59	19.42 ± 8.71	0.306; *p* = 0.737	0.001
	F	25.81 ± 8.95	24.97 ± 7.47	26.25 ± 8.69	0.450; *p* = 0.638	0.001	25.22 ± 8.73	26.02 ± 7.79	24.83 ± 8.66	0.364; *p* = 0.695	0.001
Muscle mass (kg)	M	21.74 ± 5.08	22.08 ± 4.78	22.75 ± 4.14	1.407; *p* = 0.245	0.004	22.00 ± 5.06	22.13 ± 4.48	22.14 ± 4.60	0.056; *p* = 0.946	0.001
	F	15.54 ± 2.68	15.52 ± 2.98	16.12 ± 2.89	0.539; *p* = 0.583	0.001	15.33 ± 2.67	15.84 ± 2.96	16.03 ± 3.02	0.883; *p* = 0.414	0.002
Sum of three skinfolds (cm)	M	44.52 ± 25.98	44.63 ± 26.35	45.46 ± 23.49	0.035; *p* = 0.965	0.001	44.40 ± 24.25	45.64 ± 29.00	43.01 ± 19.94	0.219; *p* = 0.803	0.001
	F	60.00 ± 23.83	57.62 ± 20.56	61.21 ± 21.92	0.610; *p* = 0.544	0.002	58.64 ± 23.45	60.10 ± 20.77	57.93 ± 22.72	0.208; *p* = 0.812	0.001
Corrected arm girth (cm)	M	22.33 ± 3.13	22.60 ± 3.19	22.91 ± 2.58	1.044; *p* = 0.353	0.003	22.50 ± 3.24	22.63 ± 2.92	22.52 ± 2.83	0.109; *p* = 0.897	0.001
	F	19.99 ± 2.39	19.93 ± 2.18	20.25 ± 2.28	0.292; *p* = 0.747	0.001	19.85 ± 2.33	20.14 ± 2.22	20.15 ± 2.36	0.535; *p* = 0.586	0.001
Corrected thigh girth (cm)	M	41.82 ± 5.87	41.92 ± 4.79	42.39 ± 4.57	0.338; *p* = 0.713	0.001	41.94 ± 5.49	42.02 ± 4.84	41.86 ± 4.70	0.022; *p* = 0.979	0.001
	F	38.25 ± 3.96	38.11 ± 3.77	38.97 ± 3.91	0.769; *p* = 0.464	0.002	37.96 ± 3.95	38.55 ± 3.75	38.83 ± 4.03	0.917; *p* = 0.400	0.002
Corrected calf girth (cm)	M	30.13 ± 3.14	30.56 ± 2.91	30.58 ± 2.70	0.935; *p* = 0.393	0.003	30.45 ± 3.15	30.35 ± 2.77	30.36 ± 2.72	0.048; *p* = 0.953	0.001
	F	28.16 ± 3.09	28.17 ± 3.47	28.54 ± 2.41	0.371; *p* = 0.690	0.001	28.12 ± 3.11	28.28 ± 3.36	28.44 ± 2.46	0.211; *p* = 0.810	0.001
Waist girth (cm)	M	71.99 ± 9.80	72.67 ± 9.13	73.72 ± 7.75	0.945; *p* = 0.389	0.003	72.35 ± 9.47	73.08 ± 9.31	71.99 ± 6.91	0.434; *p* = 0.648	0.001
	F	66.39 ± 7.49	66.42 ± 6.68	67.89 ± 7.96	0.792; *p* = 0.453	0.002	65.91 ± 6.64	67.43 ± 7.79	66.58 ± 7.25	1.355; *p* = 0.259	0.004
Hip girth (cm)	M	89.58 ± 10.28	90.69 ± 10.38	92.72 ± 8.57	2.560; *p* = 0.078	0.007	90.07 ± 10.04	91.24 ± 10.42	91.09 ± 9.29	0.739; *p* = 0.478	0.002
	F	90.90 ± 8.60	90.47 ± 7.63	92.39 ± 7.71	0.941; *p* = 0.391	0.003	90.21 ± 7.94	91.58 ± 8.06	91.67 ± 8.56	1.023; *p* = 0.360	0.003

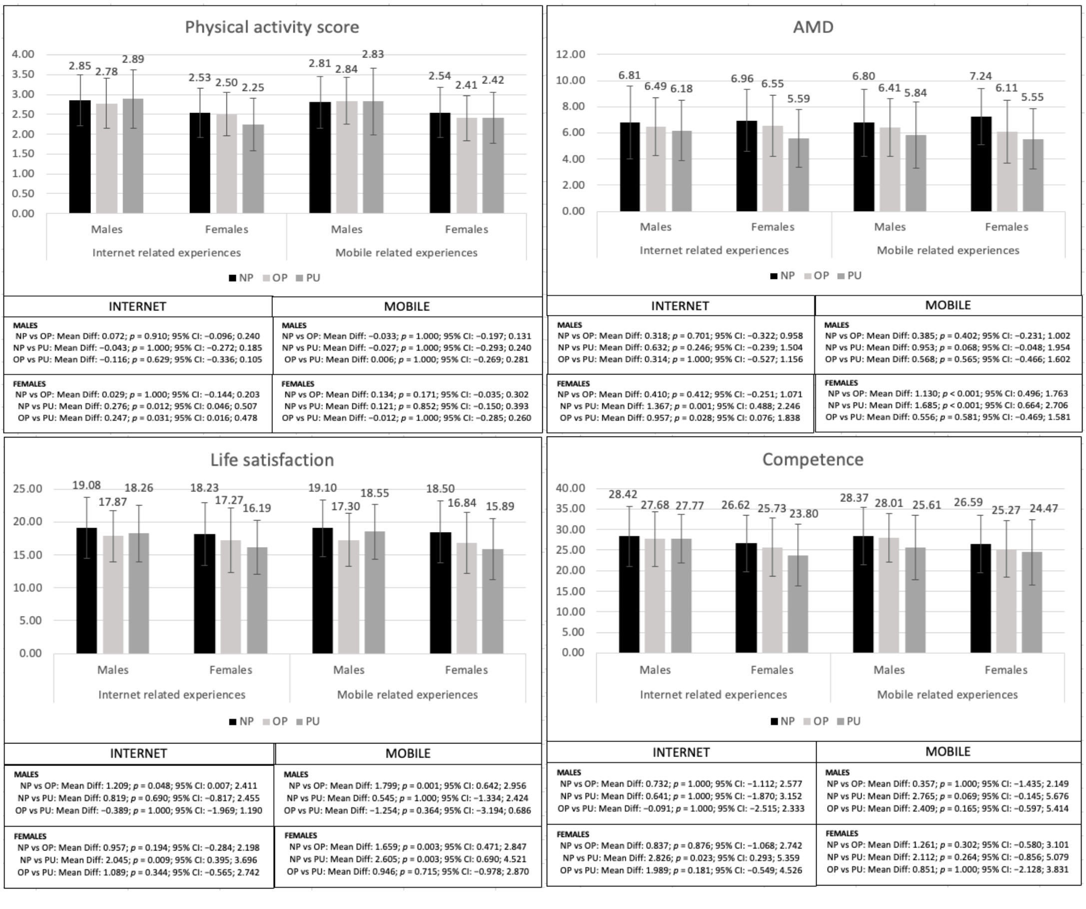
Waist-to-hip	M	0.80 ± 0.04	0.80 ± 0.06	0.80 ± 0.04	0.745; *p* = 0.475	0.002	0.80 ± 0.06	0.80 ± 0.04	0.79 ± 0.03	1.208; *p* = 0.300	0.003
ratio	F	0.73 ± 0.04	0.73 ± 0.04	0.73 ± 0.04	0.302; *p* = 0.739	0.001	0.74 ± 0.04	0.74 ± 0.04	0.73 ± 0.03	0.891; *p* = 0.411	0.002
AMD	M	6.81 ± 2.77	6.49 ± 2.19	6.18 ± 2.32	1.652; *p* = 0.192	0.004	6.80 ± 2.56	6.41 ± 2.19	5.84 ± 2.55	3.064; *p* = 0.047	0.008
	F	6.96 ± 2.35	6.55 ± 2.35	5.59 ± 2.21	6.978; *p* = 0.001	0.018	7.24 ± 2.16	6.11 ± 2.41	5.55 ± 2.29	13.114; *p* < 0.001	0.034
Life satisfaction	M	19.08 ± 4.63	17.87 ± 3.86	18.26 ± 4.32	2.939; *p* = 0.054	0.008	19.10 ± 4.30	17.30 ± 4.01	18.55 ± 4.20	7.004; *p* = 0.001	0.019
	F	18.23 ± 4.78	17.27 ± 4.89	16.19 ± 4.14	4.750; *p* = 0.009	0.013	18.50 ± 4.69	16.84 ± 4.68	15.89 ± 4.68	8.412; *p* < 0.001	0.022
Competence	M	28.42 ± 7.29	27.68 ± 6.55	27.77 ± 5.91	0.482; *p* = 0.618	0.001	28.37 ± 6.97	28.01 ± 5.96	25.61 ± 7.76	2.602; *p* = 0.075	0.007
	F	26.62 ± 6.85	25.73 ± 7.05	23.80 ± 7.42	3.590; *p* = 0.028	0.010	26.59 ± 6.98	25.27 ± 6.90	24.47 ± 7.97	2.245; *p* = 0.107	0.006
Autonomy	M	26.01 ± 7.44	26.18 ± 5.59	26.82 ± 4.99	0.368; *p* = 0.692	0.001	26.19 ± 6.37	26.68 ± 5.85	24.68 ± 6.84	1.537; *p* = 0.216	0.004
	F	25.28 ± 6.74	25.61 ± 6.02	23.61 ± 5.56	2.218; *p* = 0.110	0.006	25.53 ± 6.67	24.99 ± 5.87	24.11 ± 6.24	0.886; *p* = 0.413	0.002
Relatedness	M	24.93 ± 7.28	25.08 ± 5.13	25.21 ± 5.15	0.052; *p* = 0.950	0.001	24.82 ± 6.57	25.97 ± 4.86	22.76 ± 6.08	4.620; *p* = 0.010	0.012
	F	24.85 ± 5.91	24.36 ± 6.13	23.80 ± 6.11	0.691; *p* = 0.501	0.002	24.72 ± 5.88	24.59 ± 6.13	22.92 ± 6.14	1.449; *p* = 0.235	0.004
VO2 max.	M	42.37 ± 5.48	42.10 ± 5.86	42.52 ± 5.14	0.210; *p* = 0.811	0.001	42.14 ± 5.66	42.13 ± 5.42	43.50 ± 5.92	1.253; *p* = 0.286	0.003
(ml/kg/min)	F	36.96 ± 4.50	37.22 ± 4.06	35.78 ± 4.96	1.741; *p* = 0.176	0.005	37.25 ± 4.51	36.58 ± 4.18	36.50 ± 4.91	0.818; *p* = 0.442	0.002
Right arm	M	29.26 ± 9.13	30.51 ± 8.81	33.45 ± 8.86	7.193; *p* = 0.001	0.019	29.79 ± 8.87	31.03 ± 9.55	32.57 ± 7.39	2.871; *p* = 0.057	0.008
handgrip (kg)	F	22.22 ± 4.44	22.72 ± 5.32	24.07 ± 4.67	1.378; *p* = 0.253	0.004	22.26 ± 5.04	22.96 ± 4.74	23.82 ± 4.76	0.839; *p* = 0.433	0.002
Left arm	M	27.84 ± 8.58	28.27 ± 7.90	30.60 ± 7.79	4.004; *p* = 0.019	0.011	27.94 ± 8.24	28.80 ± 8.33	30.24 ± 6.99	2.250; *p* = 0.106	0.006
handgrip (kg)	F	20.79 ± 4.27	21.06 ± 4.31	21.48 ± 3.88	0.243; *p* = 0.785	0.001	20.65 ± 4.41	21.32 ± 3.97	21.30 ± 4.42	0.471; *p* = 0.625	0.001
Sit-and-reach	M	12.59 ± 6.34	12.51 ± 7.80	14.18 ± 8.44	1.043; *p* = 0.353	0.003	12.63 ± 6.94	12.70 ± 8.04	14.17 ± 8.39	0.596; *p* = 0.551	0.002
(cm)	F	18.90 ± 8.77	19.31 ± 8.84	19.70 ± 8.97	0.221; *p* = 0.802	0.001	19.16 ± 8.99	18.48 ± 8.69	22.38 ± 8.05	3.523; *p* = 0.055	0.009
CMJ (cm)	M	25.80 ± 7.38	26.09 ± 7.61	28.54 ± 6.93	4.310; *p* = 0.014	0.011	25.38 ± 8.02	27.28 ± 6.79	28.35 ± 5.96	5.795; *p* = 0.003	0.015
	F	20.16 ± 4.93	21.08 ± 5.11	21.35 ± 5.06	1.095; *p* = 0.335	0.003	20.23 ± 4.97	21.04 ± 5.04	21.66 ± 5.24	1.091; *p* = 0.336	0.003
20 m sprint (s)	M	3.70 ± 0.66	3.75 ± 0.49	3.67 ± 0.33	0.666; *p* = 0.514	0.002	3.71 ± 0.64	3.75 ± 0.41	3.67 ± 0.28	0.430; *p* = 0.651	0.001
	F	4.20 ± 0.40	4.12 ± 0.34	4.10 ± 0.65	1.293; *p* = 0.275	0.003	4.17 ± 0.40	4.17 ± 0.35	3.99 ± 0.75	2.350; *p* = 0.096	0.006

M: male; F: female; NP: no problems; OP: occasional problems; PU: problematic use; BMI: body mass index; AMD: adherence to Mediterranean diet; VO2 max: maximum oxygen consumption; CMJ: countermovement jump; η^2: effect size.

With respect to internet use, PU females showed a worse physical activity score ($p = 0.012$), AMD ($p = 0.001$), life satisfaction ($p = 0.009$), and competence ($p = 0.023$) than NPs, as well as a worse score than OPs in physical activity score ($p = 0.031$) and AMD ($p = 0.028$). Regarding males, NPs showed higher scores in life satisfaction ($p = 0.048$) than OPs, while PUs showed higher scores than OPs and NPs in right arm handgrip ($p < 0.001$–0.018), left arm handgrip ($p = 0.018$–0.048), and CMJ ($p = 0.015$–0.028) (Figure 2).

Regarding mobile phone use (Figure 2), NP females showed higher scores than OPs and PUs in AMD (<0.001) and life satisfaction ($p = 0.003$). For males, OPs showed a lower score than NPs in life satisfaction ($p = 0.001$), but a higher one than PUs in relatedness ($p = 0.010$); meanwhile, NPs showed a lower score than OPs ($p = 0.018$) and PUs ($p = 0.025$) in CMJ.

Figure 2. Bonferroni post-hoc analyses of the variables that showed significant differences between the different levels of problematic internet and mobile use in males and females.



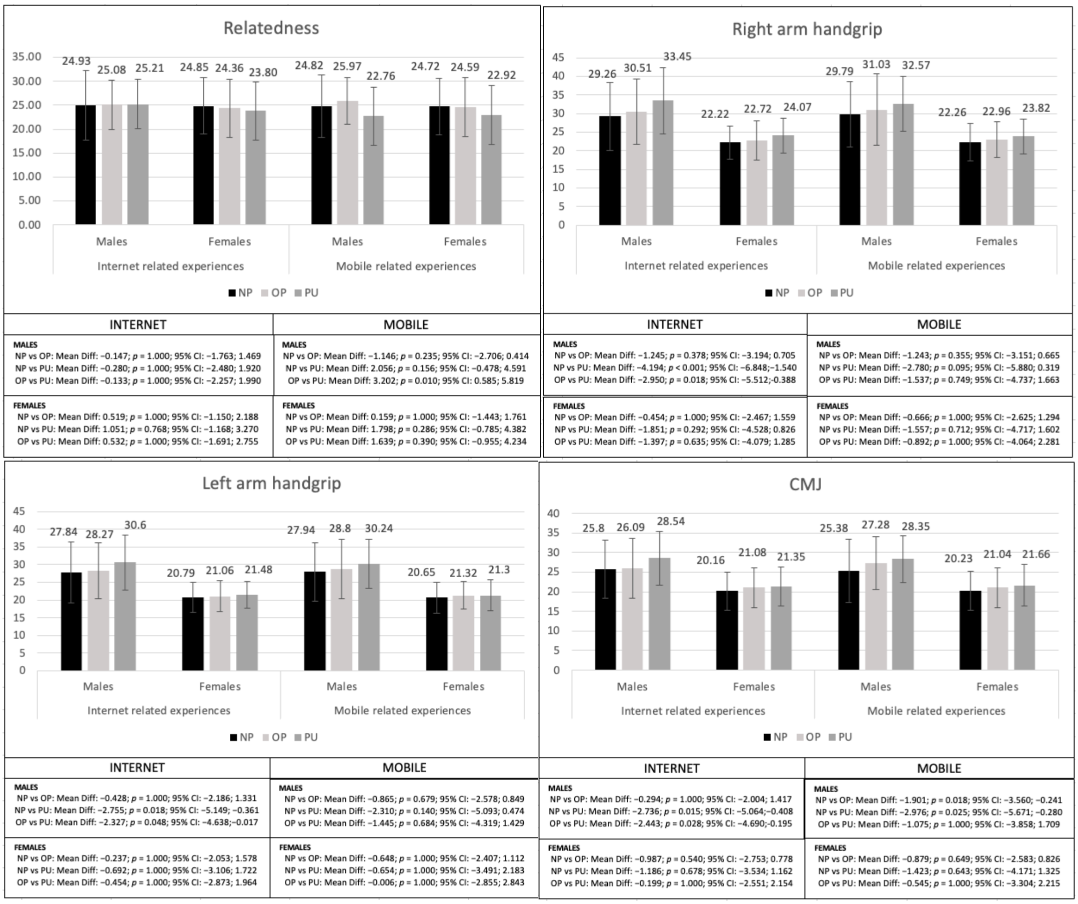


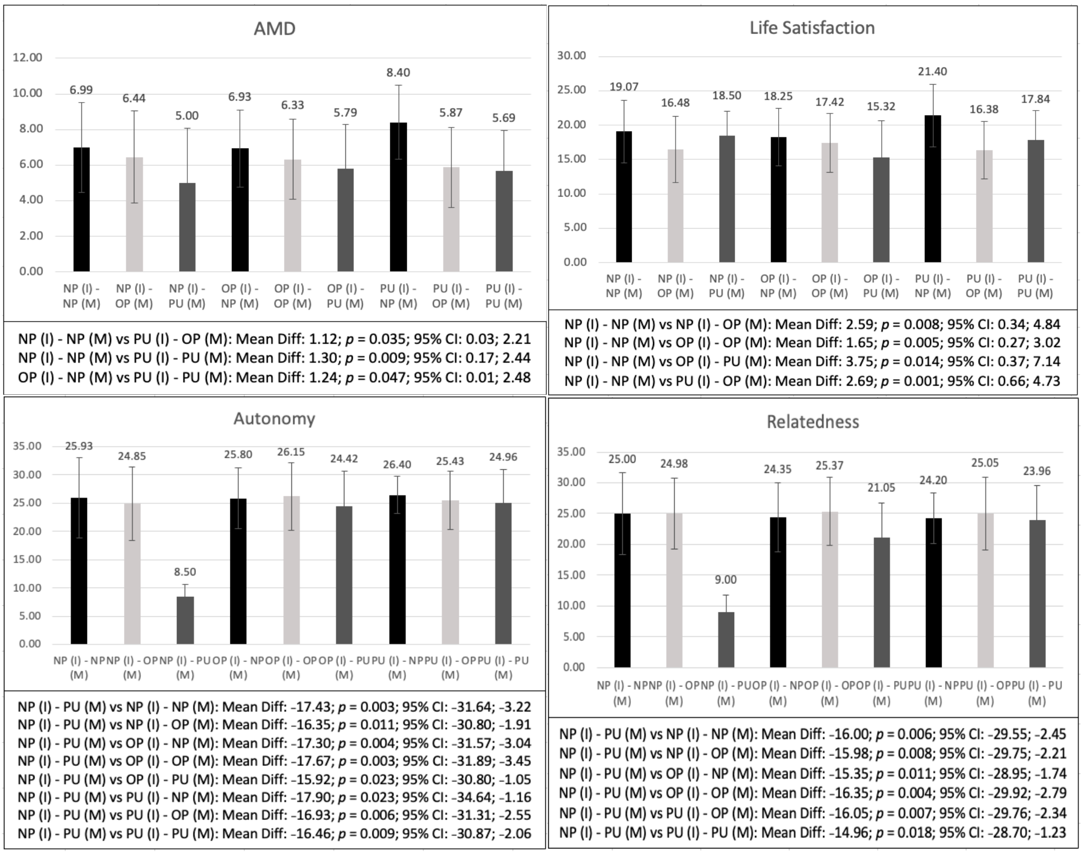
Table 2 shows the differences when considering the problematic use of the internet and mobile phone in combination. The results showed statistically significant differences in AMD ($p < 0.001$), life satisfaction ($p < 0.001$), autonomy ($p = 0.014$), and relatedness ($p = 0.001$). Thus, in Figure 3, it is observed that adolescent NPs for both internet and mobile phone use presented higher scores in AMD (p = 0.009–0.035) and life satisfaction (p = 0.001–0.014) than those who presented OP or PU on the internet, mobile phones, or both. Furthermore, for measurements of AMD, adolescents with OP on internet use but NP on mobile phone use presented higher scores than those with PU on both the use of the internet and mobile phones ($p = 0.047$). It should also be noted that for autonomy (p = 0.003–0.023) and relatedness (0.004–0.018), adolescents with NP on internet use and PU on mobile phone use showed lower scores than the rest of the groups.

Table 2. Differences in the physical activity level, kinanthropometric variables, AMD, psychological state, and physical condition among adolescents with different levels of problematic internet and mobile phone use.

	NP (I)– NP (M) (*n* = 243)	**NP (I)– OP(M) (*n* = 48)**	**NP (I)– PU (M) (*n* = 11)**	**OP (I)– NP (M) (*n* = 121)**	**OP (I)– OP (M) (*n* = 193)**	**OP (I)– PU (M) (*n* = 39)**	**PU (I)– NP (M) (*n* = 20)**	**PU (I)– OP (M) (*n* = 61)**	**PU (I)– PU (M) (*n* = 55)**	***p***	**η^2**
Physical activity	2.69 ± 0.67	2.64 ± 0.54	2.56 ± 0.36	2.68 ± 0.62	2.63 ± 0.60	2.72 ± 0.66	2.82 ± 0.47	2.54 ± 0.74	2.60 ± 0.82	0.864	0.005
Body mass	56.13 ± 12.93	57.44 ± 16.17	41.32 ± 6.75	57.64 ± 14.13	56.46 ± 12.21	59.99 ± 19.10	63.14 ± 10.54	60.37 ± 12.87	57.43 ± 9.90	0.223	0.014
Height	162.45 ± 8.85	162.26 ± 8.37	152.55 ± 5.44	164.42 ± 9.81	163.19 ± 8.44	163.96 ± 11.05	166.48 ± 10.71	165.16 ± 9.72	165.12 ± 7.68	0.106	0.018
BMI	21.20 ± 4.15	21.66 ± 4.64	16.78 ± 3.08	21.19 ± 3.58	21.14 ± 3.75	21.98 ± 4.53	22.89 ± 3.70	22.02 ± 3.80	21.07 ± 3.14	0.504	0.010
Fat mass	22.65 ± 10.49	25.49 ± 10.97	16.84 ± 12.01	21.62 ± 9.45	22.43 ± 10.33	25.88 ± 11.03	30.45 ± 13.13	25.05 ± 11.12	21.02 ± 7.95	0.061	0.020
Muscle mass	18.69 ± 5.19	17.91 ± 4.52	15.62 ± 0.01	19.70 ± 5.60	18.77 ± 4.83	19.04 ± 6.34	19.67 ± 4.21	19.77 ± 5.32	19.23 ± 4.47	0.427	0.011
Sum of 3 skinfolds	51.47 ± 25.66	58.20 ± 27.42	40.00 ± 33.38	48.48 ± 22.89	50.80 ± 25.43	57.91 ± 27.57	68.87 ± 29.38	56.24 ± 26.06	48.28 ± 20.05	0.133	0.017
Corrected arm girth	21.21 ± 3.11	20.81 ± 2.44	18.39 ± 0.03	21.54 ± 3.29	21.31 ± 2.95	21.24 ± 3.07	21.29 ± 2.35	21.76 ± 2.82	21.48 ± 2.79	0.674	0.008
Corrected thigh girth	40.05 ± 5.42	39.79 ± 4.59	36.10 ± 1.82	40.47 ± 4.95	39.98 ± 4.53	40.55 ± 5.73	38.74 ± 3.83	41.15 ± 4.92	40.43 ± 4.22	0.694	0.008
Corrected calf girth	29.26 ± 3.41	28.51 ± 2.38	26.66 ± 1.30	29.78 ± 3.17	29.39 ± 3.53	28.55 ± 3.22	28.42 ± 3.59	29.50 ± 2.89	29.79 ± 2.52	0.285	0.013
Waist girth	69.00 ± 8.68	69.89 ± 11.15	62.77 ± 7.96	70.19 ± 9.33	69.48 ± 8.07	70.40 ± 9.85	76.16 ± 7.86	72.01 ± 9.47	69.14 ± 6.59	0.228	0.014
Hip girth	90.05 ± 9.17	91.75 ± 10.65	79.50 ± 9.05	90.17 ± 9.23	90.57 ± 8.79	92.35 ± 12.28	93.31 ± 7.84	93.48 ± 8.91	91.47 ± 7.21	0.136	0.017
Waist-to-hip ratio	0.77 ± 0.05	0.76 ± 0.06	0.79 ± 0.01	0.78 ± 0.07	0.77 ± 0.05	0.76 ± 0.05	0.82 ± 0.06	0.77 ± 0.05	0.76 ± 0.05	0.133	0.017
AMD	6.99 ± 2.51	6.44 ± 2.59	5.00 ± 3.07	6.93 ± 2.17	6.33 ± 2.26	5.79 ± 2.51	8.40 ± 2.07	5.87 ± 2.24	5.69 ± 2.24	<0.001	0.041
Life satisfaction	19.07 ± 4.60	16.48 ± 4.84	18.50 ± 3.54	18.25 ± 4.19	17.42 ± 4.30	15.32 ± 5.38	21.40 ± 4.51	16.38 ± 4.19	17.84 ± 4.25	<0.011	0.053
Competence	27.75 ± 7.07	26.71 ± 6.95	25.50 ± 2.12	27.24 ± 7.04	26.88 ± 6.45	23.74 ± 8.62	27.20 ± 4.03	25.69 ± 6.78	25.87 ± 7.41	0.057	0.023
Autonomy	25.93 ± 7.05	24.85 ± 6.49	8.50 ± 2.12	25.80 ± 5.40	26.17 ± 5.99	24.42 ± 6.20	26.40 ± 3.29	25.43 ± 5.18	24.96 ± 6.02	0.014	0.026
Relatedness	25.00 ± 6.62	24.98 ± 5.78	9.00 ± 2.83	24.35 ± 5.58	25.35 ± 5.48	21.05 ± 5.72	24.20 ± 4.09	25.05 ± 5.90	23.96 ± 5.53	0.001	0.034
VO2 max.	39.82 ± 5.78	38.26 ± 4.93	41.97 ± 8.86	40.22 ± 5.65	39.81 ± 5.57	39.33 ± 6.65	40.51 ± 5.38	38.30 ± 5.71	40.16 ± 6.43	0.369	0.012
Right arm handgrip	25.99 ± 7.98	24.09 ± 7.54	18.90 ± 1.98	27.27 ± 8.53	26.79 ± 8.29	27.19 ± 8.94	28.00 ± 16.06	28.96 ± 9.15	28.87 ± 7.01	0.056	0.023
Left arm handgrip	24.36 ± 7.74	23.71 ± 6.78	17.45 ± 1.06	25.29 ± 7.44	24.83 ± 7.44	25.17 ± 7.98	26.76 ± 12.62	25.98 ± 7.86	26.28 ± 7.12	0.423	0.011
Sit-and-reach	15.96 ± 8.49	15.36 ± 8.24	13.25 ± 0.35	14.73 ± 8.70	15.98 ± 9.06	16.66 ± 9.21	14.00 ± 7.39	15.17 ± 8.77	19.02 ± 9.26	0.243	0.014
CMJ	23.03 ± 6.98	22.24 ± 6.21	21.90 ± 5.37	23.20 ± 7.93	24.35 ± 6.34	23.37 ± 7.44	23.44 ± 7.81	24.58 ± 7.76	25.68 ± 6.18	0.143	0.016
20 m sprint	3.94 ± 0.63	4.06 ± 0.42	4.09 ± 0.16	3.86 ± 0.52	3.94 ± 0.42	4.02 ± 0.45	4.09 ± 0.53	3.98 ± 0.47	3.76 ± 0.62	0.138	0.016

I: internet related experiences; M: mobile phone related experiences; NP: no problems; OP: occasional problems; PU: problematic use; BMI: body mass index; AMD: adherence to Mediterranean diet; VO2 max: maximum oxygen consumption; CMJ: countermovement jump; η2: effect size.

Figure 3. Bonferroni post-hoc analyses of the variables that showed significant differences when comparing adolescents with and without problematic use of both the internet and mobile phones.



5.5. Discussion

The present research attempts to fill a gap in the previous scientific literature, in which it is unknown how the degree of problematic internet and mobile use affects the level of physical activity, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness. In addition, it is not known whether the joint problematic use of the internet and the mobile phone has a more negative influence on these variables, nor whether there are differences according to the gender of the adolescents. For this reason, the aims of the present study were to determine the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness according to gender and different levels of problematic use of the internet and mobile phones and to establish the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness among adolescents when considering problematic use of the internet and mobile phones in combination.

Regarding the first objective, to determine the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness according to gender and different levels of problematic use of the internet and mobile phones, the results found that females with internet or mobile phone PU had worse levels of physical activity, AMD, life satisfaction, and competence, as compared to OP and NP females; furthermore, with respect to the use of internet and mobile phone in males, the NPs had the highest score in life satisfaction and relatedness, although the PUs scored higher in handgrip and CMJ. The differences found in the psychological state in males and females are similar to the findings of previous research (Alaca, 2020; Columb et al., 2021), but the most important results are the differences found in AMD and the level of physical activity of females, which could be explained by the different uses of the internet and mobile phones according to the adolescent's gender, with playing video games being common among males, while among females the use of social networks is more common (Dufour et al., 2016). These social networks are full of healthy content related to exercise or nutrition; however, previous research has shown that knowing this information is not directly related to changing habits (Martín-Criado, 2007), in addition to the fact that users who abuse the use of social networks tend to show unhealthy behaviors, more prevalent in the case of females (Paakkari et al., 2021). Furthermore, the information on healthy habits available on social networks is not scientifically proven, and adolescents are not able to look for information on healthy habits in reliable sources (Plaisime et al., 2020). Therefore, although this information should be contrasted in future research, it could indicate the need to educate adolescents about the websites they could use to obtain relevant information related to healthy habits, especially for females.

The relevance of these results lies in the fact that no previous research has analyzed the differences in a specific nutritional pattern, such as AMD, as a function of the different degrees of problematic use of the internet and mobile phones. It is true that the relationship between AMD and kinanthropometric variables (Mistretta et al., 2017), physical condition (Galan-Lopez et al., 2019), and physical activity (Jiménez Boraita et al., 2020) has been extensively studied, but this is a novel aspect that may be of great relevance for the healthy development of adolescents. Furthermore, the existence of gender differences, with females being more affected in terms of AMD when considering problematic internet and mobile phone use, establishes a line of research that should be confirmed in future studies.

It should be noted that differences were only found for males in handgrip and CMJ, with males with internet and mobile phone PU scoring higher. A possible explanation for these results lies in the fact that handgrip strength and CMJ are variables that measure muscle strength and power, and previous research has found an association between handgrip strength and aggressiveness only in males (Muñoz-Reyes et al., 2012), with aggressiveness being more present in adolescents with problematic use of the internet and mobile phones (Koo & Kwon, 2014; Woongyong, 2011). Another possible explanation would be related to the sports practices of adolescents, as those who are more aggressive tend to participate in activities related to martial arts and team-based sports, where strength and power are mainly developed (Da Costa et al., 2020).

As for the second objective, to establish the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness among adolescents when considering problematic use of the internet and mobile phones in combination, the results showed that adolescents with NP in both internet and mobile phone use scored higher in AMD and life satisfaction than those with OP or PU of the internet, mobile phone, or both. In those studies that conducted the analysis separately, the results were similar, with higher scores on nutritional habits and psychological state found for adolescents without problematic usage (Alaca, 2020; Columb et al., 2021; Kamran et al., 2018; Ying et al., 2021). The results obtained are in line with the previous scientific literature and, although this is the first study that jointly analyzed the use of the internet and the mobile phone, it seems clear that a correct use of both technologies must be maintained if the aim is to achieve an adequate psychological development of adolescents, as well as an adequate acquisition of healthy habits that may be decisive in this and later stages of life. Therefore, this is a novel aspect of the present research, since no previous research had analyzed the joint use of both technologies and shows that it is necessary to teach adolescents the importance of the correct use of new technologies, since they seem to play a determining role in relation to fundamental variables for the correct development of adolescents.

However, one particularly relevant aspect that should be taken into consideration is that adolescents with NP in internet use, but PU of mobile phones showed lower scores in autonomy and relatedness as compared to the rest of the groups. Previous research has shown how integrated mobile phones have become in the adolescent population (Bhanderi et al., 2021), and that mobile phone use from ages 8 to 17 years old is progressively increasing (Lauricella et al., 2014). In this regard, it highlights the fact that there is an increase in the use of mobile phones at night, between the ages of 13 and 16, for texting, phoning, or messaging, which leads to serious sleep disturbances that affect mood, the possibility of depression, decreased self-esteem, and coping skills (Vernon et al., 2018); this may be the reason why adolescents are affected in their autonomy and relationships, as they are in a state of vulnerability that hinders their development in these areas. However, it should be noted that the sample size of the group of adolescents with NP with internet use, and PU of the mobile phone, is very small, which could be influencing the statistical analyses performed. Therefore, although future research is needed that attempts to establish the differences in the psychological variables of the adolescents by considering the possible problematic use of the internet and the mobile phone together, the main novelty of the present research shows the special relevance that the mobile phone could have in the differences found in the psychological state of the adolescent population.

The results obtained in the present investigation show that in females the problematic use of internet and mobile phone seems to have a greater impact on the level of physical activity, AMD, and psychological state, while in males, it influences their psychological state and physical condition. This is an important aspect to consider, since previous research has shown how the practice of physical activity is lower in adolescent females than in males (Peral-Suárez et al., 2020), and problematic internet use may have a greater impact on the physical practice of females. In addition, it was not found that adolescents with problematic use or occasional problems of both mobile phones and the internet presented significant differences in any variable with respect to adolescents with problematic use or occasional problems with the internet or mobile phones exclusively.

Based on the results obtained, the first practical implication derived from the present investigation is that problematic use or occasional problems may influence the adolescents' daily state of health, mainly affecting their level of physical activity or AMD, in the case of females, or psychological state in the case of both males and females. Furthermore, the second novel aspect lies in the fact that, although adolescents with NP on internet and mobile phone use showed higher scores in AMD and life satisfaction, the PU of the mobile phone could play a more determinant role in the psychological state of adolescents than internet use, as adolescents who showed NP on internet use, but PU of mobile phones obtained lower scores in autonomy and relatedness.

The present research is not free of limitations. As this is a descriptive study, it is not possible to verify the causal relationship between internet and mobile phone use and the changes in the variables analyzed. Although education centers were chosen from different areas and those with the largest samples of adolescent populations, the sampling was non-probabilistic by convenience. For the joint analysis of internet and mobile phone use, certain groups had a reduced sample size. The use of questionnaires, despite being validated, is always risky, as it depends on the subjective completion of the questionnaire by the adolescents. The adolescents (12–16 years old) in the present investigation are in the middle of puberty, so maturation may influence them. More specifically, in the case of females, those who are in the menstrual process and those who have not yet gone through this process have not been considered, which is a factor that could influence the results, as has been shown in previous studies in which the practice of physical activity was evaluated (Dumith et al., 2012).

5.6. Conclusions

To conclude, problematic internet and mobile phone use could have different effects on adolescent males and females, with females being more affected in terms of physical activity level, AMD, and psychological state (life satisfaction and competence), while males are affected in terms of AMD, physical condition, and psychological state (life satisfaction and relatedness). Problematic internet use in females led to a lower level of physical activity, AMD, life satisfaction, and competence compared to NP and OP girls. In males, problematic internet use led to lower life satisfaction, but higher handgrip and CMJ scores. In terms of problematic mobile phone use, females showed worse AMD and life satisfaction, while males showed lower life satisfaction and relatedness, but higher CMJ scores. In addition, adolescents with NP with both internet and mobile phones showed higher AMD and life satisfaction scores than those who presented with OP or PU of the internet, mobile phone, or both. However, special attention should be paid in future research to adolescents with PU of mobile phones, as they seem to be more affected in their psychological state than the rest of the groups. The relevance of the results found lies in the fact that the use of mobile phones and the internet can have a negative effect on the physical activity, AMD, physical condition, and psychological state of adolescents, which are determining factors and should be considered in programs that seek to improve the health of this population from a global point of view. In addition, the effect sizes obtained in the present study are low for all the variables analyzed, so the results obtained should be taken with caution and show the need for future research in this area to delve deeper into the subject.

Based on the present investigation, future research should include objective measurement of the level of physical activity, since it would provide more information on the physical activity behavior of adolescents. Furthermore, the maturational process in which adolescents are immersed is a fundamental aspect to be considered due to the physical, psychological, and behavioral changes that occur during this stage, and future research should focus on the maturational stage.

Ve – ESTUDIO 5: The importance of healthy habits to compensate for differences between adolescent males and females in anthropometric, psychological, and physical fitness variables

ESTUDIO 5 – THE IMPORTANCE OF HEALTHY HABITS TO COMPENSATE FOR DIFFERENCES BETWEEN ADOLESCENT MALES AND FEMALES IN ANTHROPOMETRIC, PSYCHOLOGICAL, AND PHYSICAL FITNESS VARIABLES

5.1. Abstract

Adolescence is a crucial stage in human development, and differences in psychological, physical and body composition variables between males and females have been amply demonstrated. However, the role played by certain healthy habits, such as the practice of physical activity, adherence to the Mediterranean diet (AMD) or the maintenance of an adequate weight status, in compensating for the differences found between males and females in these variables, is not well known. For this reason, the study aimed to analyze whether the practice of physical activity, optimal AMD, and adequate weight status can compensate for the differences between adolescent males and females in anthropometric variables, psychological state, and physical fitness. The sample was composed of 791 adolescents (404 males and 387 females) aged twelve to sixteen years old, whose anthropometric, psychological (autonomy, competence, relatedness, and life satisfaction), and physical fitness variables (cardiorespiratory fitness, upper strength and explosive lower limb power, hamstring and lower back flexibility, and speed) were measured. All measurements were carried out in a single day using the sports pavilion of the four participating schools. The most novel results of this research show that the practice of physical activity was determinant mainly in females, as it reduced the differences found in comparison with males in psychological (p < 0.001–0.045) and anthropometric variables (p < 0.001). Regarding weight status and AMD, these were still relevant for the adolescent population, mainly the achievement of optimal AMD, but males continued to present higher values in physical fitness tests (p < 0.001) and lower values in fat accumulation (p < 0.001), regardless of weight status or AMD. Thus, physical activity seems to be the most determining factor that compensates for the differences between adolescent boys and girls.

5.2. Introduction

Adolescence is a fundamental stage in the development of individuals and is characterized by physical, hormonal, and cognitive changes before reaching adulthood (Goddings, 2015; Handelsman et al., 2018). However, the timing of the onset of physical, hormonal, and cognitive changes differs between males and females, with females developing the earliest (Beunen et al., 2006; Beunen & Malina, 1988). Moreover, the changes between males and females at this stage do not only differ in the time at which they occur, as hormonal differences during puberty are notable depending on the sex (Handelsman et al., 2018; Roemmich & Rogol, 1999), giving rise to a phenomenon known as sexual dimorphism (Nikitovic, 2018). These differences in the maturation process between males and females during adolescence lead to changes in their behaviors related to physical activity (Steene-johannessen et al., 2020), nutritional habits (Washi & Ageib, 2010), and weight status (Faguy, 2016), as well as in personal variables such as the anthropometry and derived variables (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c), psychological state (Henkens et al., 2022), or physical fitness (Rodrigues et al., 2010).

With respect to the differences in the behavior of adolescent females and males, the regular practice of a physical activity is essential for the proper development of adolescents, as it influences their health during all stages of their lives, helping to prevent certain chronic diseases (Anderson & Durstine, 2019) and favoring the development of their physical abilities (Mateo-Orcajada, González-Gálvez, et al., 2022). In addition, physical activity during adolescence plays a key role (Kjønniksen et al., 2009) in the maintenance of an active lifestyle during adulthood, as well as in the acquisition of other healthy lifestyle habits and the prevention of harmful lifestyle habits (Schnermann et al., 2022). Furthermore, previous research has shown differences between males and females in the level of physical activity (Steene-johannessen et al., 2020), with males practicing sports to a greater extent and with greater intensity than females (Manzano-Sánchez et al., 2022).

Nutritional habits have also been considered one of the most determining factors in maintaining healthy habits (Korczak et al., 2021; Washi & Ageib, 2010). These are some of the main elements to consider during adolescence, as previous research has shown that adolescents with poorer adherence to the Mediterranean diet (AMD) have a worse profile of plasmatic inflammation markers, along with the risk this poses for the development of metabolic syndrome, obesity, or insulin resistance (Sureda et al., 2018), worse physical activity level (Idelson et al., 2017), and worse mental health (Glabska et al., 2020). However, previous research has not shown differences between males and females, with similar levels of AMD observed in both genders (De Santi et al., 2020; Rosi et al., 2020).

In addition, weight status, and mainly, perceived weight status, are some of the most analyzed parameters in recent years due to their close relationship with health (Tan et al., 2022). Obesity and overweight have been identified as the greatest pandemic of the 21st century, affecting an increasing number of children and adolescents at very early ages every year (Bravo-Saquicela et al., 2022) and producing numerous non-communicable diseases such as diabetes, hypertension, hypercholesterolemia, asthma, cerebrovascular accidents, among others (Faguy, 2016). In this sense, it is relevant to know that the prevalence of obesity and overweight affects adolescent males and females differently, with males showing higher values than females regardless of the criteria used (Ajejas Bazán et al., 2018).

Previous scientific literature has shown how differences seem to be evident in the habits of adolescent males and females, to which we must also add the differences found, according to gender, in anthropometry and derived variables (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c), psychological state (Rubio et al., 2019), and physical fitness (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). These changes occur because of the great hormonal changes between males and females from the peak of growth onwards, which result in sexual dimorphism (Handelsman et al., 2018; Nikitovic, 2018) and mainly influence the sex differences in the accumulation of fat and muscle development (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c; Roemmich & Rogol, 1999). Specifically, from this moment on, females tend to accumulate more fat (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022b), while males tend to have greater muscle development (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a, 2022c). Considering that muscle development provides a competitive advantage for physical actions that depend on strength and power and that fat is a competitive disadvantage for actions that depend on endurance, agility, and power, biological differences could be the main cause of the differences in physical fitness that occur from this age onwards (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a, 2022b), mainly influencing endurance, strength, speed, agility, power, and flexibility, with all of these being greater for males, except in the case of flexibility, where the rapid increase in muscle mass experienced by males becomes a handicap for this ability, being greater in girls (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). With respect to psychological state, the COVID-19 pandemic suffered in recent years had a great influence on adolescents (Imran et al., 2020), mainly on females, leaving them in a state of greater psychological vulnerability due to the decrease in well-being and behavioral changes, increasing their anxiety and depression to a greater extent (Halldorsdottir et al., 2021). In addition, the aforementioned body changes greatly influence self-concept and body image, with a particularly negative effect on females (Francisco et al., 2015).

Thus, differences in anthropometry and derived variables between adolescent males and females have been noted in previous research (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). In this sense, adolescent males present greater muscle development, while adolescent females accumulate a higher percentage of fat mass (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). This difference is fundamental because of the relationship between the increase in fat mass and the decrease in muscle mass, an increased risk of certain diseases (Kammar-García et al., 2019), and a decrease in physical performance (Galan-Lopez et al., 2020).

Mental health problems are also a determining factor during adolescence due to their influence on the behavior of adolescents (Hoare et al., 2020), which became more apparent after the COVID-19 pandemic, which led to significant changes in lifestyle habits and the way of relating (Luijten et al., 2021). It greatly affected the psychological state of adolescents (Jones et al., 2021; Panchal et al., 2021), more noticeably and with greater risk for females (Marie et al., 2022). However, the existing differences in certain psychological variables according to the gender of the adolescents are still unclear, as previous research in this area has not shown significant differences in life satisfaction between adolescent males and females (Cavioni et al., 2021). In contrast, other studies have shown lower scores in this variable and competence in adolescent females (Henkens et al., 2022; Rubio et al., 2019).

In terms of physical fitness, the differences between adolescent males and females after the maturation period have been previously mentioned (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c), with males performing better in strength and power tests while females scored higher in flexibility tests. These results acquire special importance because participation in certain physical activities is conditioned by the physical abilities relevant to these activities (Klomsten et al., 2005), giving rise to significant differences in sports participation between male and female adolescents. Males tend to participate to a greater extent, as most of the activities in which adolescents participate are collaborative-opposition group sports, such as soccer or basketball, where strength, speed, and power are decisive (Peral-Suárez et al., 2020), while females see their sports practice reduced to individual and more aesthetic activities such as rhythmic gymnastics or swimming, decreasing their sports participation (Peral-Suárez et al., 2020).

Therefore, previous scientific literature has shown that the healthy habits of adolescent boys and girls are different (Faguy, 2016; Steene-johannessen et al., 2020; Washi & Ageib, 2010) and that there are significant differences between genders in anthropometric and derived variables (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c), psychological state (Rubio et al., 2019), and physical condition (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). However, given this situation, no previous research has analyzed whether the lifestyle habits of adolescents are determinant in the changes produced in the anthropometric and derived variables, in psychological state and physical condition, and whether the differences between boys and girls could disappear in the anthropometric and derived variables, in psychological state and/or in physical condition when adopting a certain healthy habit. This leads to the following research question: is it possible that adolescent females, who normally have a greater accumulation of fat mass and less muscle mass development, who have more alterations in their psychological state, and who have a worse physical condition, can reduce, or even reverse the differences found with respect to males in these variables, by adopting a greater practice of physical activity, an optimal AMD and/or an adequate weight status?

This question leads to the following general aim for the present study: to analyze whether the practice of physical activity, optimal AMD, and adequate weight status can compensate for the differences between adolescent males and females in anthropometric and derived variables, psychological state, and physical fitness. In order to achieve this general aim, the following four specific objectives were proposed (a) to establish the differences between male and female adolescents in anthropometric and derived variables, psychological state, and physical fitness; (b) to determine whether the practice of physical activity can compensate for the differences found according to gender, in the anthropometric and derived variables, psychological state and physical fitness of the adolescents; (c) to analyze whether optimal AMD can compensate for the gender differences found in the anthropometric and derived variables, psychological state and physical fitness of the adolescents; and (d) to establish whether the maintenance of an adequate weight status can compensate for the differences found according to gender in the anthropometric and derived variables, psychological state and physical fitness of the adolescents.

Based on previous scientific literature and the objectives of the present investigation, the following hypotheses are proposed: (H1) males will show higher scores in all variables, except in those related to body fat and flexibility, compared to females; (H2) for females, the regular practice of physical activity will compensate for the differences in anthropometric and derived variables, psychological state and physical fitness with respect to males; (H3) for females, optimal AMD will compensate for the differences in anthropometric and derived variables, psychological state and physical fitness with respect to males; and (H4) for females, maintaining a normal weight will compensate for the differences in anthropometric and derived variables, psychological state and physical fitness with respect to males.

5.3. Materials and Methods

The research was carried out using a cross-sectional design, and the sample selection was performed with a non-probability convenience method. The STROBE statement was followed for the design of the research study and for drafting the manuscript (Vandenbroucke et al., 2014). In accordance with the World Medical Association and the guidelines of the Helsinki Declaration, the institutional ethics committee of the Catholic University of Murcia reviewed and approved the protocol before starting research (code: CE022102).

5.3.1. Research model

Table 1 shows a summary of the dependent and independent variables included in the present research.

Table 1. Dependent and independent variables of the study.

Variable Type	Construct	Variable
Independent	Physical activity	Physical activity status (active or sedentary)
	Diet	Adherence to Mediterranean Diet (AMD, poor adherence, or optimal adherence)
	Weight status	Weight status (normal weight or overweight/obese)
Dependent	Anthropometric and derived variables	Body mass (kg)
		Height (cm)
		BMI (kg/m^2)
		Waist girth (cm)
		Hip girth (cm)
		Waist/hip ratio
		Sum 3 skinfolds (cm)
		Corrected arm girth (cm)
		Corrected thigh girth (cm)
		Corrected calf girth (cm)
		Fat mass (%)
		Muscle mass (kg)
	Psychological variables	Life satisfaction (punctuation)
		Competence (punctuation)
		Autonomy (punctuation)
		Relatedness (punctuation)
	Physical fitness variables	VO_2 max. (ml/kg/min)
		Handgrip right arm (kg)
		Handgrip left arm (kg)
		Sit-and-reach (cm)
		CMJ (cm)
		20-m-sprint (s)
	Physical activity	Physical activity level (punctuation)
	Diet	Adherence to Mediterranean diet (punctuation)

BMI: body mass index; AMD; adherence to Mediterranean diet; CMJ: countermovement jump; VO_2 max.: maximum oxygen consumption.

5.3.2. Participants

The sample consisted of adolescents enrolled in four schools in the Region of Murcia, selected from different geographical areas (north, south, east, and west), including the schools with the largest sample of adolescent students in compulsory secondary education, according to data from the Ministry of Education, thus achieving a representative sample of the Region of Murcia.

For the sample size calculation, the Rstudio 3.15.0 statistical software (Rstudio Inc., Boston, MA, USA) was used following the methodology from previous studies based on the standard deviation (SD) (Bhalerao & Kadam, 2010). Thus, with an SD of 0.50 from previous research that examined the differences between adolescent males and females in the physical activity level (Sánchez-Miguel et al., 2021) and with an estimated error (d) for a 99% confidence interval of 0.05, the minimum sample necessary for the conducting the research was 750 adolescents.

The final sample consisted of 791 adolescents (404 males and 387 females; mean age: 14.39 ± 1.26 years old; males' mean age: 14.37 ± 1.25; females' mean age: 14.40 ± 1.27). Participation in the study was voluntary, and all adolescents who met the following inclusion criteria were included: (a) attending compulsory secondary education; (b) completing all the measurements (questionnaires, anthropometric measurements, and physical fitness test); (c) participating in body composition measurements; (d) age between twelve and sixteen years old; and (e) not presenting any musculoskeletal injury or illness that would hinder participation in the physical tests or the completion of the questionnaires.

5.3.3. Instrumentation

*5.3.3.1. **Questionnaire measures***

The questionnaires used in the present study were the "Physical Activity Questionnaire for Adolescents" (PAQ-A) (Kowalski et al., 1997; Martínez-Gómez et al., 2009), KIDMED (Serra-Majem et al., 2004), "Satisfaction with life scale" (SWLS) (Diener et al., 1985), and the "Basic Psychological Needs Scale" (BPNS) (Wilson et al., 2006).

The PAQ-A, previously validated in Spanish (Martínez-Gómez et al., 2009), has an intraclass correlation coefficient of 0.71 and consists of nine items. The first eight are answered with a Likert scale of 1 to 5 points and allow information to be collected on the last seven days of physical activity. The last item allows for discovering if the subject could not perform physical activity in the week prior to the study. This questionnaire makes it possible to establish the physical activity status by discriminating between active and sedentary adolescents, obtaining a score between 1 and 5 according to the sum and subsequent averaging of the first eight items. For this purpose, a cut-off point of 2.75 was established, with active subjects being those above this value and sedentary those who were not (Benítez-Porres et al., 2016).

To establish the AMD level, the "Mediterranean Diet Quality Index for children and adolescents" (KIDMED) questionnaire was used. This questionnaire was designed and validated with Spanish adolescents and showed moderate reliability and reproducibility values for use in adolescents (α = 0.79) (Carrillo & Ramírez-Vélez, 2020). It allows determining the level of AMD by means of 16 items rated by the adolescents with a score of 1 or 0, depending on whether the criterion was met. Subsequently, the scores obtained were totaled, considering that twelve of the questions had a positive connotation (+1) (favoring a good adherence), and four had a negative connotation (−1) (favoring an inadequate adherence). The final score was between 0 and 12 points, indicating the following adolescents' AMD: poor adherence (0–3 points), need to improve adherence (4–7 points), or optimal adherence (8–12 points) (Serra-Majem et al., 2004).

The SWLS assesses the level of satisfaction with life by means of five items that are answered with a Likert scale of 1 to 5 points, with the final score ranging from 5 to 25 (Atienza et al., 2000; Diener et al., 1985). This scale was translated into Spanish and showed an adequate internal consistency (α = 0.84) for use with adolescents (Atienza et al., 2000). The BPNS assesses autonomy, competence, and relatedness by means of eighteen items (six items for each dimension) using a Likert scale from 1 to 6 points, with 6 being the minimum score and 36 being the maximum score in each dimension. The BPNS was previously translated and validated in Spanish (Moreno-Murcia et al., 2011). This scale presents adequate external validity and internal consistency (competence = 0.80; autonomy = 0.69; and relatedness = 0.73) (Moreno-Murcia et al., 2011; Wilson et al., 2006). Therefore, both scales were used to assess life satisfaction and basic psychological needs, with both psychological constructs being of great relevance in the adolescent population, as previous research has shown their relationship with the acquisition of healthy habits such as physical activity (Rubio et al., 2019), nutritional pattern (López-Gil & García-Hermoso, 2022), or weight status (Christoph et al., 2018).

5.3.3.2. *Anthropometric measurements*

The anthropometric evaluation was composed of two basic measurements, body mass and height, performed using a TANITA BC-418-MA Segmental (TANITA, Tokyo, Japan) with an accuracy of 100 g and a SECA stadiometer 213 (SECA, Hamburg, Germany) with an accuracy of 0.1 cm, respectively; three skinfolds, triceps, thigh and calf, measured using a skinfold caliper (Harpenden, Burgess Hill, UK) with an accuracy of 0.2 mm; and five girths, arm relaxed, waist, hips, thigh, and calf, using an inextensible tape Lufkin W606PM (Lufkin, Missouri City, TX, USA) with a 0.1 cm accuracy for it measurements. All the instruments were previously calibrated, and all measurements were performed according to the protocol standardized by the International Society for the Advancement of Kinanthropometry (ISAK) (Esparza-Ros et al., 2019). The measurements were taken by anthropometrists (levels 2 to 4) accredited by the ISAK, following the protocol of this organization (Esparza-Ros et al., 2019).

It should be noted that all the measurements corresponding to the same subject were performed by the same anthropometrist, who took a minimum of two measurements per variable, with a third measurement being necessary when the difference between the first two measurements was greater than 5% in the skinfolds and 1% in the rest of the measurements. The mean of the values when two measurements were taken, or the median when three measurements were taken, was used as the final value (Esparza-Ros et al., 2019).

With the final values obtained from the anthropometric measurements, the BMI (kg/m^2), Σ3 skinfolds (triceps, thigh, and calf), corrected arm girth [arm relaxed girth − (π × triceps skinfold)], corrected thigh girth [middle thigh girth − (π × thigh skinfold)] corrected calf girth [calf girth − (π × calf skinfold)], fat mass (%) (Slaughter et al., 1988), and muscle mass (Poortmans et al., 2005) were calculated.

The intra- and inter-evaluator technical error of measurements (TEM) were calculated in a sub-sample. The inter-evaluator TEM was 1.98% for skinfolds; 0.06% for the girths; and 0.03% for the basic measurements; and the intra-evaluator TEM was 1.21% for skinfolds; 0.04% for the girths; and 0.02% for the basic measurements.

5.3.3.3. *Physical fitness measurement*

Cardiorespiratory fitness: To assess the cardiorespiratory fitness of the adolescents, the 20-m shuttle run test was performed, in which the participants had to run 20 m as many times as possible following the incremental running beep set by a sound signal. The test ended when the adolescents were exhausted or when they did not run the 20 m in the time allowed. The last speed at which the adolescent finished the test was used to predict maximal oxygen consumption (VO_2 max.) (Léger et al., 1988; Tomkinson et al., 2019).

Strength and power: To measure the upper body strength and the explosive lower limb power, the handgrip strength test (Matsudo et al., 2014) and the countermovement jump (CMJ) (Barker et al., 2018) test were used, respectively. The handgrip strength test consists of applying the maximum possible force on a Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo, Japan) with the elbow fully extended, as this is the position in which maximum force is produced (España-Romero et al., 2010). The CMJ consists of a vertical jump in which the aim is to reach the highest possible height. For this, the adolescent must maintain verticality throughout the flight phase and keep their hands on their hips. Initially, the subject stands with their hands on the waist, flexes their knees to 90, and performs a maximum knee extension (Barker et al., 2018). To measure performance in this test, a force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) was used.

Flexibility: The sit-and-reach test was used to assess hamstring and lower back flexibility. The participants were required to sit on the floor with their knees straight, legs together, ankles flexed at 90°, toes pointed upward, and the soles of the feet positioned flat against an Acuflex Tester III box (Novel Products, Rockton, IL, USA). From this initial position and with palms down, the subject performed a maximum trunk flexion, keeping the knees and arms fully extended, trying to reach the maximum possible distance by sliding the palms of the hands, one on top of the other, across the box (López-Miñarro et al., 2015).

Speed: For speed measurement, the 20-m sprint test was performed. To carry out this test, the adolescent had to run 20 m as fast as possible, after which the minimum time required to do so was recorded. At the start, the subject stood on the starting line and decided when to start the sprint (García-Manso et al., 1996). To reduce the risk of the arms cutting the single-beamed photocells from 60% to 4%, the photocells were placed at hip height instead of chest height (Altmann et al., 2017; Cronin & Templeton, 2008).

5.3.4. Procedure

First, the adolescents completed the questionnaires on physical activity level, AMD, life satisfaction, and satisfaction of basic psychological needs in a random order. Subsequently, anthropometric measurements were carried out. Once completed, an attempt at the sit-and-reach test was performed prior to the warm-up so that it would not influence the test result (Díaz-Soler et al., 2015). After completing this test, the adolescents were familiarized with the correct execution of the handgrip strength, CMJ, and 20-m sprint tests after an explanation was given. After familiarization, a warm-up was performed that included progressive running and joint mobility, after which the handgrip, CMJ, and 20-m sprint tests were performed twice. These tests were performed randomly for each adolescent, leaving two minutes of rest between each test attempt. Finally, the 20-m shuttle run test was performed. Five minutes of rest between runs were provided. A total of four researchers oversaw the familiarization and measurements of the tests. The researchers had previous experience in measuring physical fitness tests in adolescent populations. To avoid an inter-evaluator error in the assessments, the same researcher was responsible for measuring the same test during all the measurements.

All the measurements were performed on the same day, using the physical education class hour. The covered sports pavilions of the education centers were selected to reduce the polluting variables as much as possible. Given that the assessment of the physical fitness tests was carried out in a single measurement day, the metabolic demands of each test were considered, as well as the time needed for the subject to recover from the fatigue generated, by establishing the order of the tests according to the recommendations from the National Strength and Conditioning Association (NSCA) (Coburn & Malek, 2014).

5.3.5. Data analysis

The Kolmogorov-Smirnov normality test, as well as kurtosis, skewness, and variance, were used to analyze the normality of the data. Parametric tests were used because all of the variables had a normal distribution. First, descriptive statistics were performed for all the variables analyzed (mean values and standard deviation). Subsequently, a one-factor ANCOVA was conducted to determine the differences between adolescent males and females, with physical activity status, AMD, and weight status as covariates in the model. Three MANOVA analyses were performed. The first is to establish the differences between active and sedentary males and females; the second is to analyze the differences between normal weight and overweight/obese males and females; the third is to establish the differences between males and females with poor and optimal AMD. A pairwise comparison was then performed using the Bonferroni post-hoc test. The effect size calculation (η^2) was performed according to previous research. Thus, the following values were utilized; small: ES ≥ 0.10; moderate: ES ≥ 0.30; large: ≥ 1.2; or very large: ES ≥ 2.0, with an error of $p < 0.05$ (Hopkins et al., 2009). A value of $p < 0.05$ was set to determine statistical significance. The statistical analysis was performed with the SPSS statistical package (v.25.0; SPSS Inc., Chicago, IL, USA).

To clarify the statistical analysis, the adolescents were classified according to their level of physical activity, AMD, and weight status. Thus, the classification of males and females according to their level of physical activity was active males (AM), active females (AF), sedentary males (SM), and sedentary females (SF). Regarding AMD, the classification was poor adherence males (PDM), poor adherence females (PDF), optimal adherence males (ODM), and optimal adherence females (ODF). According to weight status, the classification was normal-weight males (NWM), normal-weight females (NWF), overweight/obese males (OWM), and overweight/obese females (OWF). It should be noted that in the AMD groups, adolescents with a poor AMD and need to improve AMD were pooled so that the sample size of this group would be similar when compared with optimal AMD, as with the weight status group in which overweight and obese adolescents were pooled so that the sample size would be as that of normal weight.

5.4. Results

5.4.1. Coefficient of variation (CV) and intraclass correlation coefficients (ICC) in physical fitness test

The coefficient of variation (CV) and the intraclass correlation coefficients (ICC) were calculated for the physical fitness tests that were repeated twice. The results are as follows: for the handgrip right arm test, ICC = 0.940, and CV = 3.14%;

for the handgrip left arm test, ICC = 0.953, and CV = 3.10%; for the CMJ test, ICC = 0.892, and CV = 3.35%; and for the 20-m sprint test, ICC = 0.913, and CV = 2.15%.

5.4.2. Differences between male and female adolescents in anthropometric variables, psychological variables, physical fitness variables, physical activity level, AMD, and weight status

Table 2 shows the differences between males and females in anthropometric variables, psychological variables, physical fitness variables, physical activity level, AMD, and weight status. Differences were found in all analyzed variables except for hips girth ($p = 0.659$), relatedness ($p = 0.185$), AMD ($p = 0.540$), and BMI ($p = 0.083$). Males showed higher scores in physical activity level ($p < 0.001$), life satisfaction ($p = 0.008$), competence ($p < 0.001$), and autonomy ($p = 0.020$), all physical condition variables ($p < 0.001$), except for the sit-and-reach test ($p < 0.001$); and all anthropometric variables ($p < 0.001$), except for the sum of 3 skinfolds ($p < 0.001$) and fat mass ($p < 0.001$). The inclusion of the physical activity status and the level of AMD in the model significantly affected the differences in relatedness ($p < 0.001$), with the rest of the variables maintaining the same significant differences. In addition, BMI had a significant effect on hip girth ($p < 0.001$), with the rest of the variables keeping the same significant differences, except for the case of autonomy, which ceased to be significant when considering this variable ($p = 0.066$).

5.4.3. Differences between male and female adolescents with different physical activity status in anthropometric variables, psychological variables, physical fitness variables, AMD, and weight status

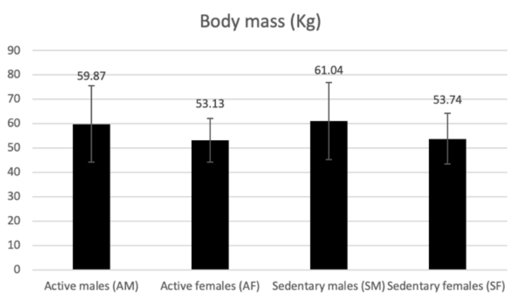
The differences between AM, AF, SM, and SF are shown in Figure 1. When comparing males with different levels of physical activity (AM vs. SM), significant differences were observed in competence ($p < 0.001$), autonomy ($p = 0.011$), and VO_2 max. ($p < 0.001$), and AMD ($p = 0.001$), while for females with different levels of physical activity (PA vs. SF), the differences were significant in life satisfaction ($p < 0.001$), basic psychological needs ($p < 0.001$), and VO_2 max. ($p < 0.001$), sit-and-reach ($p = 0.007$), CMJ ($p < 0.001$), 20-m sprint ($p = 0.003$), and AMD ($p = 0.010$), with active males and females showing higher scores in all the variables.

Table 2. Differences in psychological, anthropometric, and physical fitness variables between males and females and the influence of physical activity status, AMD, and weight status as covariables in the differences depend on gender.

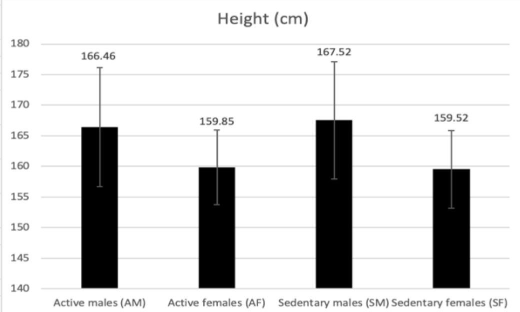
Variable	Descriptors (M + SD)					Gender*Physical activity			Gender*BMI			Gender*AMD		
	Males (n = 404)	Females (n = 387)	F	*p*	ES (η^2)	F	*p*	ES (η^2)	F	*p*	ES (η^2)	F	*p*	ES (η^2)
Body mass (Kg)	60.36 ± 14.85	53.54 ± 10.00	53.286	<0.001	0.067	27.083	<0.001	0.068	313.114	<0.001	0.457	27.667	<0.001	0.069
Height (cm)	166.91 ± 9.66	159.63 ± 6.28	146.409	<0.001	0.164	73.391	<0.001	0.165	73.579	<0.001	0.165	73.281	<0.001	0.165
Waist girth (cm)	72.59 ± 9.18	66.58 ± 7.15	98.236	<0.001	0.117	50.005	<0.001	0.119	489.182	<0.001	0.568	49.351	<0.001	0.117
Hip girth (cm)	90.61 ± 10.10	90.90 ± 7.99	0.194	0.659	0.001	0.382	0.683	0.001	277.267	<0.001	0.427	1.227	0.294	0.003
Waist/Hip ratio	0.80 ± 0.05	0.73; 0.04	454.176	<0.001	0.379	227.505	<0.001	0.380	276.630	<0.001	0.427	228.429	<0.001	0.381
Sum 3 skinfolds (cm)	44.72 ± 25.71	59.12 ± 22.16	66.624	<0.001	0.082	35.118	<0.001	0.086	271.552	<0.001	0.422	35.238	<0.001	0.087
Corrected arm girth (cm)	22.58 ± 3.07	20.00 ± 2.28	163.373	<0.001	0.180	81.945	<0.001	0.181	191.159	<0.001	0.340	81.605	<0.001	0.180
Corrected thigh girth (cm)	41.96 ± 5.17	38.27 ± 3.84	118.886	<0.001	0.138	61.506	<0.001	0.142	138.021	<0.001	0.271	60.491	<0.001	0.140
Corrected calf girth (cm)	30.41 ± 2.97	28.21 ± 3.17	94.370	<0.001	0.113	47.905	<0.001	0.114	75.962	<0.001	0.170	47.183	<0.001	0.113
Fat mass (%)	20.31 ± 11.30	25.49 ± 8.28	50.300	<0.001	0.063	27.210	<0.001	0.068	262.921	<0.001	0.414	27.395	<0.001	0.069
Muscle mass (kg)	22.09 ± 4.79	15.62 ± 2.83	490.082	<0.001	0.397	245.723	<0.001	0.398	363.749	<0.001	0.495	245.806	<0.001	0.398
Life satisfaction	18.37 ± 4.26	17.50 ± 4.78	7.016	0.008	0.009	8.739	<0.001	0.023	3.523	0.030	0.009	8.473	<0.001	0.022
Competence	27.97 ± 6.73	25.81 ± 7.07	18.211	<0.001	0.024	45.339	<0.001	0.109	9.432	<0.001	0.025	18.706	<0.001	0.048
Autonomy	26.22 ± 6.24	25.15 ± 6.29	5.424	0.020	0.007	15.606	<0.001	0.040	2.732	0.066	0.007	9.624	<0.001	0.025
Relatedness	25.04 ± 6.00	24.46 ± 6.03	1.759	0.185	0.002	10.353	<0.001	0.027	1.030	0.357	0.003	9.485	<0.001	0.025
VO_2 max.	42.27 ± 5.60	36.89 ± 4.41	209.870	<0.001	0.220	138.551	<0.001	0.272	133.079	<0.001	0.264	107.825	<0.001	0.225
Handgrip right arm	30.52 ± 9.02	22.71 ± 4.89	211.228	<0.001	0.221	106.201	<0.001	0.222	123.703	<0.001	0.250	105.690	<0.001	0.221
Handgrip left arm	28.48 ± 8.17	21.00 ± 4.22	241.497	<0.001	0.245	120.912	<0.001	0.246	137.521	<0.001	0.270	121.681	<0.001	0.247
Sit-and-reach	12.81 ± 7.51	19.20 ± 8.81	114.365	<0.001	0.133	60.241	<0.001	0.140	57.193	<0.001	0.133	57.135	<0.001	0.133
CMJ	26.38 ± 7.46	20.77 ± 5.01	142.791	<0.001	0.161	78.631	<0.001	0.175	94.606	<0.001	0.203	71.370	<0.001	0.161
20-m sprint	3.72 ± 0.54	4.15 ± 0.43	144.494	<0.001	0.163	78.866	<0.001	0.175	81.831	<0.001	0.181	72.158	<0.001	0.163
Physical activity level	2.83 ± 0.63	2.48 ± 0.61	59.888	<0.001	0.075	-	-	-	30.910	<0.001	0.078	50.447	<0.001	0.121
AMD	2.23 ± 0.66	2.26 ± 0.63	0.377	0.540	0.001	22.097	<0.001	0.053	0.371	0.690	0.001	-	-	-
BMI (kg/m²)	21.53 ± 4.15	21.03 ± 3.61	3.021	0.083	0.004	1.623	0.198	0.004	-	-	-	2.340	0.097	0.006

BMI: body mass index; AMD; adherence to Mediterranean diet; CMJ: countermovement jump; VO_2 max.: maximum oxygen consumption.

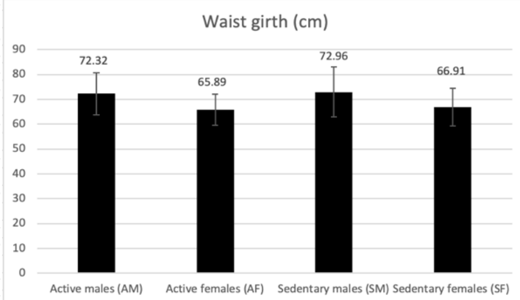
Figure 1. Differences in anthropometric, psychological, and physical fitness variables between males and females with different physical activity statuses.



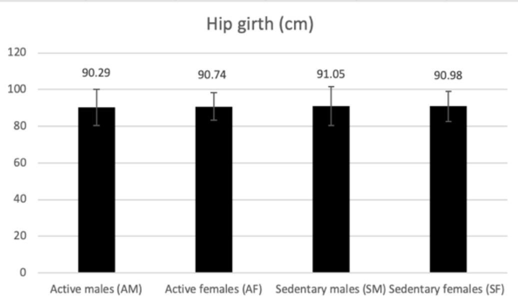
AM vs SM: Mean Diff: −1.172; p=0.373; 95% CI Diff: −1.406; 3.750
AM vs AF: Mean Diff: 6.736; p<0.001; 95% CI Diff: 3.863; 9.608
AM vs SF: Mean Diff: 6.131; p<0.001; 95% CI Diff: 3.009; 9.254
AF vs SM: Mean Diff: −7.907; p<0.001; 95% CI Diff: −12.017; −3.798
AF vs SF: Mean Diff: −0.604; p=0.676; 95% CI Diff: −3.437; 2.228
SM vs SF: Mean Diff: 7.303; p<0.001; 95% CI Diff: 4.770; 9.836



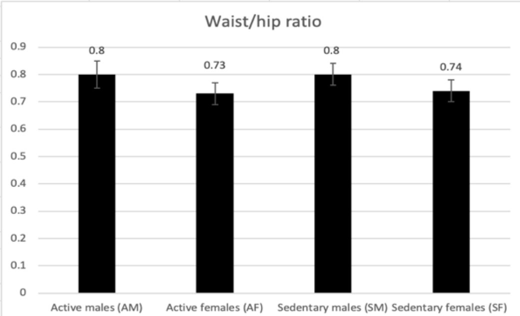
AM vs SM: Mean Diff: −1.059; p=1.000; 95% CI Diff: −3.295; 1.178
AM vs AF: Mean Diff: 6.612; p<0.001; 95% CI Diff: 4.120; 9.104
AM vs SF: Mean Diff: 6.937; p<0.001; 95% CI Diff: 4.927; 8.947
AF vs SM: Mean Diff: −7.671; p<0.001; 95% CI Diff: −10.316; −5.025
AF vs SF: Mean Diff: 0.325; p=1.000; 95% CI Diff: −2.132; 2.782
SM vs SF: Mean Diff: 7.996; p<0.001; 95% CI Diff: 5.798; 10.193



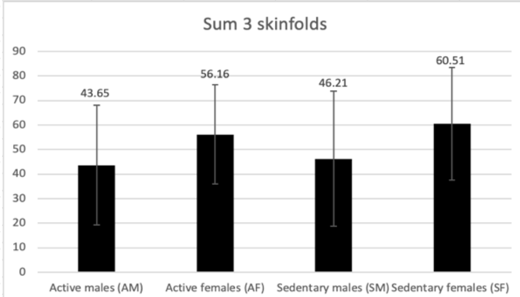
AM vs SM: Mean Diff: −0.646; p=1.000; 95% CI Diff: −2.897; 1.606
AM vs AF: Mean Diff: 6.426; p<0.001; 95% CI Diff: 3.917; 8.935
AM vs SF: Mean Diff: 5.404; p<0.001; 95% CI Diff: 3.380; 7.428
AF vs SM: Mean Diff: −7.072; p<0.001; 95% CI Diff: −9.735; −4.409
AF vs SF: Mean Diff: −1.022; p=1.000; 95% CI Diff: −3.496; 1.452
SM vs SF: Mean Diff: 6.050; p<0.001; 95% CI Diff: 3.838; 8.262



AM vs SM: Mean Diff: −0.764; p=1.000; 95% CI Diff: −3.257; 1.730
AM vs AF: Mean Diff: −0.455; p=1.000; 95% CI Diff: −3.234; 2.323
AM vs SF: Mean Diff: −0.694; p=1.000; 95% CI Diff: −2.935; 1.548
AF vs SM: Mean Diff: −0.308; p=1.000; 95% CI Diff: −3.258; 2.641
AF vs SF: Mean Diff: −0.238; p=1.000; 95% CI Diff: −2.978; 2.501
SM vs SF: Mean Diff: 0.070; p=1.000; 95% CI Diff: −2.380; 2.520

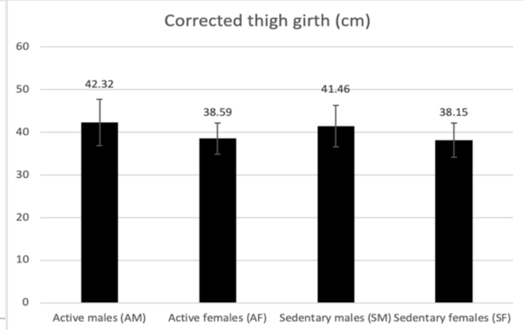


AM vs SM: Mean Diff: 0.001; p=1.000; 95% CI Diff: −0.011; 0.013
AM vs AF: Mean Diff: 0.075; p<0.001; 95% CI Diff: 0.062; 0.089
AM vs SF: Mean Diff: 0.067; p<0.001; 95% CI Diff: 0.056; 0.078
AF vs SM: Mean Diff: −0.074; p<0.001; 95% CI Diff: −0.088; −0.060
AF vs SF: Mean Diff: −0.009; p=0.512; 95% CI Diff: −0.022; 0.005
SM vs SF: Mean Diff: 0.065; p<0.001; 95% CI Diff: 0.054; 0.077

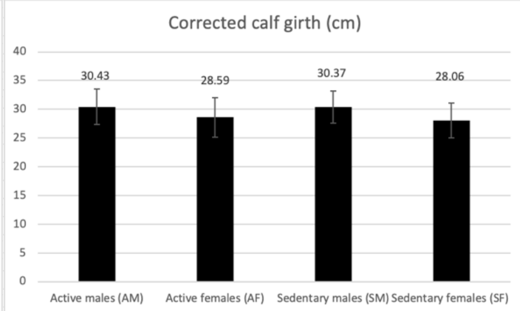


AM vs SM: Mean Diff: −2.561; p=1.000; 95% CI Diff: −9.109; 3.987
AM vs AF: Mean Diff: −12.517; p<0.001; 95% CI Diff: −19.813; −5.221
AM vs SF: Mean Diff: −16.868; p<0.001; 95% CI Diff: −22.753; −10.983
AF vs SM: Mean Diff: 9.956; p<0.004; 95% CI Diff: 2.211; 17.702
AF vs SF: Mean Diff: −4.351; p=0.660; 95% CI Diff: −11.545; 2.843
SM vs SF: Mean Diff: −14.307; p<0.001; 95% CI Diff: −20.741; −7.873

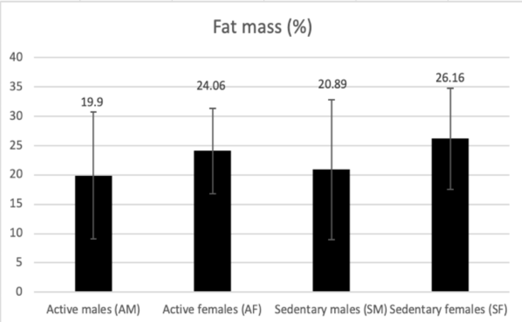
AM vs SM: Mean Diff: 0.145; p=1.000; 95% CI Diff: −0.597; 0.887
AM vs AF: Mean Diff: 2.488; p<0.001; 95% CI Diff: 1.661; 3.315
AM vs SF: Mean Diff: 2.670; p<0.001; 95% CI Diff: 2.003; 3.337
AF vs SM: Mean Diff: −2.343; p<0.001; 95% CI Diff: −3.221; −1.465
AF vs SF: Mean Diff: 0.182; p=1.000; 95% CI Diff: −0.634; 0.997
SM vs SF: Mean Diff: 2.525; p<0.001; 95% CI Diff: 1.795; 3.254



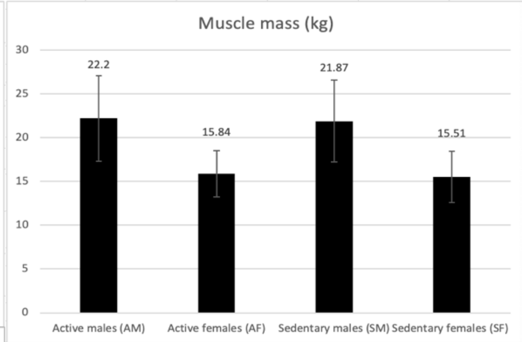
AM vs SM: Mean Diff: 0.865; p=0.402; 95% CI Diff: −0.383; 2.114
AM vs AF: Mean Diff: 3.735; p<0.001; 95% CI Diff: 2.344; 5.126
AM vs SF: Mean Diff: 4.171; p<0.001; 95% CI Diff: 3.049; 5.292
AF vs SM: Mean Diff: −2.870; p<0.001; 95% CI Diff: −4.346; −1.393
AF vs SF: Mean Diff: 0.435; p=1.000; 95% CI Diff: −0.936; 1.807
SM vs SF: Mean Diff: 3.305; p<0.001; 95% CI Diff: 2.079; 4.532



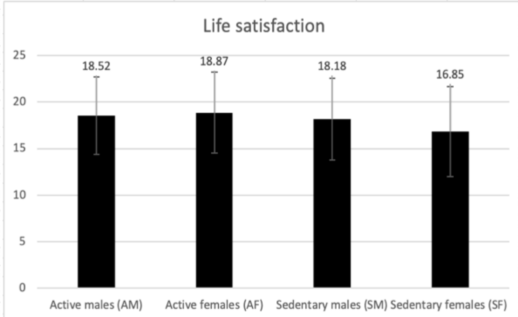
AM vs SM: Mean Diff: 0.059; p=1.000; 95% CI Diff: −0.775; 0.892
AM vs AF: Mean Diff: 1.839; p<0.001; 95% CI Diff: 0.910; 2.768
AM vs SF: Mean Diff: 2.375; p<0.001; 95% CI Diff: 1.626; 3.124
AF vs SM: Mean Diff: −1.780; p<0.001; 95% CI Diff: −2.766; −0.795
AF vs SF: Mean Diff: 0.536; p=0.730; 95% CI Diff: −0.379; 1.452
SM vs SF: Mean Diff: 2.317; p<0.001; 95% CI Diff: 1.498; 3.135



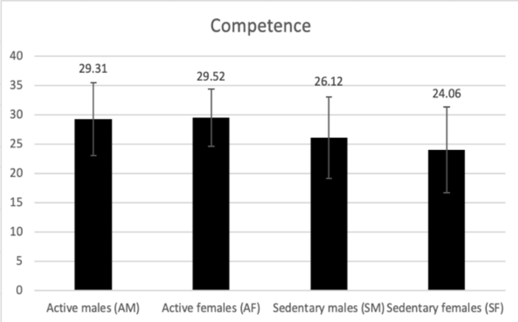
AM vs SM: Mean Diff: −1.001; p=1.000; 95% CI Diff: −3.710; 1.708
AM vs AF: Mean Diff: −4.171; p=0.002; 95% CI Diff: −7.189; −1.153
AM vs SF: Mean Diff: −6.272; p<0.001; 95% CI Diff: −8.707; −3.837
AF vs SM: Mean Diff: 3.170; p=0.054; 95% CI Diff: −0.034; 6.374
AF vs SF: Mean Diff: −2.101; p=0.373; 95% CI Diff: −5.077; 0.875
SM vs SF: Mean Diff: −5.271; p<0.001; 95% CI Diff: −7.932; −2.609



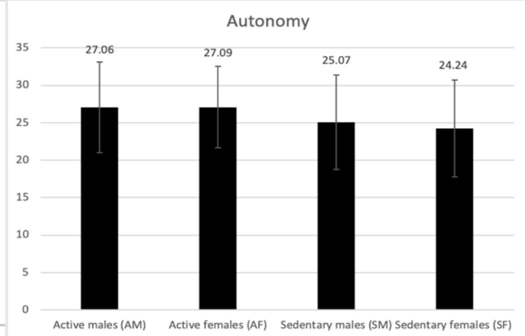
AM vs SM: Mean Diff: 0.335; p=1.000; 95% CI Diff: −0.748; 1.418
AM vs AF: Mean Diff: 6.361; p<0.001; 95% CI Diff: 5.155; 7.568
AM vs SF: Mean Diff: 6.695; p<0.001; 95% CI Diff: 5.722; 7.669
AF vs SM: Mean Diff: −6.027; p<0.001; 95% CI Diff: −7.308; −4.746
AF vs SF: Mean Diff: 0.334; p=1.000; 95% CI Diff: −0.856; 1.524
SM vs SF: Mean Diff: 6.360; p<0.001; 95% CI Diff: 5.296; 7.425



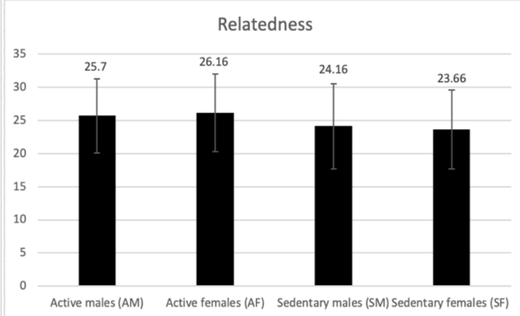
AM vs SM: Mean Diff: 0.340; p=1.000; 95% CI Diff: −0.878; 1.557
AM vs AF: Mean Diff: −0.352; p=1.000; 95% CI Diff: −1.708; 1.005
AM vs SF: Mean Diff: 1.665; p<0.001; 95% CI Diff: 0.571; 2.760
AF vs SM: Mean Diff: 0.692; p=1.000; 95% CI Diff: −0.748; 2.132
AF vs SF: Mean Diff: 2.017; p<0.001; 95% CI Diff: 0.680; 3.355
SM vs SF: Mean Diff: 1.325; p=0.021; 95% CI Diff: 0.129; 2.522



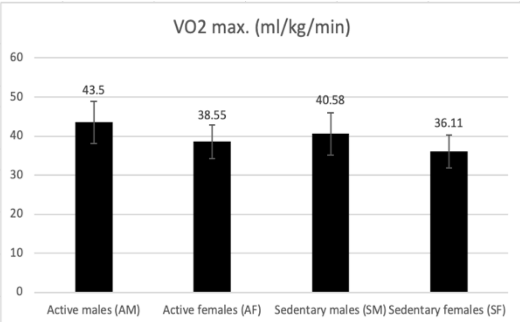
AM vs SM: Mean Diff: 3.196; p<0.001; 95% CI Diff: 1.406; 4.986
AM vs AF: Mean Diff: −0.209; p=1.000; 95% CI Diff: −2.204; 1.786
AM vs SF: Mean Diff: 5.251; p<0.001; 95% CI Diff: 3.642; 6.860
AF vs SM: Mean Diff: 3.405; p<0.001; 95% CI Diff: 1.287; 5.523
AF vs SF: Mean Diff: 5.460; p<0.001; 95% CI Diff: 3.493; 7.427
SM vs SF: Mean Diff: 2.055; p=0.012; 95% CI Diff: 0.296; 3.814



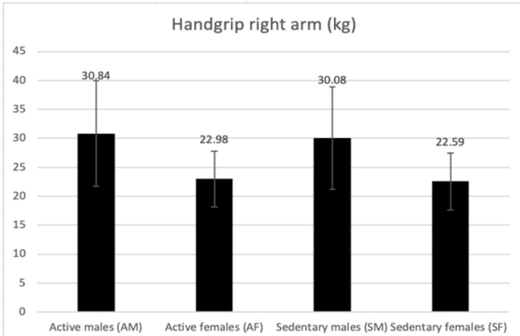
AM vs SM: Mean Diff: 1.984; p=0.011; 95% CI Diff: 0.306; 3.663
AM vs AF: Mean Diff: −0.029; p=1.000; 95% CI Diff: −1.899; 1.841
AM vs SF: Mean Diff: 2.816; p<0.001; 95% CI Diff: 1.308; 4.325
AF vs SM: Mean Diff: 2.013; p=0.045; 95% CI Diff: 0.028; 3.999
AF vs SF: Mean Diff: 2.845; p<0.001; 95% CI Diff: 1.001; 4.689
SM vs SF: Mean Diff: 0.832; p=1.000; 95% CI Diff: −0.818; 2.481



AM vs SM: Mean Diff: 1.528; p=0.076; 95% CI Diff: −0.090; 3.146
AM vs AF: Mean Diff: −0.469; p=1.000; 95% CI Diff: −2.272; 1.334
AM vs SF: Mean Diff: 2.028; p=0.001; 95% CI Diff: 0.573; 3.482
AF vs SM: Mean Diff: 1.997; p=0.036; 95% CI Diff: 0.083; 3.911
AF vs SF: Mean Diff: 2.497; p=0.001; 95% CI Diff: 0.719; 4.274
SM vs SF: Mean Diff: 0.500; p=1.000; 95% CI Diff: −1.090; 2.090

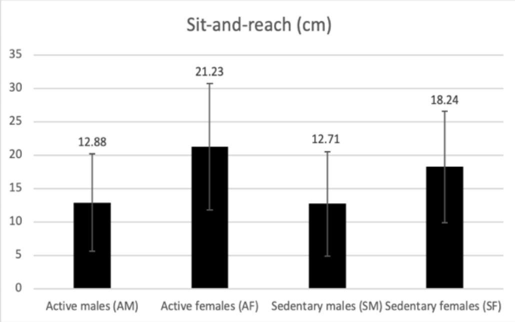


AM vs SM: Mean Diff: 2.921; p<0.001; 95% CI Diff: 1.587; 4.254
AM vs AF: Mean Diff: 4.943; p<0.001; 95% CI Diff: 3.457; 6.428
AM vs SF: Mean Diff: 7.384; p<0.001; 95% CI Diff: 6.186; 8.583
AF vs SM: Mean Diff: −2.022; p=0.004; 95% CI Diff: −3.599; −0.445
AF vs SF: Mean Diff: 2.442; p<0.001; 95% CI Diff: 0.977; 3.907
SM vs SF: Mean Diff: 4.464; p<0.001; 95% CI Diff: 3.154; 5.774

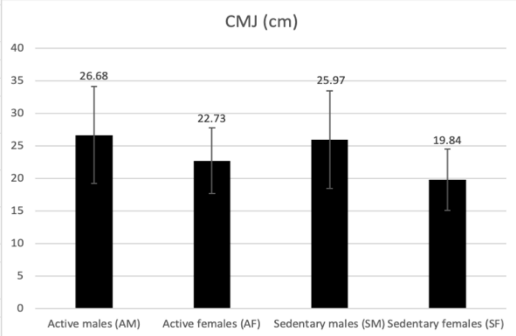


AM vs SM: Mean Diff: 0.762; p=1.000; 95% CI Diff: −1.235; 2.759
AM vs AF: Mean Diff: 7.860; p<0.001; 95% CI Diff: 5.635; 10.086
AM vs SF: Mean Diff: 8.253; p<0.001; 95% CI Diff: 6.458; 10.049
AF vs SM: Mean Diff: −7.098; p<0.001; 95% CI Diff: −9.461; −4.736
AF vs SF: Mean Diff: 0.393; p=1.000; 95% CI Diff: −1.801; 2.588
SM vs SF: Mean Diff: 7.491; p<0.001; 95% CI Diff: 5.529; 9.454

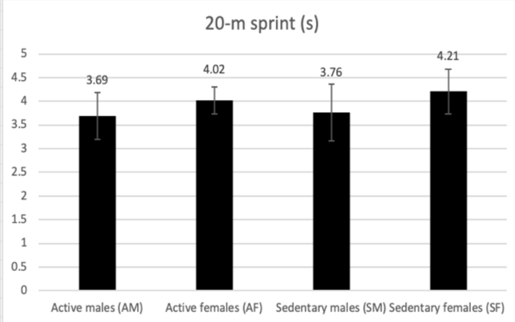
AM vs SM: Mean Diff: 0.492; p=1.000; 95% CI Diff: −1.300; 2.284
AM vs AF: Mean Diff: 7.570; p<0.001; 95% CI Diff: 5.573; 9.567
AM vs SF: Mean Diff: 7.750; p<0.001; 95% CI Diff: 6.140; 9.361
AF vs SM: Mean Diff: −7.078; p<0.001; 95% CI Diff: −9.198; −4.958
AF vs SF: Mean Diff: 0.180; p=1.000; 95% CI Diff: −1.788; 2.149
SM vs SF: Mean Diff: 7.258; p<0.001; 95% CI Diff: 5.497; 9.019



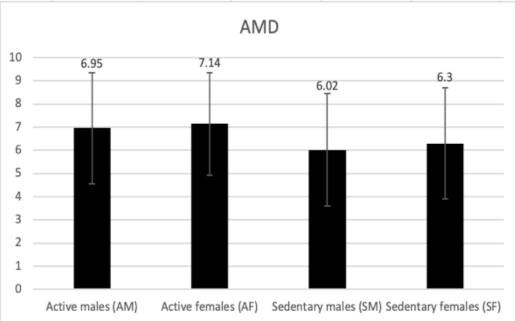
AM vs SM: Mean Diff: 0.164; p=1.000; 95% CI Diff: −2.046; 2.374
AM vs AF: Mean Diff: −8.359; p<0.001; 95% CI Diff: −10.822; −5.897
AM vs SF: Mean Diff: −5.369; p<0.001; 95% CI Diff: −7.355; −3.382
AF vs SM: Mean Diff: 8.523; p<0.001; 95% CI Diff: 5.909; 11.137
AF vs SF: Mean Diff: 2.991; p=0.007; 95% CI Diff: 0.562; 5.419
SM vs SF: Mean Diff: −5.533; p<0.001; 95% CI Diff: −7.704; −3.361



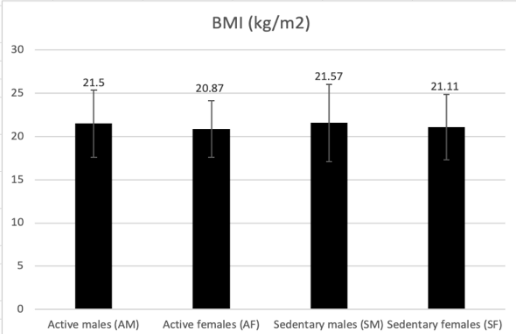
AM vs SM: Mean Diff: 0.711; p=1.000; 95% CI Diff: −1.015; 2.437
AM vs AF: Mean Diff: 3.944; p<0.001; 95% CI Diff: 2.020; 5.867
AM vs SF: Mean Diff: 6.831; p<0.001; 95% CI Diff: 5.280; 8.383
AF vs SM: Mean Diff: −3.233; p<0.001; 95% CI Diff: −5.275; −1.191
AF vs SF: Mean Diff: 2.888; p<0.001; 95% CI Diff: 0.991; 4.784
SM vs SF: Mean Diff: 6.120; p<0.001; 95% CI Diff: 4.424; 7.817



AM vs SM: Mean Diff: −0.069; p=0.994; 95% CI Diff: −0.202; 0.063
AM vs AF: Mean Diff: −0.331; p<0.001; 95% CI Diff: −0.478; −0.184
AM vs SF: Mean Diff: −0.521; p<0.001; 95% CI Diff: −0.640; −0.402
AF vs SM: Mean Diff: 0.262; p<0.001; 95% CI Diff: 0.105; 0.418
AF vs SF: Mean Diff: −0.190; p=0.003; 95% CI Diff: −0.335; −0.045
SM vs SF: Mean Diff: −0.452; p<0.001; 95% CI Diff: −0.582; −0.322



AM vs SM: Mean Diff: 0.932; p=0.001; 95% CI Diff: 0.287; 1.578
AM vs AF: Mean Diff: −0.188; p=1.000; 95% CI Diff: −0.908; 0.532
AM vs SF: Mean Diff: 0.656; p=0.017; 95% CI Diff: 0.075; 1.236
AF vs SM: Mean Diff: 1.121; p=0.001; 95% CI Diff: 0.357; 1.885
AF vs SF: Mean Diff: 0.844; p=0.010; 95% CI Diff: 0.134; 1.554
SM vs SF: Mean Diff: −0.277; p=1.000; 95% CI Diff: −0.911; 0.358



AM vs SM: Mean Diff: −0.064; p=1.000; 95% CI Diff: −1.127; 0.998
AM vs AF: Mean Diff: 0.629; p=0.962; 95% CI Diff: −0.555; 1.814
AM vs SF: Mean Diff: 0.394; p=1.000; 95% CI Diff: −0.561; 1.349
AF vs SM: Mean Diff: −0.694; p=0.869; 95% CI Diff: −1.951; 0.564
AF vs SF: Mean Diff: −0.235; p=1.000; 95% CI Diff: −1.403; 0.932
SM vs SF: Mean Diff: 0.458; p=1.000; 95% CI Diff: −0.586; 1.503

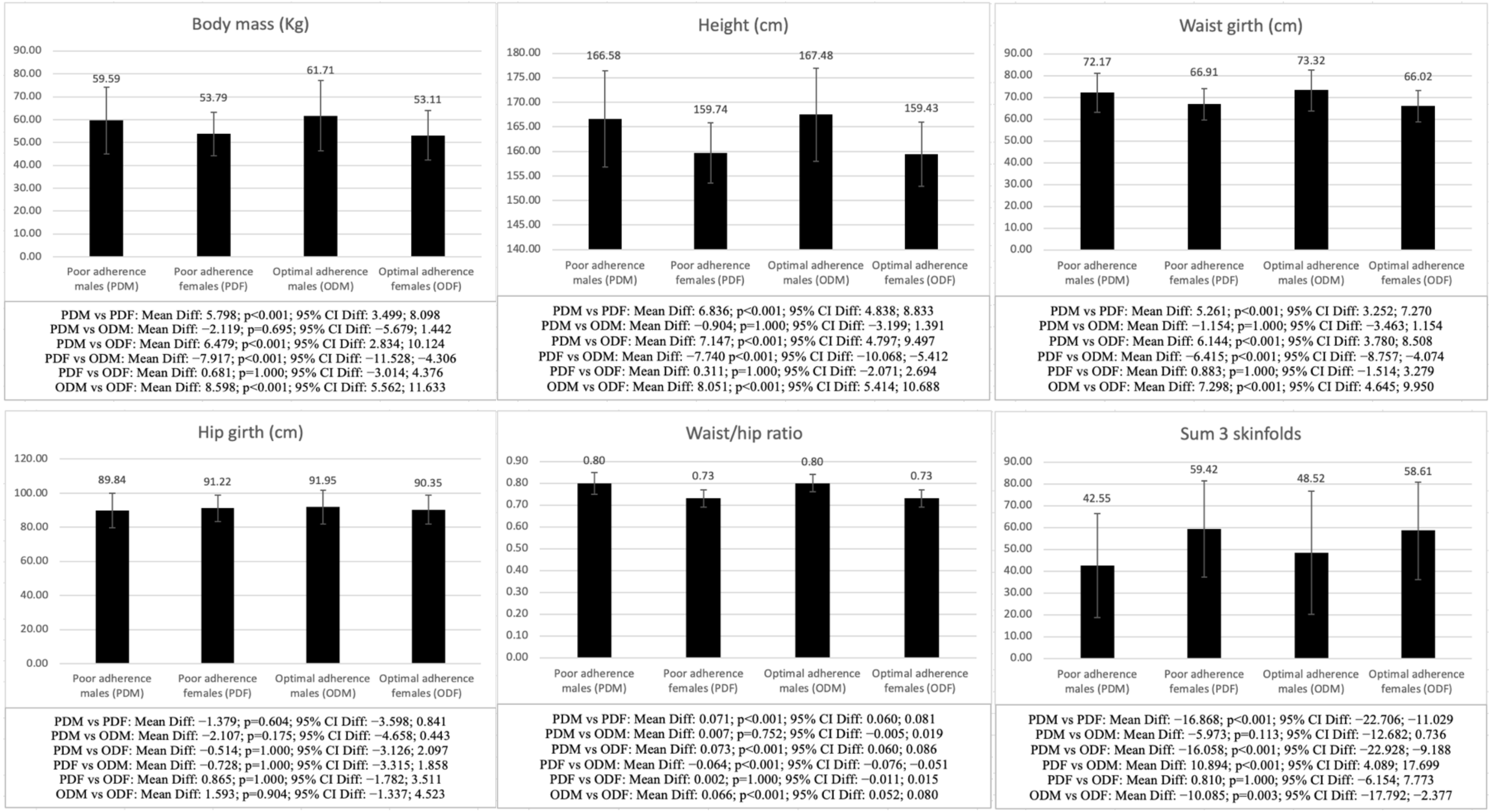
When comparing males and females with a similar level of physical activity (SM vs. SF and AM vs. AF), significant differences were observed in both active and inactive groups in all the variables analyzed, except for hip girth (SM vs. SF: $p = 1.000$; AM vs. AF: $p = 1.000$), autonomy (SM vs. SF: $p = 1.000$; AM vs. AF: $p = 1.000$), relatedness (SM vs. SF: $p = 1.000$; AM vs. AF: $p = 1.000$), AMD (SM vs. SF: $p = 1.000$; AM vs. AF: $p = 1.000$), and BMI (SM vs. SF: $p = 1.000$; AM vs. AF: $p = 0.962$), as well as life satisfaction (AM vs. AF: $p = 1.000$) and competence (AM vs. AF: $p = 1.000$) in the groups of active adolescents, in which no significant differences were found. The males in both groups showed higher scores in the anthropometric (SM vs. SF: $p < 0.001$; AM vs. AF: $p < 0.001$), psychological (SM vs. SF: competence $p = 0.012$, life satisfaction $p = 0.021$), and physical fitness (SM vs. SF: $p < 0.001$; AM vs. AF: $p < 0.001$) values, except for the sum of 3 skinfolds (SM vs. SF: $p < 0.001$; AM vs. AF: $p < 0.001$), fat mass (SM vs. SF: $p < 0.001$; AM vs. AF: $p = 0.002$) and sit-and-reach test (SM vs. SF: $p < 0.001$; AM vs. AF: $p < 0.001$), for which the females showed higher values.

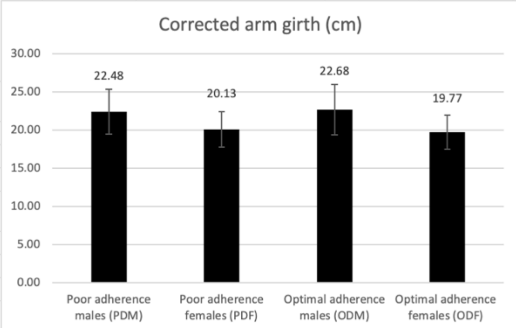
Regarding the comparison of AM vs. SF, significant differences were found in all the analyzed variables, except for hip girth ($p = 1.000$) and BMI ($p = 1.000$), with AM showing higher scores ($p < 0.001$), except in the sum of 3 skinfolds ($p < 0.001$), fat mass ($p < 0.001$) and sit-and-reach test ($p < 0.001$); while for the AF vs. SM comparison, the differences were significant in all the variables, except for hip girth ($p = 1.000$), fat mass ($p = 0.054$), life satisfaction ($p = 1.000$), and BMI ($p = 0.869$), with the SM showing higher values in the anthropometric ($p < 0.001$) and physical fitness variables ($p < 0.001$), except for the sum of 3 skinfolds ($p = 0.004$) and-sit-and reach test ($p < 0.001$), while AF showed higher scores in basic psychological needs (competence: $p < 0.001$; autonomy: $p = 0.045$; relatedness: $p = 0.036$) and AMD ($p = 0.001$).

5.4.4. Differences between male and female adolescents with different AMD in anthropometric variables, psychological variables, physical fitness variables, physical activity level, and weight status

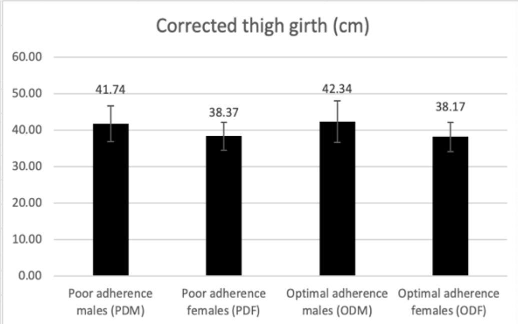
Figure 2 shows the differences between PDM, ODM, PDF, and ODF. The differences between males with different AMD (PDM vs. ODM) were significant in relatedness ($p = 0.035$) and physical activity level ($p < 0.001$), while in females with different AMD (PDF vs. ODF), the differences were significant in competence ($p =$

Figure 2. Differences in psychological, anthropometric, and physical fitness variables between males and females with different adherence to the Mediterranean diet.

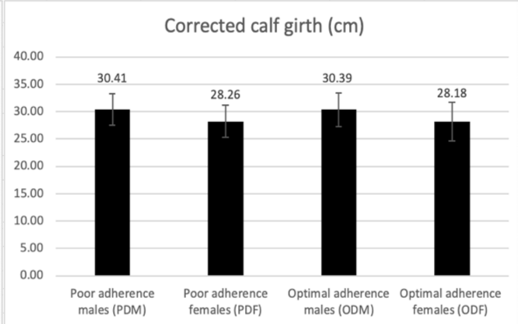




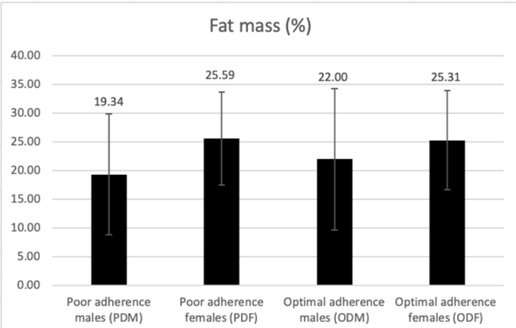
PDM vs PDF: Mean Diff: 2.343; p<0.001; 95% CI Diff: 1.681; 3.006
PDM vs ODM: Mean Diff: −0.206; p=1.000; 95% CI Diff: −0.967; 0.555
PDM vs ODF: Mean Diff: 2.706; p<0.001; 95% CI Diff: 1.926; 3.485
PDF vs ODM: Mean Diff: −2.549; p<0.001; 95% CI Diff: −3.321; −1.778
PDF vs ODF: Mean Diff: 0.362; p=1.000; 95% CI Diff: −0.428; 1.152
ODM vs ODF: Mean Diff: 2.912; p<0.001; 95% CI Diff: 2.038; 3.786



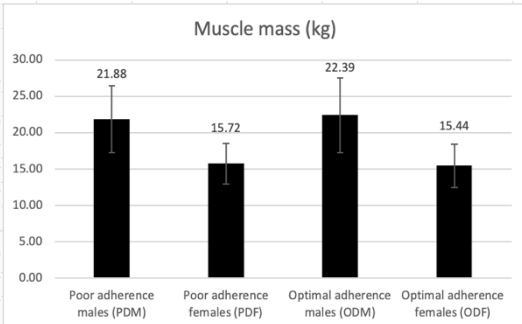
PDM vs PDF: Mean Diff: 3.375; p<0.001; 95% CI Diff: 2.259; 4.491
PDM vs ODM: Mean Diff: −0.601; p=1.000; 95% CI Diff: −1.884; 0.681
PDM vs ODF: Mean Diff: 3.574; p<0.001; 95% CI Diff: 2.261; 4.887
PDF vs ODM: Mean Diff: −3.976; p<0.001; 95% CI Diff: −5.277; −2.675
PDF vs ODF: Mean Diff: 0.199; p=1.000; 95% CI Diff: −1.132; 1.530
ODM vs ODF: Mean Diff: 4.175; p<0.001; 95% CI Diff: 2.702; 5.649



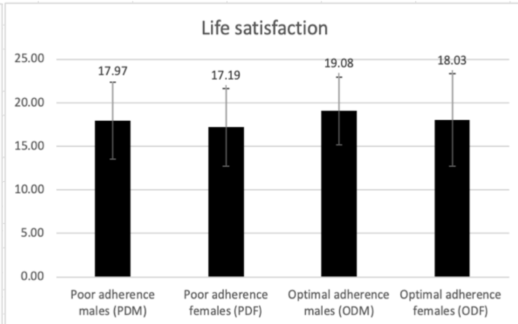
PDM vs PDF: Mean Diff: 2.158; p<0.001; 95% CI Diff: 1.413; 2.904
PDM vs ODM: Mean Diff: 0.023; p=1.000; 95% CI Diff: −0.833; 0.880
PDM vs ODF: Mean Diff: 2.237; p<0.001; 95% CI Diff: 1.360; 3.114
PDF vs ODM: Mean Diff: −2.135; p<0.001; 95% CI Diff: −3.004; −1.267
PDF vs ODF: Mean Diff: 0.079; p=1.000; 95% CI Diff: −0.810; 0.968
ODM vs ODF: Mean Diff: 2.214; p<0.001; 95% CI Diff: 1.230; 3.198



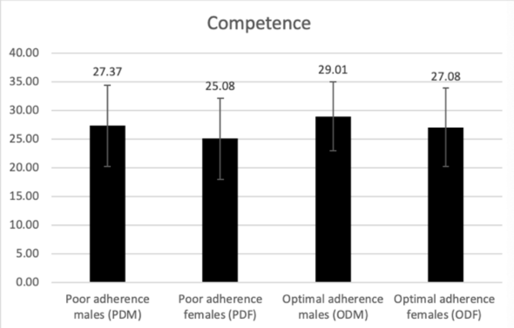
PDM vs PDF: Mean Diff: −6.247; p<0.001; 95% CI Diff: −8.662; −3.831
PDM vs ODM: Mean Diff: −2.659; p=0.069; 95% CI Diff: −5.434; 0.116
PDM vs ODF: Mean Diff: −5.971; p<0.001; 95% CI Diff: −8.813; −3.129
PDF vs ODM: Mean Diff: 3.588; p=0.005; 95% CI Diff: 0.773; 6.403
PDF vs ODF: Mean Diff: 0.276; p=1.000; 95% CI Diff: −2.604; 3.157
ODM vs ODF: Mean Diff: −3.312; p=0.037; 95% CI Diff: −6.500; −0.123



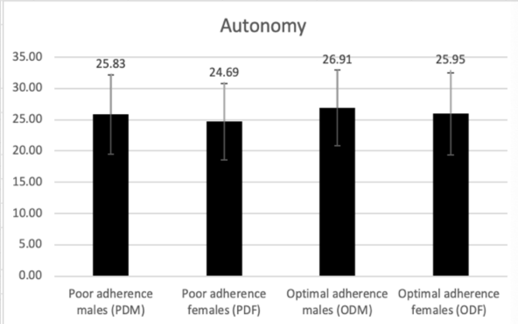
PDM vs PDF: Mean Diff: 6.158; p<0.001; 95% CI Diff: 5.192; 7.125
PDM vs ODM: Mean Diff: −0.510; p=1.000; 95% CI Diff: −1.621; 0.601
PDM vs ODF: Mean Diff: 6.441; p<0.001; 95% CI Diff: 5.304; 7.579
PDF vs ODM: Mean Diff: −6.668; p<0.001; 95% CI Diff: −7.795; −5.542
PDF vs ODF: Mean Diff: 0.283; p=1.000; 95% CI Diff: −0.869; 1.436
ODM vs ODF: Mean Diff: 6.951; p<0.001; 95% CI Diff: 5.675; 8.227



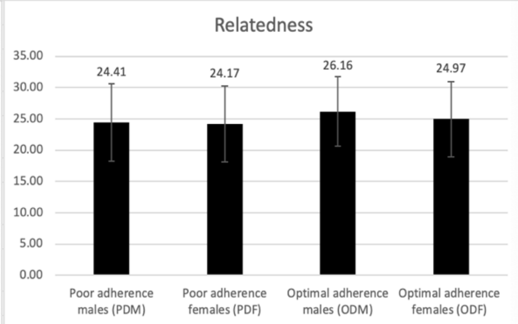
PDM vs PDF: Mean Diff: 0.779; p=0.359; 95% CI Diff: −0.314; 1.872
PDM vs ODM: Mean Diff: −1.106; p=0.120; 95% CI Diff: −2.362; 0.149
PDM vs ODF: Mean Diff: −0.059; p=1.000; 95% CI Diff: −1.345; 1.227
PDF vs ODM: Mean Diff: −1.885; p=0.001; 95% CI Diff: −3.159; −0.611
PDF vs ODF: Mean Diff: −0.838; p=0.538; 95% CI Diff: −2.141; 0.466
ODM vs ODF: Mean Diff: 1.047; p=0.331; 95% CI Diff: −0.395; 2.490



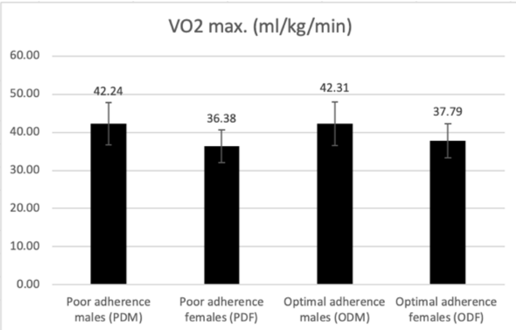
PDM vs PDF: Mean Diff: 2.287; p=0.002; 95% CI Diff: 0.621; 3.952
PDM vs ODM: Mean Diff: −1.637; p=0.143; 95% CI Diff: −3.551; 0.276
PDM vs ODF: Mean Diff: 0.294; p=1.000; 95% CI Diff: −1.666; 2.253
PDF vs ODM: Mean Diff: −3.924; p<0.001; 95% CI Diff: −5.864; −1.983
PDF vs ODF: Mean Diff: −1.993; p=0.049; 95% CI Diff: −3.979; −0.007
ODM vs ODF: Mean Diff: 1.931; p=0.123; 95% CI Diff: −0.267; 4.129



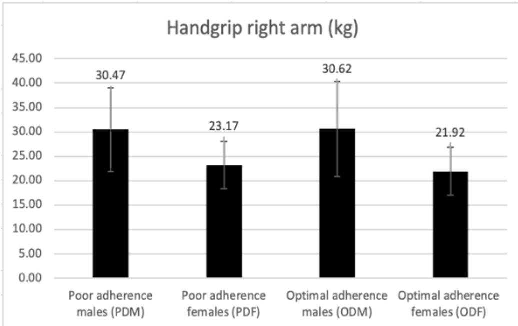
PDM vs PDF: Mean Diff: 1.132; p=0.294; 95% CI Diff: −0.387; 2.651
PDM vs ODM: Mean Diff: −1.090; p=0.594; 95% CI Diff: −2.835; 0.656
PDM vs ODF: Mean Diff: −0.129; p=1.000; 95% CI Diff: −1.916; 1.658
PDF vs ODM: Mean Diff: −2.222; p=0.006; 95% CI Diff: −3.992; −0.452
PDF vs ODF: Mean Diff: −1.261; p=0.396; 95% CI Diff: −3.073; 0.550
ODM vs ODF: Mean Diff: 0.961; p=1.000; 95% CI Diff: −1.045; 2.966



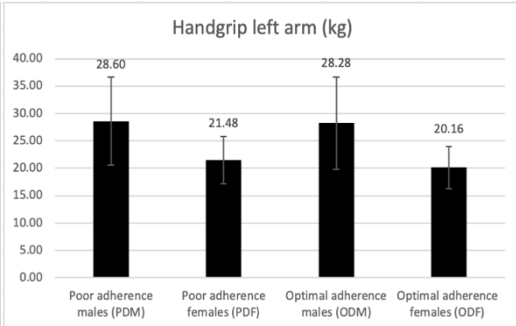
PDM vs PDF: Mean Diff: 0.240; p=1.000; 95% CI Diff: −1.215; 1.695
PDM vs ODM: Mean Diff: −1.750; p=0.035; 95% CI Diff: −3.422; −0.077
PDM vs ODF: Mean Diff: −0.563; p=1.000; 95% CI Diff: −2.275; 1.149
PDF vs ODM: Mean Diff: −1.989; p=0.012; 95% CI Diff: −3.685; −0.293
PDF vs ODF: Mean Diff: −0.803; p=1.000; 95% CI Diff: −2.538; 0.933
ODM vs ODF: Mean Diff: 1.187; p=0.616; 95% CI Diff: −0.734; 3.107



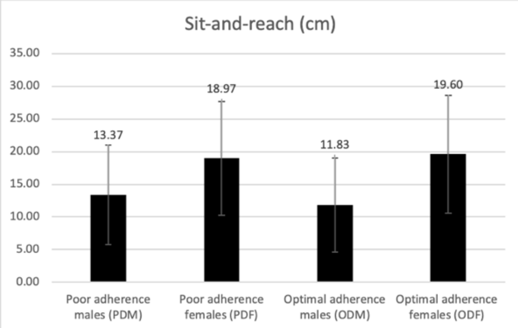
PDM vs PDF: Mean Diff: 5.861; p<0.001; 95% CI Diff: 4.634; 7.087
PDM vs ODM: Mean Diff: −0.071; p=1.000; 95% CI Diff: −1.480; 1.339
PDM vs ODF: Mean Diff: 4.451; p<0.001; 95% CI Diff: 3.008; 5.895
PDF vs ODM: Mean Diff: −5.931; p<0.001; 95% CI Diff: −7.361; −4.501
PDF vs ODF: Mean Diff: −1.409; p=0.066; 95% CI Diff: −2.872; 0.054
ODM vs ODF: Mean Diff: 4.522; p<0.001; 95% CI Diff: 2.902; 6.142



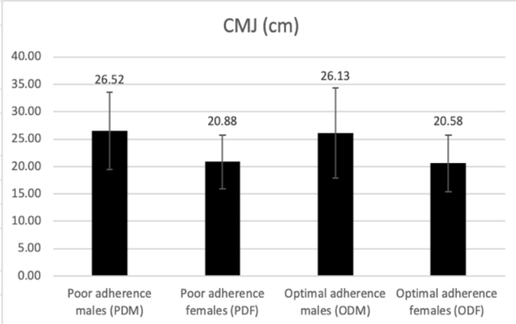
PDM vs PDF: Mean Diff: 7.293; p<0.001; 95% CI Diff: 5.511; 9.075
PDM vs ODM: Mean Diff: −0.152; p=1.000; 95% CI Diff: −2.200; 1.895
PDM vs ODF: Mean Diff: 8.548; p<0.001; 95% CI Diff: 6.451; 10.645
PDF vs ODM: Mean Diff: −7.445; p<0.001; 95% CI Diff: −9.522; −5.369
PDF vs ODF: Mean Diff: 1.255; p=0.712; 95% CI Diff: −0.870; 3.380
ODM vs ODF: Mean Diff: 8.700; p<0.001; 95% CI Diff: 6.348; 11.053



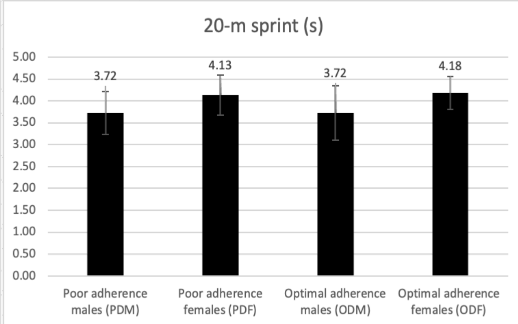
PDM vs PDF: Mean Diff: 7.122; p<0.001; 95% CI Diff: 5.525; 8.718
PDM vs ODM: Mean Diff: 0.317; p=1.000; 95% CI Diff: −1.518; 2.152
PDM vs ODF: Mean Diff: 8.435; p<0.001; 95% CI Diff: 6.556; 10.314
PDF vs ODM: Mean Diff: −6.805; p<0.001; 95% CI Diff: −8.666; −4.944
PDF vs ODF: Mean Diff: 1.314; p=0.411; 95% CI Diff: −0.591; 3.218
ODM vs ODF: Mean Diff: 8.118; p<0.001; 95% CI Diff: 6.010; 10.226



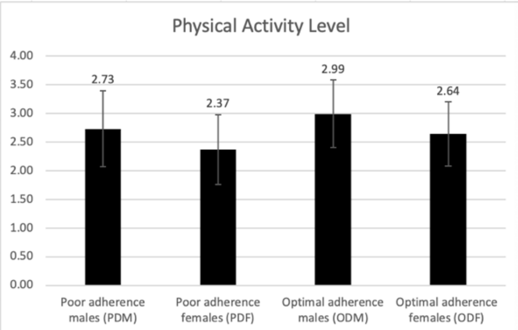
PDM vs PDF: Mean Diff: −5.605; p<0.001; 95% CI Diff: −7.588; −3.623
PDM vs ODM: Mean Diff: 1.542; p=0.442; 95% CI Diff: −0.736; 3.820
PDM vs ODF: Mean Diff: −6.232; p<0.001; 95% CI Diff: −8.564; −3.899
PDF vs ODM: Mean Diff: 7.147; p<0.001; 95% CI Diff: 4.837; 9.458
PDF vs ODF: Mean Diff: −0.626; p=1.000; 95% CI Diff: −2.991; 1.738
ODM vs ODF: Mean Diff: −7.774; p<0.001; 95% CI Diff: −10.391; −5.157



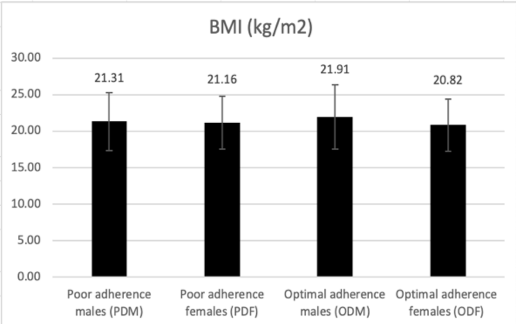
PDM vs PDF: Mean Diff: 5.638; p<0.001; 95% CI Diff: 4.079; 7.197
PDM vs ODM: Mean Diff: 0.386; p=1.000; 95% CI Diff: −1.405; 2.177
PDM vs ODF: Mean Diff: 5.938; p<0.001; 95% CI Diff: 4.104; 7.772
PDF vs ODM: Mean Diff: −5.252; p<0.001; 95% CI Diff: −7.069; −3.436
PDF vs ODF: Mean Diff: 0.300; p=1.000; 95% CI Diff: −1.559; 2.159
ODM vs ODF: Mean Diff: 5.552; p<0.001; 95% CI Diff: 3.494; 7.610



PDM vs PDF: Mean Diff: −0.411; p<0.001; 95% CI Diff: −0.531; −0.292
PDM vs ODM: Mean Diff: 0.004; p=1.000; 95% CI Diff: −0.133; 0.141
PDM vs ODF: Mean Diff: −0.461; p<0.001; 95% CI Diff: −0.601; −0.321
PDF vs ODM: Mean Diff: 0.416; p<0.001; 95% CI Diff: 0.277; 0.555
PDF vs ODF: Mean Diff: −0.049; p=1.000; 95% CI Diff: −0.191; 0.093
ODM vs ODF: Mean Diff: −0.465; p<0.001; 95% CI Diff: −0.622; −0.308



PDM vs PDF: Mean Diff: 0.355; p<0.001; 95% CI Diff: 0.205; 0.505
PDM vs ODM: Mean Diff: −0.263; p<0.001; 95% CI Diff: −0.436; −0.091
PDM vs ODF: Mean Diff: 0.082; p=1.000; 95% CI Diff: −0.095; 0.258
PDF vs ODM: Mean Diff: −0.618; p<0.001; 95% CI Diff: −0.793; −0.443
PDF vs ODF: Mean Diff: −0.273; p<0.001; 95% CI Diff: −0.452; −0.094
ODM vs ODF: Mean Diff: 0.345; p<0.001; 95% CI Diff: 0.147; 0.543



PDM vs PDF: Mean Diff: 0.153; p=1.000; 95% CI Diff: −0.795; 1.100
PDM vs ODM: Mean Diff: −0.600; p=0.871; 95% CI Diff: −1.689; 0.488
PDM vs ODF: Mean Diff: 0.495; p=1.000; 95% CI Diff: −0.620; 1.610
PDF vs ODM: Mean Diff: −0.753; p=0.430; 95% CI Diff: −1.857; 0.351
PDF vs ODF: Mean Diff: 0.342; p=1.000; 95% CI Diff: −0.788; 1.472
ODM vs ODF: Mean Diff: 1.095; p=0.125; 95% CI Diff: −0.155; 2.346

0.049) and physical activity level ($p < 0.001$), with males and females with optimal AMD showing higher scores.

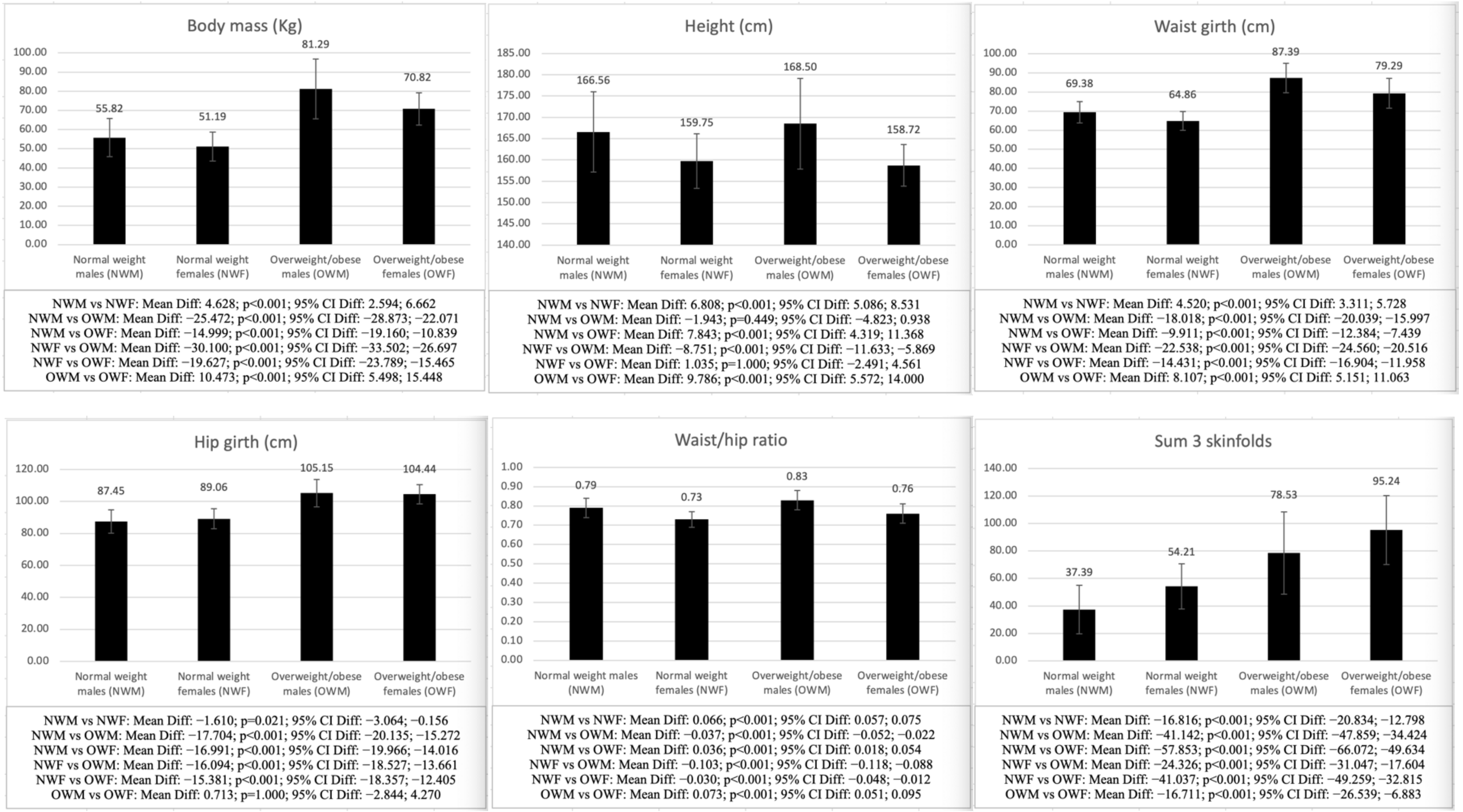
Significant differences were also found when comparing males and females with the same AMD (PDM vs. PDF and ODM vs. ODF), finding significant differences in all the analyzed variables, except for hip girth (PDM vs. PDF: $p = 0.604$; ODM vs. ODF: $p = 0.904$), life satisfaction (PDM vs. PDF: $p = 0.359$; ODM vs. ODF: $p = 0.331$), autonomy (PDM vs. PDF: $p = 0.294$; ODM vs. ODF: $p = 1.000$), relatedness (PDM vs. PDF: $p = 1.000$; ODM vs. ODF: $p = 0.616$), and BMI (PDM vs. PDF: $p = 1.000$; ODM vs. ODF: $p = 0.125$), as well as competence in the optimal AMD group (ODM vs. ODF: $p = 0.123$), with males in both the poor and optimal AMD groups showing higher scores in all the variables analyzed, except for the sum of 3 skinfolds (p < 0.001–0.003), fat mass (p < 0.001–0.037) and sit-and-reach test ($p < 0.001$), in which females showed higher scores.

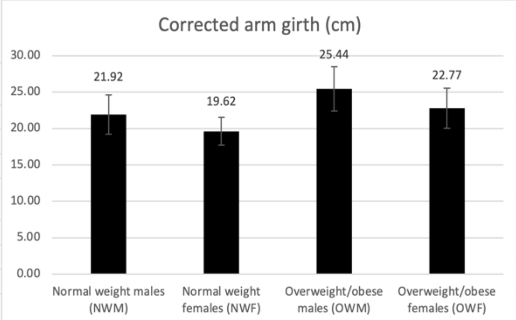
Regarding the comparison between PDF vs. ODM and PDM vs. ODF, the differences were significant between PDF vs. ODM in all the variables analyzed, except for hip girth ($p = 1.000$) and BMI ($p = 0.430$), while when comparing PDM vs. ODF, differences were found in all the variables analyzed, except for hip girth ($p = 1.000$), life satisfaction ($p = 1.000$), basic psychological needs ($p = 1.000$), physical activity level ($p = 1.000$), and BMI ($p = 1.000$), with the males, independently of their AMD, showing higher values in the anthropometric ($p < 0.001$), psychological (p < 0.001–0.012) and physical fitness ($p < 0.001$) variables, except for the sum of 3 skinfolds ($p < 0.001$), fat mass ($p < 0.001$) and sit-and-reach test ($p < 0.001$), where females, independently of their AMD, showed a higher score.

5.4.5. Differences between male and female adolescents with different weight statuses in anthropometric variables, psychological variables, physical fitness variables, physical activity level, and AMD

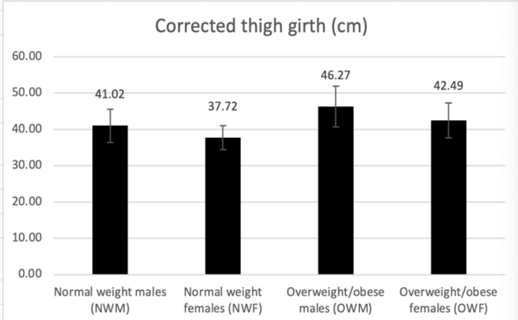
Figure 3 shows the differences between NWM, NWF, OWM, and OWF. When comparing males with different weight statuses (NWM vs. OWM) and females with different weight statuses (NWF vs. OWF), the differences were significant in both groups in all analyzed variables ($p < 0.001$), except for height (NWM vs. OWM: $p = 0.449$; NWF vs. OWF: $p = 1.000$), life satisfaction (NWM vs. OWM: $p = 0.839$; NWF vs. OWF: $p = 0.812$), basic psychological needs (NWM vs. OWM: $p = 1.000$; NWF vs. OWF: $p = 1.000$), sit-and-reach test (NWM vs. OWM: $p =$

Figure 3. Differences in psychological, anthropometric, and physical fitness variables between males and females with different weight statuses.

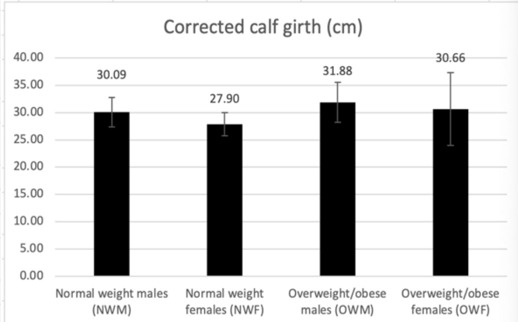




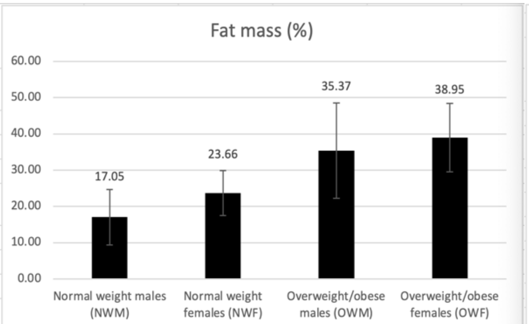
NWM vs NWF: Mean Diff: 2.300; p<0.001; 95% CI Diff: 1.786; 2.814
NWM vs OWM: Mean Diff: −3.520; p<0.001; 95% CI Diff: −4.379 −2.661
NWM vs OWF: Mean Diff: −0.848; p=0.199; 95% CI Diff: −1.900; 0.203
NWF vs OWM: Mean Diff: −5.820; p<0.001; 95% CI Diff: −6.680; −4.960
NWF vs OWF: Mean Diff: −3.149; p<0.001; 95% CI Diff: −4.200; −2.097
OWM vs OWF: Mean Diff: 2.672; p<0.001; 95% CI Diff: 1.414; 3.929



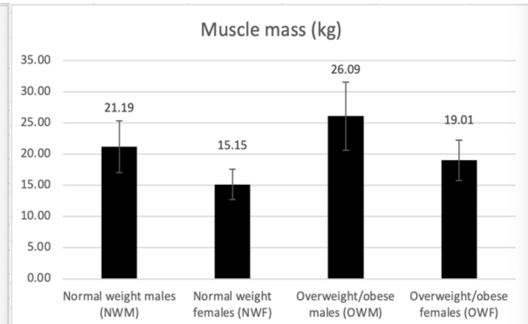
NWM vs NWF: Mean Diff: 3.301; p<0.001; 95% CI Diff: 2.414; 4.189
NWM vs OWM: Mean Diff: −5.252; p<0.001; 95% CI Diff: −6.736 −3.768
NWM vs OWF: Mean Diff: −1.467; p=0.198; 95% CI Diff: −3.283; 0.349
NWF vs OWM: Mean Diff: −8.553; p<0.001; 95% CI Diff: −10.038; −7.068
NWF vs OWF: Mean Diff: −4.768; p<0.001; 95% CI Diff: −6.585; −2.951
OWM vs OWF: Mean Diff: 3.785; p<0.001; 95% CI Diff: 1.614; 5.957



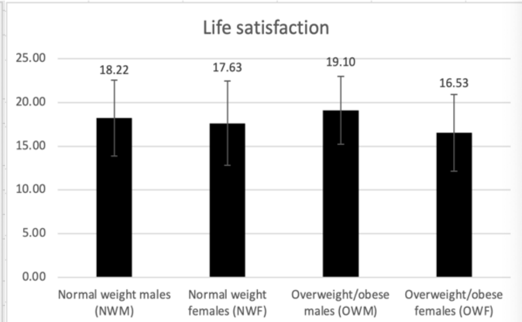
NWM vs NWF: Mean Diff: 2.190; p<0.001; 95% CI Diff: 1.568; 2.812
NWM vs OWM: Mean Diff: −1.792; p<0.001; 95% CI Diff: −2.831 −0.752
NWM vs OWF: Mean Diff: −0.571; p=1.000; 95% CI Diff: −1.844; 0.701
NWF vs OWM: Mean Diff: −3.982; p<0.001; 95% CI Diff: −5.022; −2.941
NWF vs OWF: Mean Diff: −2.761; p<0.001; 95% CI Diff: −4.034; −1.489
OWM vs OWF: Mean Diff: 1.220; p=0.205; 95% CI Diff: −0.301; 2.741



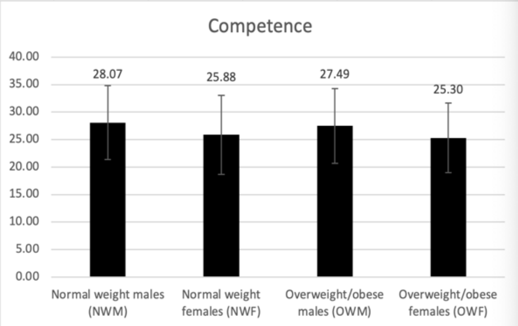
NWM vs NWF: Mean Diff: −6.612; p<0.001; 95% CI Diff: −8.265; −4.958
NWM vs OWM: Mean Diff: −18.320; p<0.001; 95% CI Diff: −21.085; −15.556
NWM vs OWF: Mean Diff: −21.908; p<0.001; 95% CI Diff: −25.290; −18.525
NWF vs OWM: Mean Diff: −11.709; p<0.001; 95% CI Diff: −14.475; −8.942
NWF vs OWF: Mean Diff: −15.296; p<0.001; 95% CI Diff: −18.680; −11.912
OWM vs OWF: Mean Diff: −3.587; p=0.115; 95% CI Diff: −7.632; 0.457



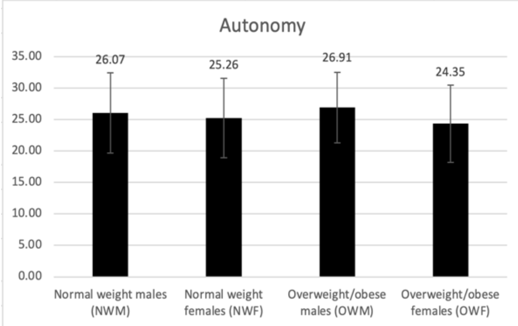
NWM vs NWF: Mean Diff: 6.036; p<0.001; 95% CI Diff: 5.271; 6.800
NWM vs OWM: Mean Diff: −4.903; p<0.001; 95% CI Diff: −6.181; −3.624
NWM vs OWF: Mean Diff: 2.174; p=0.002; 95% CI Diff: 0.610; 3.738
NWF vs OWM: Mean Diff: −10.938; p<0.001; 95% CI Diff: −12.217; −9.659
NWF vs OWF: Mean Diff: −3.862; p<0.001; 95% CI Diff: −5.427; −2.297
OWM vs OWF: Mean Diff: 7.076; p<0.001; 95% CI Diff: 5.206; 8.947



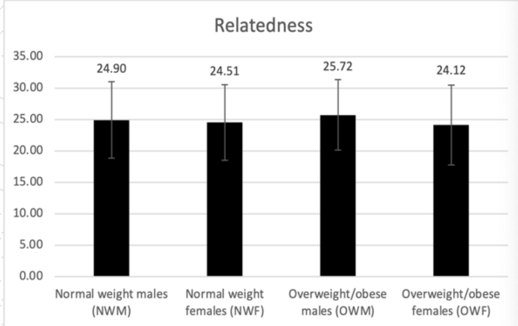
NWM vs NWF: Mean Diff: 0.587; p=0.608; 95% CI Diff: −0.360; 1.534
NWM vs OWM: Mean Diff: −0.884; p=0.839; 95% CI Diff: −2.468; 0.699
NWM vs OWF: Mean Diff: 1.682; p=0.131; 95% CI Diff: −0.255; 3.619
NWF vs OWM: Mean Diff: −1.472; p=0.085; 95% CI Diff: −3.056; 0.112
NWF vs OWF: Mean Diff: 1.095; p=0.812; 95% CI Diff: −0.843; 3.032
OWM vs OWF: Mean Diff: 2.567; p=0.021; 95% CI Diff: 0.251; 4.883



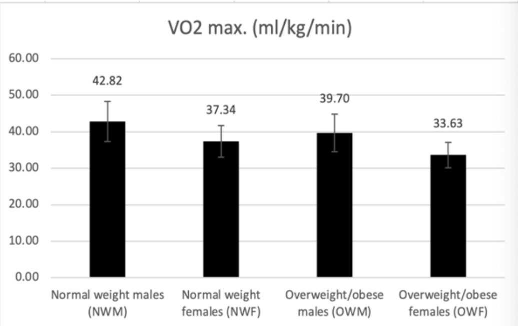
NWM vs NWF: Mean Diff: 2.189; p<0.001; 95% CI Diff: 0.740; 3.639
NWM vs OWM: Mean Diff: 0.576; p=1.000; 95% CI Diff: −1.848; 3.001
NWM vs OWF: Mean Diff: 2.767; p=0.083; 95% CI Diff: −0.199; 5.733
NWF vs OWM: Mean Diff: −1.613; p=0.474; 95% CI Diff: −4.039; 0.813
NWF vs OWF: Mean Diff: 0.577; p=1.000; 95% CI Diff: −2.390; 3.544
OWM vs OWF: Mean Diff: 2.190; p=0.616; 95% CI Diff: −1.356; 5.737



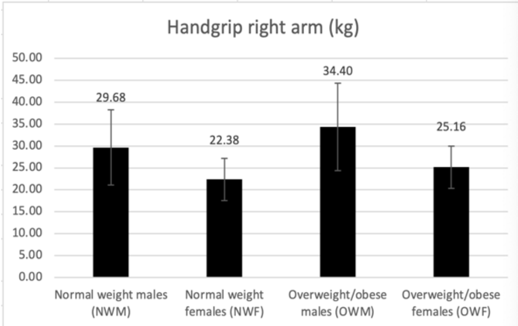
NWM vs NWF: Mean Diff: 0.810; p=0.625; 95% CI Diff: −0.507; 2.126
NWM vs OWM: Mean Diff: −0.841; p=1.000; 95% CI Diff: −3.042; 1.360
NWM vs OWF: Mean Diff: 1.723; p=0.545; 95% CI Diff: −0.969; 4.416
NWF vs OWM: Mean Diff: −1.650; p=0.287; 95% CI Diff: −3.852; 0.552
NWF vs OWF: Mean Diff: 0.914; p=1.000; 95% CI Diff: −1.780; 3.607
OWM vs OWF: Mean Diff: 2.564; p=0.213; 95% CI Diff: −0.656; 5.784



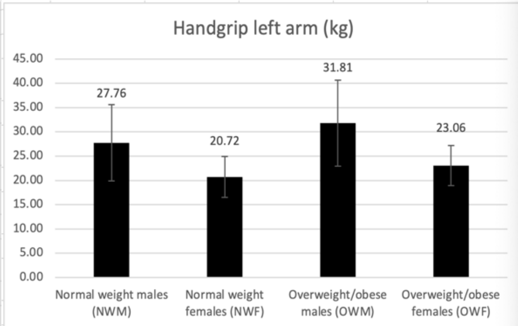
NWM vs NWF: Mean Diff: 0.390; p=1.000; 95% CI Diff: −0.874; 1.654
NWM vs OWM: Mean Diff: −0.828; p=1.000; 95% CI Diff: −2.942; 1.285
NWM vs OWF: Mean Diff: 0.780; p=1.000; 95% CI Diff: −1.806; 3.366
NWF vs OWM: Mean Diff: −1.218; p=0.768; 95% CI Diff: −3.333; 0.896
NWF vs OWF: Mean Diff: 0.390; p=1.000; 95% CI Diff: −2.197; 2.977
OWM vs OWF: Mean Diff: 1.608; p=1.000; 95% CI Diff: −1.484; 4.700



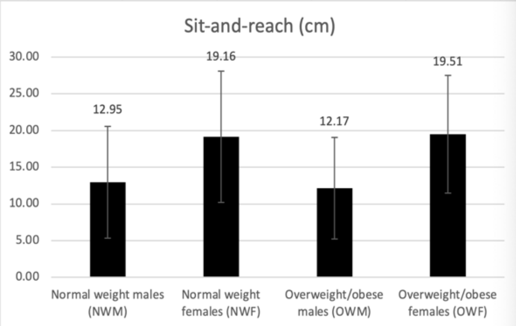
NWM vs NWF: Mean Diff: 5.485; p<0.001; 95% CI Diff: 4.450; 6.519
NWM vs OWM: Mean Diff: 3.126; p<0.001; 95% CI Diff: 1.397; 4.855
NWM vs OWF: Mean Diff: 9.198; p<0.001; 95% CI Diff: 7.082; 11.313
NWF vs OWM: Mean Diff: −2.359; p=0.002; 95% CI Diff: −4.089; −0.628
NWF vs OWF: Mean Diff: 3.713; p<0.001; 95% CI Diff: 1.596; 5.829
OWM vs OWF: Mean Diff: 6.071; p<0.001; 95% CI Diff: 3.541; 8.601



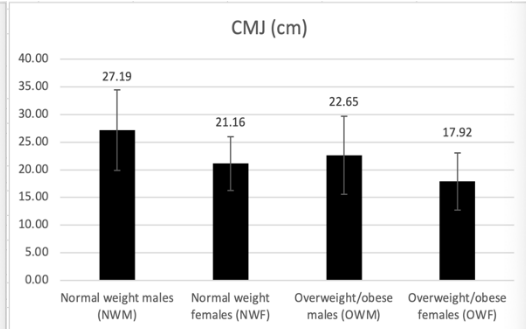
NWM vs NWF: Mean Diff: 7.296; p<0.001; 95% CI Diff: 5.785; 8.808
NWM vs OWM: Mean Diff: −4.726; p<0.001; 95% CI Diff: −7.254; −2.198
NWM vs OWF: Mean Diff: 4.520; p=0.001; 95% CI Diff: 1.427; 7.613
NWF vs OWM: Mean Diff: −12.022; p<0.001; 95% CI Diff: −14.552; −9.493
NWF vs OWF: Mean Diff: −2.776; p=0.107; 95% CI Diff: −5.870; 0.318
OWM vs OWF: Mean Diff: 9.246; p<0.001; 95% CI Diff: 5.548; 12.945



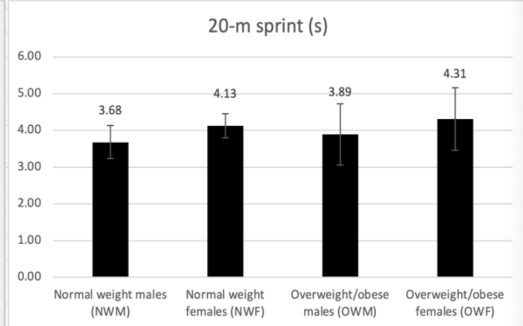
NWM vs NWF: Mean Diff: 7.044; p<0.001; 95% CI Diff: 5.686; 8.403
NWM vs OWM: Mean Diff: −4.046; p<0.001; 95% CI Diff: −6.318; −1.775
NWM vs OWF: Mean Diff: 4.704; p<0.001; 95% CI Diff: 1.925; 7.483
NWF vs OWM: Mean Diff: −11.091; p<0.001; 95% CI Diff: −13.363; −8.818
NWF vs OWF: Mean Diff: −2.340; p=0.158; 95% CI Diff: −5.120; 0.440
OWM vs OWF: Mean Diff: 8.751; p<0.001; 95% CI Diff: 5.428; 12.073



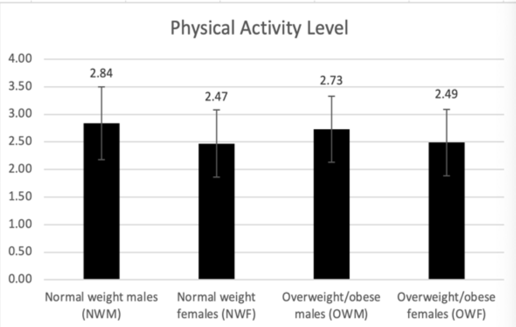
NWM vs NWF: Mean Diff: −6.215; p<0.001; 95% CI Diff: −7.931; −4.498
NWM vs OWM: Mean Diff: 0.779; p=1.000; 95% CI Diff: −2.091; 3.649
NWM vs OWF: Mean Diff: −6.566; p<0.001; 95% CI Diff: −10.078; −3.055
NWF vs OWM: Mean Diff: 6.993; p<0.001; 95% CI Diff: 4.122; 9.865
NWF vs OWF: Mean Diff: −0.352; p=1.000; 95% CI Diff: −3.864; 3.161
OWM vs OWF: Mean Diff: −7.345; p<0.001; 95% CI Diff: −11.544; −3.146



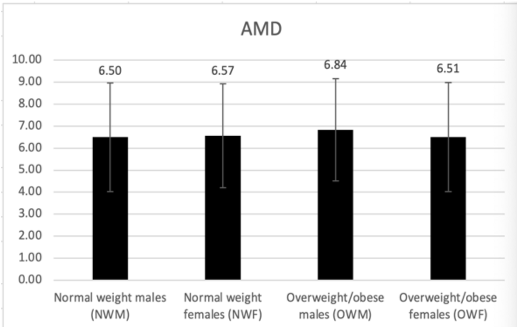
NWM vs NWF: Mean Diff: 6.028; p<0.001; 95% CI Diff: 4.716; 7.341
NWM vs OWM: Mean Diff: 4.538; p<0.001; 95% CI Diff: 2.344; 6.732
NWM vs OWF: Mean Diff: 9.265; p<0.001; 95% CI Diff: 6.580; 11.949
NWF vs OWM: Mean Diff: −1.491; p=0.437; 95% CI Diff: −3.686; 0.705
NWF vs OWF: Mean Diff: 3.236; p=0.009; 95% CI Diff: 0.551; 5.922
OWM vs OWF: Mean Diff: 4.727; p=0.001; 95% CI Diff: 1.517; 7.937



NWM vs NWF: Mean Diff: −0.447; p<0.001; 95% CI Diff: −0.549; −0.345
NWM vs OWM: Mean Diff: −0.212; p=0.006; 95% CI Diff: −0.382; −0.042
NWM vs OWF: Mean Diff: −0.631; p<0.001; 95% CI Diff: −0.839; −0.422
NWF vs OWM: Mean Diff: 0.235; p=0.002; 95% CI Diff: 0.065; 0.405
NWF vs OWF: Mean Diff: −0.184; p=0.119; 95% CI Diff: −0.392; 0.025
OWM vs OWF: Mean Diff: −0.419; p<0.001; 95% CI Diff: −0.668; −0.170



NWM vs NWF: Mean Diff: 0.373; p<0.001; 95% CI Diff: 0.241; 0.505
NWM vs OWM: Mean Diff: 0.108; p=1.000; 95% CI Diff: −0.113; 0.329
NWM vs OWF: Mean Diff: 0.353; p=0.004; 95% CI Diff: 0.083; 0.624
NWF vs OWM: Mean Diff: −0.265; p=0.010; 95% CI Diff: −0.486; −0.043
NWF vs OWF: Mean Diff: −0.020; p=1.000; 95% CI Diff: −0.290; 0.251
OWM vs OWF: Mean Diff: 0.245; p=0.272; 95% CI Diff: −0.078; 0.568



NWM vs NWF: Mean Diff: −0.076; p=1.000; 95% CI Diff: −0.582; 0.430
NWM vs OWM: Mean Diff: −0.344; p=1.000; 95% CI Diff: −1.190; 0.502
NWM vs OWF: Mean Diff: −0.015; p=1.000; 95% CI Diff: −1.050; 1.021
NWF vs OWM: Mean Diff: −0.268; p=1.000; 95% CI Diff: −1.114; 0.579
NWF vs OWF: Mean Diff: 0.061; p=1.000; 95% CI Diff: −0.975; 1.097
OWM vs OWF: Mean Diff: 0.329; p=1.000; 95% CI Diff: −0.909; 1.567

1.000; NWF vs. OWF: $p = 1.000$), physical activity level (NWM vs. OWM: $p = 1.000$; NWF vs. OWF: $p = 1.000$) and AMD (NWM vs. OWM: $p = 1.000$; NWF vs. OWF: $p = 1.000$), in addition to handgrip right arm ($p = 0.107$), handgrip left arm ($p = 0.158$) and 20-m sprint ($p = 0.\ 119$) between NWF vs. OWF, with the OWM and OWF showing higher scores in all anthropometric variables ($p < 0.001$), as well as higher scores in the handgrip strength test in both arms in the OWM ($p < 0.001$).

Regarding the comparison between males and females with the same weight status (NWM vs. NWF and OWM vs. OWF), the differences were significant in all the variables analyzed between NWM and NWF, except for life satisfaction ($p = 0.608$), autonomy ($p = 0.625$), relatedness ($p = 1.000$), and AMD ($p = 1.000$), while in the comparison between OWM and OWF, the differences were also significant in all the variables analyzed, except for hip girth ($p = 1.000$), corrected calf ($p = 0.205$), fat mass ($p = 0.115$), basic psychological needs ($p = 0.213$–1.000), physical activity level ($p = 0.272$), and AMD ($p = 1.000$), with males in both groups obtaining higher scores in all the variables ($p < 0.001$), except for the sum of 3 skinfolds ($p < 0.001$), fat mass ($p < 0.001$) and sit-and-reach test ($p < 0.001$), for which the females showed higher values.

As for the differences between males and females with different weight statuses (NWM vs. OWF and NWF vs. OWM), it should be noted that differences were significant between NWM and OWF in all the variables analyzed, except for corrected girths ($p = 0.198$–1.000), life satisfaction ($p = 0.131$), basic psychological needs ($p = 0.083$–1.000), and AMD ($p = 1.000$), with the OWF showing higher scores in all anthropometric variables ($p < 0.001$), except for height ($p < 0.001$) and muscle mass ($p = 0.002$), while the NWM showed higher physical activity level ($p = 0.004$) and physical fitness test scores ($p < 0.001$), except for the sit-and-reach test ($p < 0.001$). The differences between NWF and OWM were significant in all variables except for life satisfaction ($p = 0.085$), basic psychological needs ($p = 0.287$–0.768), CMJ ($p = 0.437$), and AMD ($p = 1.000$), with the score of the OWM being higher in all the variables analyzed ($p < 0.001$), except for the sit-and-reach test ($p < 0.001$).

5.5. Discussion

The general aim of the present study was to analyze whether the practice of physical activity, optimal AMD, and adequate weight status could compensate for the differences between adolescent males and females in anthropometric and derived variables, psychological state, and physical fitness. In order to meet this general aim, the following four specific objectives were proposed a) to establish the differences between male and female adolescents in anthropometric and derived variables, psychological state, and physical fitness; b) to determine whether the practice of physical activity could compensate for the differences found according to gender in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents; c) to analyze whether optimal AMD could compensate for the gender differences found in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents; and d) to establish whether the maintenance of an adequate weight status could compensate for the differences found according to gender in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents. The results of previous research lead us to pose the following hypotheses H1) males will show higher scores in all the variables, except in those related to body fat and flexibility, compared to females; H2) in females, the regular practice of physical activity will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness, with respect to males; H3) in females, optimal AMD will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness, with respect to males; and H4) in females, maintaining a normal weight will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness, with respect to males.

5.5.1. Differences between male and female adolescents in anthropometric variables, psychological variables, physical fitness variables, physical activity level, AMD, and weight status

According to the first specific objective, to establish the differences between male and female adolescents in anthropometric and derived variables, psychological state, and physical fitness, the results of the present study are similar to those found in previous studies. Adolescent males showed a higher level of physical activity than females, in line with previous research (Manzano-Sánchez et al., 2022; Steene-johannessen et al., 2020). With respect to physical fitness, males obtained higher scores in all the variables analyzed, except for the sit-and-reach test, corroborating the results of previous research (Albaladejo-Saura, Vaquero-

Cristóbal, García-Roca, et al., 2022c; Morina et al., 2021). As for the anthropometric variables, it was the females who obtained higher scores in the variables related to fat mass, highlighting the percentage of total fat or the sum of three skinfolds, while the males showed greater muscle mass and corrected girth, with these results being similar to those obtained previously in adolescents (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). According to the psychological variables, males showed higher scores in life satisfaction, competence, and autonomy, consistent with previous research (Henkens et al., 2022; Rubio et al., 2019). The differences found could be due to the existing sexual dimorphism between adolescent males and females, which leads to hormonal changes characterized by an increase in estrogen in girls, which favors fat accumulation and poorer sports performance, and in testosterone in males, with increases the muscle mass that facilitates performance in strength and power tests (Handelsman et al., 2018; Nikitovic, 2018). These results corroborate the first hypothesis (H1) put forward in the research, in that males would show higher scores in all variables, except those related to body fat and flexibility, compared to females.

However, these results had already been confirmed in previous research, so the real novelty of this research is that it provides information on whether the existing differences between males and females in anthropometric, psychological, and physical fitness variables increased or decreased when considering the level of physical activity, AMD, or weight status of the adolescents.

5.5.2. Differences between male and female adolescents with different physical activity statuses in anthropometric variables, psychological variables, physical fitness variables, AMD, and weight status

The second specific objective of the study was to determine whether the practice of physical activity can compensate for the differences found according to gender in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents. Regarding the comparison between AM vs. SM, and AF vs. SF, the results showed no significant differences between AM and SM, or between AF and SF, in the anthropometric variables analyzed. Previous research has shown contrary results, with differences found between active and inactive adolescents (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2022), which could be due to the fact that previous studies did not perform a separate analysis of AM and SM and AF and SF, so the introduction of males and females in the same comparison group, with the existing anthropometric differences between them (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c), could be the reason for the discrepancy with respect to the present study. Regarding the absence of differences between active and sedentary adolescents in the anthropometric variables of the present investigation, a possible explanation could be that the COVID-19 pandemic led to an increase in weight and body fat of adolescents due to a positive energy balance, regardless of their previous level of physical activity (Karatzi et al., 2021). These changes in anthropometric variables are far from being compensated by the practice of physical exercise, based on the results obtained in the present investigation, although these results should be contrasted in future research.

Regarding the psychological and physical fitness variables, it should be noted that significant differences were found between AF and SF in all the variables, while in the comparison between AM and SM, significant differences were only found in competence, autonomy, and VO_2 max. These results partially follow the line of previous research (Costa & Fernandes, 2019) in that it was observed that the psychological benefits of physical activity practice differed according to gender. This finding is consistent with the results obtained, but it was also found that males received more psychological benefits from the practice of physical activity, which is contrary to the present results. This could be due to the fact that during the COVID-19 pandemic, although both males and females were affected in terms of life satisfaction and basic psychological needs, the effect was much greater in females (Halldorsdottir et al., 2021) so that the practice of physical activity in the months following the pandemic could have had a more favorable impact on females than on males. As for the physical fitness tests, the hormonal and physical changes during adolescence could mitigate the differences between AM and SM in the variables related to power and speed. This may be because the changes that occur at the onset of puberty lead to an increase in muscle and bone mass in males, regardless of the practice of physical activity, while in females, the physical changes mainly occur in the distribution and accumulation of adipose tissue (Handelsman et al., 2018), with a smaller increase in production of muscle mass and strength. Therefore, as changes in muscle mass and strength are not as noticeable in female adolescents, the practice of physical activity could be more determinant for differences in their physical performance.

Another relevant result is that between males and females with the same level of physical activity practice, no differences were found in life satisfaction or the satisfaction of basic psychological needs between AM and AF, but the differences were significant between SM and SF, with SF scoring lower. These results partially follow the line of previous research, which indicated that males showed higher scores than females in psychological variables (Aymerich et al., 2021; Henkens et al., 2022; Rubio et al., 2019), as they agree in the case of sedentary adolescents analyzed in this research, but in the case of active adolescents, no differences were found. These results highlight the importance of physical activity for female adolescents to achieve an adequate psychological state. However, they also point to the importance of considering the physical activity practiced as a variable that could explain the lack of agreement between the differences found in previous research on the psychological state of male and female adolescents.

When comparing AM and SF, the differences between males and females were even more remarkable, following the results of previous studies in which males showed higher scores except for the variables related to fat mass and the sit-and-reach test (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). However, what is novel in the present study is that when comparing AF and SM, no differences were found between the groups in fat mass or life satisfaction, which is especially relevant as it indicates the usefulness of physical activity in decreasing the differences between males and females in fat mass accumulation, as well as in increasing the life satisfaction of adolescent females. These results corroborate the second hypothesis (H2), in that the regular practice of physical activity of females will compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness with respect to males.

5.5.3. Differences between male and female adolescents with different AMD in anthropometric variables, psychological variables, physical fitness variables, physical activity level, and weight status

The third specific objective of the present study was to analyze whether optimal AMD can compensate for the gender differences found in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents. The results with respect to the anthropometric variables and the physical fitness tests showed that the differences were not significant in either the comparison of ODM and PDM or ODF and PDF. These results are similar to those from previous research in adolescents, in which no significant differences were observed between poor and optimal AMD in both males and females groups (Galan-Lopez et al., 2018). This could be due firstly to the fact that the adoption of a healthy diet alone does not generate as many changes in anthropometric and derived variables, and physical capacities, as following a diet program combined with regular physical activity in the adolescent population (Bleich et al., 2018) and secondly to the fact that the combination of adolescents with poor AMD and need to improve AMD to obtain a sample size comparable to that of adolescents with optimal AMD, could influence the statistical analysis.

However, the results showed that both ODM and ODF had a better level of physical activity and psychological state than PDM and PDF, respectively, with the differences being significant in competence in the case of females and relatedness in the case of males. Regarding the level of physical activity, the results were similar to those from previous research, in which adolescents with a higher AMD showed a higher level of physical activity (Bibiloni et al., 2022). This could be because one of the main determinants for adopting other healthy lifestyle habits during adolescence is the practice of physical activity (Couture-Wilhelmy et al., 2021). With respect to psychological state, no previous research has analyzed differences in the satisfaction of basic psychological needs according to AMD in the adolescent population. The results of the present investigation seem to indicate that ODM and ODF showed greater satisfaction of basic psychological needs, which could be because ODM and ODF also showed a higher level of physical activity practice than PDM and PDF, but future studies in this area are needed to draw definitive conclusions.

When comparing PDM and PDF, and ODM and ODF, the differences were significant in anthropometric and physical fitness variables, similar to previous research that studied the differences between males and females (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c). However, in the psychological variables, only significant differences were found between PDM and PDF in the competence variable. The results of the present study show that although the psychological state of the adolescents differed according to the AMD in both the male and female groups, the differences in the psychological state disappeared when comparing males and females with optimal AMD. Thus, there does not seem to be differences between genders if the level of AMD is optimal. No previous research is known to have analyzed the differences in the psychological state of adolescents according to AMD and considering gender differences, but a possible explanation could be that male and female adolescents with greater AMD have better physical and psychological well-being, better family relationships, and autonomy support (Knox & Muros, 2017), with these factors being related to the satisfaction of basic psychological needs and life satisfaction in adolescents (Alcaraz et al., 2015; Povedano-Diaz et al., 2020).

It should be noted that when comparing PDM and ODF, PDF and ODM, the differences in the anthropometric and physical fitness variables continued to be greater in males, except for the variables related to body fat and the sit-and-reach test. A relevant result is that the differences were only significant in the psychological variables when comparing PDF and ODM, with the score of ODM being higher, but not when comparing PDM and ODF. These results could be explained by the fact that AMD is not the only influential factor in the psychological state of adolescents, with physical activity also playing a determining role (Lema-Gómez et al., 2021). As shown in previous research, physical activity is higher in males (Steene-johannessen et al., 2020), which could be the reason why ODM showed statistically significant differences in psychological variables as compared to PDF but not ODF with respect to PDM, with future research necessary to corroborate the influence of these variables on the psychological state of adolescents. These results allow us to reject the third research hypothesis (H3), as an optimal AMD in females did not compensate for the existing differences with males in anthropometric and derived variables, psychological state, and physical fitness.

5.5.4. Differences between male and female adolescents with different weight statuses in anthropometric variables, psychological variables, physical fitness variables, physical activity level, and AMD

The fourth specific objective was to establish whether the maintenance of an adequate weight status can compensate for the differences found according to gender in the anthropometric and derived variables, psychological state, and physical fitness of the adolescents. When comparing OWM and OWF with NWM and NWF, the results showed higher scores in the anthropometric variables related to fat mass and muscle mass in the OWM and OWF. As for the physical fitness variables, the OWM and OWF adolescents showed a lower score in cardiorespiratory capacity and CMJ, but it should be noted that in the OWM group, the score was higher as compared to the NWM group in handgrip, while in the 20-m sprint test, the NWM group scored better than the OWM one. Previous research has shown similar results (Manzano-Carrasco, Felipe, Sanchez-Sanchez, Hernandez-Martin, Gallardo, et al., 2020); however, the novelty of the present article lies in the fact that only in the male group were there differences in handgrip and 20-m sprint between normal weight and overweight/obese individuals. This could be because these tests assess strength and speed. These aspects that develop differently in adolescent males and females due to sexual dimorphism (Handelsman et al., 2018) or the differences in sports participation between adolescent males and females (Peral-Suárez et al., 2020).

Regarding the psychological variables, the differences were not significant when comparing NWM and OWM or NWF and OWF. These results are contrary to those found in previous research, in which overweight adolescents showed less satisfaction with life and suffered more social isolation and bullying (Lopez-Agudo & Marcenaro-Gutierrez, 2021). This could indicate that weight status alone is not such a determining factor in the psychological state of adolescents, with other aspects acquiring greater relevance. In this regard, the practice of physical activity was important, as shown in previous studies (Villafaina et al., 2021). The decrease in physical activity levels caused by peer teasing for being overweight/obese (Puhl et al., 2011) could be the real factor affecting the psychological state. However, this could mainly be due to the reduction in physical activity and not as much to being overweight/obese.

It is worth noting that when comparing NWM and NWF, and OWM and OWF, males continued to show higher scores in the level of physical activity performed, in the physical fitness, and anthropometric variables, except for fat mass, the sum of three skinfolds, and the sit-and-reach test, both in the normal weight and overweight/obese groups, as shown in previous research (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022c; Steene-johannessen et al., 2020). Regarding the differences between groups, hip girth was significantly higher in the NWF than in the NWM but not in the overweight/obese group. These results are similar to those found in previous research, in which females had a greater accumulation of peripheral fat in the limbs or hips (Ohzeki et al., 1996; Taylor et al., 2010). However, in obese individuals, the hypothalamic-pituitary-adrenal axis may be overly sensitive, breaking the balance between the lipogenic and lipolytic effects of the hormones related to fat accumulation, cortisol, and insulin may be the reason why no differences were found between OWM and OWF (Ohzeki et al., 1996; Roemmich & Rogol, 1999).

Regarding the differences in psychological variables in the normal weight and overweight/obese groups, the OWF showed significantly lower scores in life satisfaction, while the NWF showed a lower score in competence compared to OWM and NWM, respectively. These results are similar to those found in previous studies, in which females showed worse life satisfaction and competence than males (Henkens et al., 2022; Rubio et al., 2019). A possible explanation could be that adolescence is a crucial stage in which adolescents are prone to teasing and taunting by their peers, with this situation more evident in females, who are more likely to suffer verbal-relational victimization, which hinders their participation in certain social activities and complicates their integration with the rest of their peers (Lee et al., 2021; Puhl et al., 2011), thereby affecting their psychological state. The relevance of these results lies in the fact that adolescent females showed a lower satisfaction with life and basic psychological needs than males, providing more scientific evidence in an area that was not made clear in previous research.

The NWF scored significantly lower than NWM in competence. These results are contrary to those found in previous studies, in which females showed higher values in satisfying all basic psychological needs (Moreno-Casado et al., 2022). It must be underlined that factors such as the practice of physical activity are determinants for the satisfaction of basic psychological needs, and thus competence could be affected by this (Solís et al., 2019). The results of the present research show that adolescent males have a significantly higher level of physical activity than females, being considered active, while females are considered inactive (Benítez-Porres et al., 2016), which could be the reason why NWF showed lower competence scores than NWM. Future research in this area is necessary to establish the importance of physical activity in the satisfaction of competence in adolescent males and females.

With respect to the comparison between NWF and OWM, and NWM and OWF, it should be noted that there were significant differences in the anthropometric and physical fitness variables, although no significant differences were found in any of the comparisons in the psychological variables analyzed. Regarding the anthropometric variables, the comparison between OWM and NWF showed significant differences in all the variables analyzed, with the OWM showing the highest scores. However, in the comparison of OWF and NWM, OWF showed higher scores in all variables related to fat mass, but NWM showed higher muscle mass. Furthermore, no significant differences were found in corrected girths between OWF and NWM, which could be because overweight/obese adolescents develop greater muscle and bone mass (Vandewalle et al., 2013), which could compensate for the differences normally found in muscle mass between males and females caused by sexual dimorphism. The absence of differences with respect to psychological variables provides further evidence of the lack of relevance of weight status in the psychological state of the adolescent population. With respect to the physical fitness variables, it is noteworthy that the CMJ test showed no significant differences between NWF and OWM, which could be due to the lower performance of OWM in this test, as they had to move more body mass. These results allow us to refute the fourth research hypothesis (H4), which stated that the maintenance of normal weight in females would compensate for the differences in anthropometric and derived variables, psychological state, and physical fitness with respect to males.

Based on the results obtained, which respond to the four specific objectives and the general objective, i.e., to analyze whether the practice of physical activity, optimal AMD, and adequate weight status can compensate for the differences found between adolescent males and females in anthropometric and derived variables, psychological state, and physical fitness, the practical applications of the present study highlight that the promotion of physical activity is fundamental for the entire adolescent population. However, it is even more relevant for females than for males for the improvement of physical fitness and psychological state, as it is a key aspect for the reduction of the differences found between males and females and may even compensate for the differences found based on gender in the accumulation of fat mass and life satisfaction. Regarding AMD, it is noteworthy that there were differences between males and females with low AMD but not between males and females with optimal AMD, with this being a relevant factor to consider for the promotion of healthy habits in this population, as the psychological differences between genders disappear if optimal AMD is achieved. With respect to weight status, it is noteworthy that females, both normal weight and overweight/obese, showed lower scores in various psychological variables than males, although no differences were found when comparing NWF and OWF, so these differences may not be due to weight status alone, but to other variables such as physical activity as well. Therefore, although the promotion of the Mediterranean diet and the maintenance of healthy weight status is important for the adolescent population, physical activity seems to play a more decisive role, so programs aimed at the acquisition of healthy habits, such as AMD, should consider the inclusion of sports practice, as it seems to facilitate the acquisition of the rest of the healthy habits, and to increase the benefits obtained through these programs.

This study is not free of limitations. Despite selecting four different geographical areas, the sample was selected conveniently in the educational centers where access was allowed. By dividing the sample into subgroups such as degree of AMD or weight status, the sample sizes were reduced, and although they were similar between males and females, they represented a small part of the total sample. With respect to variables such as the level of physical activity or AMD, these were calculated based on the adolescents' scores on the questionnaires that collected information on their nutritional and sports habits in recent days, and this aspect must be considered. The maturational status of adolescents should be considered in future research, as it could influence the results obtained, as certain behavioral changes in healthy habits occur as a function of maturation. In addition, weight status was established according to the BMI classification established by the World Health Organization, which must be considered, as it could make it difficult to compare with other research studies using another classification. On the other hand, the use of BMI does not allow differentiation between the components of body composition (muscle mass or fat mass). This should be taken into account, as some adolescents with a high level of muscle mass could be included in the overweight/obese group, although this is not very common.

5.6. Conclusions

To conclude, the differences between AM-SM and AF-SF were not significant in the anthropometric variables, while in the physical fitness and psychological variables, the differences were significant between AF and SF in all variables, while for the comparison between AM and SM, significant differences were only found in competence, autonomy, and VO_2 max. When comparing males and females with the same level of physical activity (AM-AF, SM-SF), it is important to note that in the psychological variables, differences were only found between SM and SF, with SF scoring lower. Regarding the comparison between males and females with different levels of physical activity (AM-SF, AF-SM), the differences were even more evident in all the variables analyzed between AM and SF, although no differences were found between AF and SM in fat mass or life satisfaction.

Regarding AMD, no differences were found between ODM-PDM and ODF-PDF in the anthropometric and physical fitness variables, although differences were found in the psychological variables, with ODM and ODF scoring higher. In the comparison between PDM-PDF and ODM-ODF, the differences were significant in the anthropometric and physical fitness variables in both groups but only in the psychological variables between ODM-ODF. Another novel aspect is that in the psychological variables, the comparison between PDF-ODM showed significant differences, with higher values in ODM, although no differences were found between PDM-ODF.

According to weight status, the OWM and OWF showed higher scores in the anthropometric variables, and lower performance in cardiorespiratory capacity and CMJ. However, only the OWM showed higher performance in handgrip, while the NWM did so in the 20-m sprint. There were no significant differences in psychological variables between NWM-OWM nor between NWF-OWF. When comparing males and females with the same weight status (NWM-NWF and OWM-OWF), differences were more evident in anthropometric and physical fitness variables between genders, while in psychological variables, OWF and NWF showed lower values than males. As for the comparison between NWF-OWM and NWM-OWF, the psychological variables showed no significant differences, while in physical fitness, it is noteworthy that there were no differences between NWF and OWM in the CMJ. Regarding the anthropometric variables, the OWM showed higher scores than the NWF in all the variables analyzed, with this being similar in the OWF with respect to the NWM, except in muscle mass, in which the NWM obtained higher values, and in corrected girths, in which there were no differences between OWF and NWM.

Vf – ESTUDIO 6: Mandatory after-school use of step tracker apps improves physical activity, body composition and fitness of adolescents

ESTUDIO 6 – MANDATORY AFTER-SCHOOL USE OF STEP TRACKER APPS IMPROVES PHYSICAL ACTIVITY, BODY COMPOSITION AND FITNESS OF ADOLESCENTS

5.1. Abstract

Previous scientific research on the use of mobile applications to increase physical activity level and improve health among adolescents does not provide conclusive results, one of the main reasons being the lack of adherence to the intervention after the first weeks. For this reason, the main objectives of the research were to determine the changes produced by a compulsory ten-week period of after-school intervention with mobile step-tracking applications on adolescents' health; and the final objective to compare the benefits obtained by each of the mobile applications. To meet the objectives, a longitudinal study with non-probability convenience sampling was proposed. The sample consisted of 400 adolescents from two public compulsory secondary schools in the Region of Murcia, Spain, whose body composition, level of physical activity, adherence to the Mediterranean diet, and physical fitness were measured. The SPSS statistical software was used for statistical analysis. The results showed that adolescents in the experimental group showed a higher level of physical activity and better body composition and physical fitness variables after the intervention compared to the control group, with differences between the different applications used. In conclusion, this research shows the usefulness of mobile applications if they are used in a compulsory way after school hours. The relevance of these results for policymakers lies in the fact that they provide statistical data on the usefulness of mobile applications as an educational resource, being an option to make up for the lack of sufficient physical education teaching hours to meet global physical activity recommendations.

5.2. Introduction

Adolescence is crucial stage for the general population due to the establishment of certain healthy lifestyle habits that are maintained during this and later stages of life (Telama et al., 2005), reducing the possibility of suffering from cardiovascular diseases or certain types of cancer in the future (Barbiellini Amidei et al., 2022; Saint-Maurice et al., 2019). However, during this stage of human development we find the highest rate of abandonment of physical activity practice (Lunn, 2010), which has an impact on the health of adolescents in later years (Llorente-Cantarero et al., 2020), starting with the youth, where there a tendency has been found among sedentary adolescents to be sedentary young people (Kwan et al., 2012), leading to increases in variables related to fat mass, among others (Mcconnell-Nzunga et al., 2022; Vadeboncoeur et al., 2015). Therefore, adolescence is the most decisive stage in the acquisition of healthy habits in the period between childhood and adulthood, and the promotion of physical activity at this stage is essential for the physical well-being and mental health (Hallal et al., 2006).

Despite the importance of physical activity, physical inactivity and sedentary time during adolescence are increasing every year (Conger et al., 2022), reaching more than 80% and 35%, respectively, of this population in the past year. Physical inactivity includes performing less than sixty minutes of physical activity per day, while sedentary time is defined as sitting for three or more hours outside of school (Pechtl et al., 2022). This situation is very worrying, and has become a public health problem in Spain, because the current education law only stipulates two days of curricular physical education classes per week, which added to the decrease in out-of-school physical activity, and the increase in time spent in sedentary activities (Pechtl et al., 2022), results in a completely sedentary adolescent population, and an inability to meet physical activity recommendations with adolescents during school hours. Therefore, the only way to reach the minimum days of physical activity practice for adolescents to be considered active, is to practice physical exercise in their leisure time. However, the level of physical activity in leisure time has decreased to such extent in the last years, that from ages of 9-10 years old until young adulthood, most of the subjects do not reach the minimum recommendations (Corder et al., 2019; Farooq et al., 2020), resulting in a considerable decrease in physical fitness and a body composition far from healthy parameters (Lovecchio et al., 2020; Radulović et al., 2022).

In addition, the COVID-19 pandemic experienced in the last two years has had a major influence on the decline in the physical activity levels (Elnaggar et al., 2022; Yomoda & Kurita, 2021), deteriorating physical fitness (López-Bueno et al., 2021), and adherence to the Mediterranean diet (AMD) (Sánchez-Sánchez et al., 2020), while also increasing the variables related to fat mass (Karatzi et al., 2021), as well as the increased use of new technologies by adolescents (Ventura et al., 2021). Among the new technologies most widely used in this population, mobile phones stand out as being commonly associated with mental disorders and sedentary behavior in adolescents (Fanchang et al., 2021; Xiang et al., 2021), as well as poorer peer relationships and academic performance (Legkauskas & Steponavičiūtė-Kupčinskė, 2021). However, mobile phones also offers a multitude of possibilities for the establishment of healthy lifestyle habits, among which mobile applications stand out (Groen et al., 2022; Kracht et al., 2021). In recent years, numerous health-related applications have been developed related to physical activity (Mokmin & Jamiat, 2021), highlighting those that push the users to try to increase the number of steps or daily distance covered (Schoeppe et al., 2017), being valid and acceptable tools to measure physical activity (Parmenter et al., 2022). This could be a resource for physical education teachers to promote and monitor physical activity performed by students outside of the school environment.

However, the use of mobile applications that promote physical activity among adolescents has shown very mixed results in increasing the level of physical activity and in improving body composition and AMD (Böhm et al., 2019; Dute et al., 2016; Macdonald et al., 2017). Thus, much of the previous research does not allow drawing solid conclusions on the usefulness of mobile applications for improving adolescents' healthy habits. This could be because previous studies have significant methodological limitations such as small sample sizes, short follow-up periods, lack of quality in the design, or lack of methodological rigor in the selection and use of the instruments used to measure adolescents (Pakarinen et al., 2017; Rose et al., 2017). In addition, one of the main problems encountered is the lack of adherence to mobile applications, with their use decreasing greatly after the initial weeks of practice (He et al., 2021).

More specifically, in the educational field, there is only one research study conducted on physical education with mobile applications (Zhu & Dragon, 2016). This study proved the usefulness of these tools in increasing the level of physical activity of adolescents during physical education classes and the results showed that the use of mobile devices in the physical education classroom was not directly related to increased physical activity (Zhu & Dragon, 2016). The lack of effectiveness in the use of mobile applications aimed at increasing the practice of physical activity during physical education classes could be due to the fact that they do not have an adequate design that facilitates their didactic use, thus lacking educational potential in the classroom (Alonso-Fernández et al., 2022).

However, research has also been conducted in the field of education with mobile applications that encourage physical activity outside school hours (Direito et al., 2015; Gil-Espinosa et al., 2020; Seah & Koh, 2021). Although this research the use of mobile application outside of school was shown to be more effective than the use during school hours, the results were not completely clear. Thus, the use of mobile applications during the weekend, for adolescent females, was shown to be effective in increasing the number of total steps, but with an effect that was stable only during the first two weeks, perhaps due to the novelty of the intervention (Seah & Koh, 2021). Other research studies investigated the effectiveness of immersive (Zombies Run) and non-immersive (Get Running) apps on adolescents after school hours, finding no significant changes in the physical activity and physical fitness variables analyzed after the intervention (Direito et al., 2015a). The third study used the Endomondo app with high school students to increase their activity level after school hours and showed that new technologies could be a useful resource to increase the physical activity time of adolescents (Gil-Espinosa et al., 2020). However, in all of these studies, the practice of physical activity outside school hours was promoted from the subject of Physical Education, but not as an obligation for the student, but rather as an option.

In this situation, previous scientific evidence describes a research gap regarding the real effectiveness of mobile applications promoted from the field of education, as physical education homework, aimed at increasing the number of daily steps, on the level of physical activity, body composition and physical condition of the adolescent population (Direito et al., 2015a; Seah & Koh, 2021; Zhu & Dragon, 2016). In this regard, mobile applications such as Strava, Pacer or

MapMyWalk have been shown to be ideal for this purpose, as they utilize numerous behavioral change techniques (Bondaronek et al., 2018), but their effectiveness has only been demonstrated in the adult population (Leong & Wong, 2017; Peng et al., 2016; Petersen et al., 2020). Thus, in the adolescent population, attempts to integrate the use of mobile apps in the educational setting have shown no or small benefits on physical activity, fitness, AMD, and body composition in adolescents (Direito et al., 2015a; Gil-Espinosa et al., 2020), probably due to the lack of adherence to this type of interventions or to the optional nature of their use (He et al., 2021; Seah & Koh, 2021).

Therefore, it seems clear that interventions promoted in the educational setting, but conducted outside school hours, appear to be more effective, but the results are reduced. This leads to the research question as to whether the mandatory use of the mobile application by students in compulsory secondary education would lead to greater adherence and superior benefits in this population. Thus, as the main differentiating aspect of this research, the lack of adherence to the intervention with mobile applications will be solved with the collaboration of physical education teachers who will promote the mandatory use of mobile applications by students as "homework" for the subject outside school hours. Furthermore, no previous intervention is known to have compared the effect of similar mobile applications (step-tracker apps) on physical activity levels, physical fitness, AMD, or body composition in an adolescent population.

Given that the number of hours of physical education cannot be modified in the curriculum and are not sufficient to make secondary school students be active, and that there are numerous studies that have tried to integrate mobile applications in physical education classes without much success, this research focuses on complementing the work performed in physical education classes using mobile applications during out-of-school hours. This research presents the novel idea of the "mandatory" use of mobile apps as "homework" in the subject of physical education, educating adolescents on a sports culture from an early age. For this reason, the main objectives of the present research were a) to determine the changes produced by a compulsory ten-week period of after-school intervention with mobile step-tracking applications on the level of physical activity, body composition, physical fitness, and AMD of adolescents aged twelve to sixteen years old; and b) to compare the benefits obtained by each of the mobile applications on the level of physical activity, body composition, physical fitness, and AMD of adolescents.

5.2.1. Hypotheses

Based on previous scientific literature, in which the use of mobile applications had an influence on physical activity, body composition, physical fitness, and AMD of adolescents, although their effects were reduced in the first weeks of intervention due to lack of adherence (He et al., 2021; Seah & Koh, 2021), the following research hypotheses are proposed: H1) the mandatory use of the mobile application as "homework" for the physical education subject will lead to a high number of adolescents completing the intervention, and its use will show improvements in the level of physical activity, body composition and physical fitness, and AMD, as compared to the control group; and H2) there will be no significant differences between intervention groups using different mobile apps in physical activity level, body composition, physical fitness, and AMD.

5.3. Materials and Methods

5.3.1. Design

A longitudinal study, with non-probability convenience sampling was conducted. Prior to the start of the study, the institutional ethics committee approved the research design in accordance with the World Medical Association (code: CE022102) and following the guidelines of the Helsinki Declaration. The measurement protocol was registered before the start of the study at ClinicalTrials.gov (code: NCT04860128) and followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines. Two public compulsory secondary schools from different areas in the Region of Murcia and with the largest number of students in compulsory education (over 200 students per center) in the selected localities, were selected. First, the management teams of the schools where the research was to be conducted were contacted. After obtaining approval, data collection was coordinated with those responsible for the physical education area. Finally, in a meeting with the parents and adolescents, the objective and procedures were explained, as well as the confidentiality in the treatment of the data obtained.

The parents of the students who wished to participate voluntarily signed the informed consent form.

5.3.1.1. ***Research model***

The research model designed for the study is shown in Table 1. The importance of the model lies in the fact that previous research that attempted to analyze the changes produced in the physical activity level, body composition, physical condition, or AMD of adolescents, through mobile applications, were scarce, used small samples and, on occasions, used invalid and unreliable methods for data collection. The novelty of the present research is the mandatory use of mobile applications, with which the level of physical activity performed is expected to increase significantly in the intervention groups. This aspect has not been considered previously, perhaps due to the precociousness of the subject matter addressed, as recent research showed that adherence to this type of intervention was very low after the first few weeks (He et al., 2021; Seah & Koh, 2021). Therefore, the present research aims to go beyond previous studies, by trying to achieve a greater adherence to the intervention, and by including a more representative measurement of body composition (with twelve variables measured and calculated) and physical fitness (with seven physical fitness tests) than previous research, which will allow discovering the benefits produced by mobile applications as an educational complement to physical education classes.

5.3.2. Participants

For the calculation of the sample size, the methodology from previous studies based on the standard deviation (SD) were used (Bhalerao & Kadam, 2010). The sample size was calculated using Rstudio 3.15.0 statistical software (Rstudio Inc., USA) and using SD from previous research that used mobile applications to improve the level of physical activity (SD=0.66) (Direito et al., 2015a) in adolescents aged twelve to sixteen years old. The estimated error (d) for a 99% confidence interval was 0.09 for physical activity level. The minimum sample necessary for the development of the research was 390 adolescents.

Table 1. Constructs and operational definitions included in the research model.

Variable type	Construct	Operational definition	Scope conditions
Independent	Mandatory mobile application use	Recording of the kilometers traveled through the mobile application	Applied individually, without location limitations, during after-school hours
Dependent	Physical activity level	Results of the PAQ-A questionnaire (Kowalski et al., 2004)	Applied individually, in a classroom of the educational center, during the physical education class timetable
Dependent	Adherence to Mediterranean diet	Results of the KIDMED questionnaire (Serra-Majem et al., 2004)	Applied individually, in a classroom of the educational center, during the physical education class timetable
Dependent	Body composition	Measurement of body mass, height, sitting height; triceps, thigh, and calf skinfolds; relaxed arm, waist, hip, thigh, and calf girth; and calculation of BMI, muscle mass, sum of the three skinfolds, corrected girths, and waist-to-hip ratio (Esparza-Ros et al., 2019; Poortmans et al., 2005)	Applied individually, in one of the locker rooms of the school's sports pavilion, during physical education class
Dependent	Physical fitness	With the measurement of cardiorespiratory fitness (20 m shuttle run test) (Léger et al., 1988), upper limb strength (hand grip strength and arm flexion) (Castro-Piñero et al., 2010; Matsudo et al., 2014), hamstring and lower back flexibility (sit and reach) (Ayala et al., 2012), lower limb explosive power (countermovement jump) (Barker et al., 2018), abdominal muscular strength and endurance (curl-up) (Garcia-Pastor et al., 2016) and speed (20 m sprint) (García-Manso et al., 1996)	Applied individually or collectively (20-m shuttle run test), in the sports pavilion of the school, during the physical education class

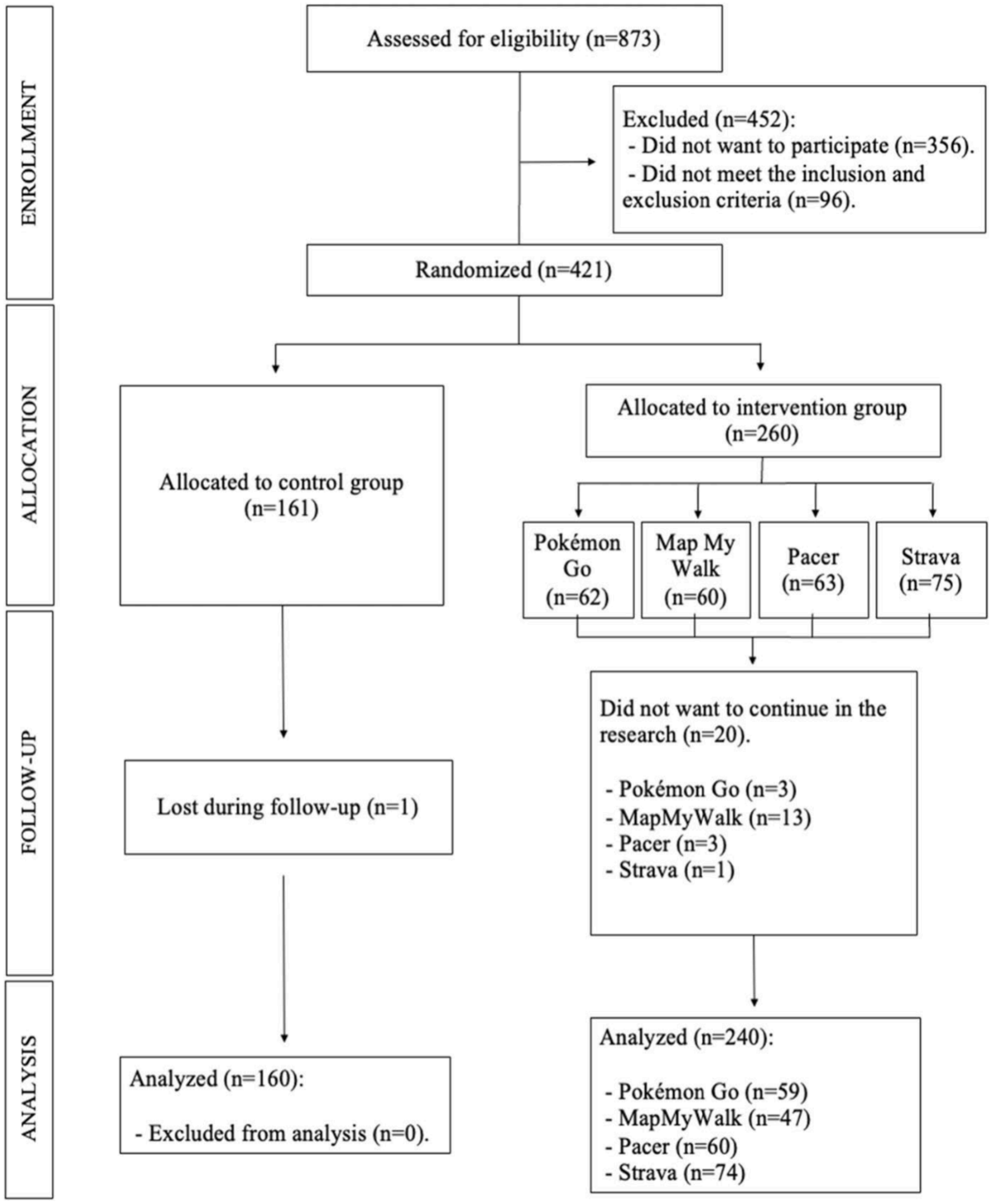
The sample population of all students in compulsory secondary education in the Region of Murcia was 69,888 at the time of measurement, being reduced to 873 students in the two centers that agreed to participate. Figure 1 shows the final sample selection flowchart. The final sample consisted of 400 adolescents (210 boys and 190 girls) between the ages of twelve and sixteen (mean age: 13.96±1.21), who voluntarily participated in the research study after obtaining parental consent. The inclusion criteria for the present study were a) ages between twelve and sixteen years old; b) attending compulsory secondary education; c) not presenting any disabling disease that prevented participation; d) completing all the questionnaires and physical tests in their entirety; and e) participating in the measurements taken before (pre-test) and after (post-test) the intervention. The exclusion criteria were a) missing more than 80% of the physical education sessions scheduled during the course; b) not having a mobile phone; c) changing schools during the intervention; and d) starting or abandoning regular physical activity during the intervention, including gym training or enrollment in a sports, as well as an increase in the number of daily steps on days when the app was not used, that could modify the level of physical activity practiced for reasons unrelated to the intervention.

5.3.3. Instruments

*5.3.3.1. **Questionnaire measurements***

The level of physical activity of the adolescents was assessed using the "Physical Activity Questionnaire for Adolescents" (PAQ-A) (Kowalski et al., 2004). This questionnaire is composed of nine items, the first eight items being answered with a Likert scale of 1 to 5 points (1, low level of physical activity, and 5, high level of physical activity), and the last item by a dichotomous response (yes or no) to find out whether the subject was ill in the last week, which would have prevented him/her from practicing physical activity. The arithmetic mean of the scores from the first eight items allows obtaining a final physical activity score, with adolescents being classified as active or sedentary depending on whether the score was higher or lower than 2.75, respectively (Benítez-Porres et al., 2016). This questionnaire was previously validated and used in previous research and has an intraclass correlation coefficient of 0.71 for the final score of the questionnaire (Martínez-Gómez et al., 2009).

Figure 1. Selection and division process of the research sample.



The adolescents' nutritional habits, specifically AMD, were assessed using the KIDMED questionnaire (Serra-Majem et al., 2004), as it is the most valid and reliable instrument for use in the adolescent population (Štefan, Prosoli, et al., 2017). Sixteen items that are answered using a dichotomous scale (yes or no) compose this questionnaire. The score of each item varies depending on whether the connotation is negative (-1) or positive (+1). Of the sixteen items, twelve had a positive value and four had a negative value, for a final score between 0 and 12 points.

5.3.3.2. ***Body composition measurement***

ISAK accredited anthropometrists (levels 2 to 4) carried out the measurement and analysis of the adolescents' body composition. The measurement consisted of three basic measurements (body mass, height, sitting height), three skinfolds (triceps, thigh, and calf), and five girths (arm relaxed, waist, hip, thigh, and calf). All measurements were performed according to the protocol standardized by the International Society for the Advancement of Kinanthropometry (ISAK) (Esparza-Ros et al., 2019).

Two measurements of each variable were carried out, with a third measurement in cases where the difference between the first two measurements was greater than 5% in skinfolds or 1% in the rest of the measurements. When two measurements were taken, the final value was their mean, but when a third measurement was taken, the median of the three was used as the final value (Esparza-Ros et al., 2019).

To measure girths, an inextensible tape, Lufkin W606PM (Lufkin, Missouri) with a 0.1 cm accuracy was used a skinfold caliper (Harpenden, Burgess Hill, UK) with an accuracy of 0.2 mm was used for measuring skinfolds; for body mass, a TANITA BC 418-MA Segmental (TANITA, Tokyo) with an accuracy of 100 g; and for height and sitting height a SECA stadiometer 213 (SECA, Hamburg) with an accuracy of 0.1 cm were used. All the instruments were previously calibrated.

The intra- and inter-evaluator technical error of measurements (TEM) were calculated in a sub-sample. The intra-evaluator TEM was 0.02% for the basic measurements; 1.21% for skinfolds, and 0.04% for the girths; and the inter-evaluator TEM was 0.03% for the basic measurements; 1.98% for skinfolds and 0.06% for the girths.

The final values of the anthropometric measurements were used to calculate the BMI, muscle mass (Poortmans et al., 2005), Σ3 skinfolds (triceps, thigh, and calf), corrected girths of the arm [arm relaxed girth – (π * triceps skinfold)], thigh [middle thigh girth – (π * thigh skinfold)] and calf [calf girth – (π * calf skinfold)], and waist-to-hip ratio (waist girth/hip girth).

5.3.3.3. *Physical fitness test*

To measure hamstring and lower back flexibility, the test used was the sit-and-reach, due to its moderate validity in adolescents (Ayala et al., 2012). Participants were seated with knees extended, feet hip-width apart, ankles in 90° flexion, toes pointed upward, and the sole of the foot fully supported on an Acuflex Tester III box (Novel Products, USA). From that position, the subjects had to perform maximum trunk flexion, keeping the knees and arms fully extended, and reach the maximum possible distance by sliding the palms of their hands, one on top of the other, on the box (López-Miñarro et al., 2015).

Two tests were used for upper limb strength. First, the handgrip strength, as it has been shown to be a valid test for the measurement of physical fitness in adolescents (Matsudo et al., 2014). Participants applied the force with the elbow fully extended, as this is the most appropriate position to measure maximal strength (España-Romero et al., 2010). The instrument used for the measurement was a Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo, Japan). Secondly, the push-up test was used in which the adolescents had to lay in the prone position, with the tips of their feet in contact with the floor and their arms placed on both sides of the body with the elbows flexed at 90º. From this position, the participants had to lift themselves off the floor until they fully extended their arms, keeping their legs and back straight, and repeat this movement as many times as possible. The test ended when the arms were not fully extended or when exhaustion was reached (Castro-Piñero et al., 2010).

The countermovement jump (CMJ) was used to measure the explosive power of the lower limbs. This test consists of a vertical jump in which the aim is to reach the maximum possible height. For this, the subjects initially stand with their hands on their waists, perform a quick knee flexion to a 90º position, and then fully extend their knees to jump. Following the protocol by Barker et al. (2018), the hands should remain at the waist throughout the execution, the knee flexion should be as fast as possible, and the trunk and legs should remain extended during the flight phase. A force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) was used to perform the test.

Abdominal muscular strength and endurance were evaluated by means of the curl-up test. Subjects were laid in the supine position with knees bent at 90º and feet flat on the floor. The arms were placed crossed over the chest, and from this position the participants had to perform the maximum number of trunk flexions, with the repetitions in which the upper back area was no longer in contact with the floor deemed as valid (Garcia-Pastor et al., 2016).

Adolescents' speed was measured using the 20-m sprint test. At the beginning of the test, the participants stood at the starting line, and they decided when to start the maximum sprint (García-Manso et al., 1996). To measure the time it took the adolescents to run the 20 meters, single-beamed photocells (Polifemo Light, Microgate, Italy) located at hip height were used, with this beam placement being an influential factor in the reliability of the test, due to the fact that at this height, there is only a 4% probability of the arms cutting the photocell before the body, while at chest height there is a 60% probability of this occurring (Altmann et al., 2017; Cronin & Templeton, 2008).

Cardiorespiratory fitness was assessed by means of the 20-m shuttle run test (Léger et al., 1988). This test consists of running 20 meters as many times as possible before the beep sounds. The test ends when the participant reaches exhaustion or when he/she is not able to cover the distance before the beep sounds. This incremental test has a high validity and reliability for use with adolescents (Tomkinson et al., 2019). The last speed test at which the subject completed the distance was used to predict maximal oxygen consumption (VO2 max) using the formula from Léger et al. (1988).

To avoid inter-evaluator error in the assessments, five researchers conducted the physical fitness tests. Each investigator was assigned specific tests and performed familiarization and measurement procedures of the same tests on all the adolescents during the pre- and post-test. The selected investigators had previous experience in measuring physical fitness tests.

5.3.4. Measurement procedure

First, the adolescents completed questionnaires on their level of physical activity and nutritional habits. Subsequently, anthropometric measurements were taken to determine body composition. Prior to warming up, in order to prevent the activation generated during the warm-up from influencing the performance of the test, the sit-and-reach was performed (Díaz-Soler et al., 2015). Once the sit-and-reach test was completed, the correct executions of the handgrip strength, CMJ, curl up, push up and 20-m sprint test were explained to the adolescents so that they became familiarized with them. After completing the familiarization process, a progressive running warm-up with joint mobility was performed, and the handgrip strength, curl up, push up, CMJ, and 20-m sprint tests were carried out. The 20-m shuttle run test was performed after the rest of the physical tests. All the physical fitness tests were performed twice by each adolescent, leaving two minutes between each of the test attempts, and five minutes between tests, considering the best value obtained, except for the sit-and-reach and the 20-m shuttle run test, which were performed only once.

The recommendations established by the National Strength and Conditioning Association (NSCA) were followed to determine the order of the physical fitness tests. To produce the least possible interference in the results, five-minute rest were taken between physical fitness tests to allow the subjects to recover from the fatigue generated and the metabolic demands of the different tests (Coburn & Malek, 2014). The protocol for performing the physical fitness tests has been previously used in research with similar populations (Albaladejo-Saura, Vaquero-Cristóbal, García-Roca, et al., 2022a).

5.3.5. Mobile application intervention

To carry out the intervention, the initial sample (n=421) was distributed into five groups (four experimental groups and one control group). Each of the experimental groups used one of the following applications: Pokémon Go®, Pacer®, Strava® and MapMyWalk®. The distribution of the adolescents in the experimental and control groups was randomized, including the entire school class in the corresponding group. Because the number of adolescents participating in the research was different in each school class, the experimental groups had slight initial sample differences (Pokémon Go: n=62; MapMyWalk: n=60; Pacer: n=63; Strava: n=75).

Before starting the intervention, the adolescents were measured for level of physical activity, body composition, physical fitness, and AMD (pre-test). After the pre-test, the 10-week intervention was conducted in which adolescents in the experimental groups used the assigned mobile apps in their after-school schedule.

Adolescents in the experimental group had to use the application a minimum of three times a week, in which they walked a minimum of 5000 steps or 3.19 kilometers, considering that one kilometer corresponded to approximately 1565 steps (Morency et al., 2007), which is the minimum to stop being considered sedentary (Lubans et al., 2015). Those subjects who did not reach this minimum being excluded from the study. Pacer, Strava and MapMyWalk were selected because they include numerous behaviors change techniques (8-10 change techniques per application) (Bondaronek et al., 2018), while Pokémon Go is a game that has been used in previous interventions with children and adults, and has been shown to be effective in increasing the level of physical activity and the number of daily steps (Khamzina et al., 2020; Lee et al., 2021), being suitable options to increase the level of physical activity in this population. The control group did not use any app during their after-school schedule, and attended physical education classes normally, along with the experimental group. At the end of the 10-week intervention, the level of physical activity, body composition, physical fitness, and AMD of the experimental and control groups were measured again (post-test).

The completion rate of the intervention was different between applications. Of the 421 adolescents who started the study, 400 completed the research (4.99% attrition). Regarding the mobile apps used, 59 adolescents on Pokémon Go (4.84% attrition), 47 on MapMyWalk (21.67% attrition), 60 on Pacer (4.76% attrition) and 74 on Strava (1.33% attrition) completed at least 5000 steps three times per week.

5.3.6. Statistical analysis

After analyzing the normality of the variables using the Kolmogorov-Smirnov test (p=0.054-0.249), as well as kurtosis (p=-0.136-3.389), skewness (p=-3.095-2.491), and variance (p=0.003-25.535), a Student's t-test was performed to determine the homogeneity of the experimental and control groups at baseline, and two two-way ANOVAs with repeated measures in one-way were carried out to analyze inter- and intra-group differences, following the guidelines from previous research in which educational interventions were carried out with two measurements and two groups (González-Gálvez et al., 2020; Seah & Koh, 2021). The first ANOVA analyzed differences between adolescents who completed the minimum training volume with the app and those who did not, while the second was used to find differences between different mobile app groups at the level of physical activity, body composition, physical fitness, and AMD. The Bonferroni post-hoc test was used to evaluate the statistical significance of the variables. Partial eta squared ($\eta 2$) was used to calculate the effect size and was defined as small: ES ≥ 0.10; moderate: ES ≥ 0.30; large: ≥ 1.2; or very large: ES ≥ 2.0, with an error of $p<0.05$ (Hopkins et al., 2009). A value of $p<0.05$ was set to determine statistical significance. The statistical analysis was performed with the SPSS statistical package (v. 25.0; SPSS Inc., IL).

5.4. Results

Before analyzing the differences between the pre- and post-intervention, the differences between the experimental and control groups before the start of the intervention were determined to obtain their homogeneity at baseline. Thus, the results showed no significant differences between adolescents who participated in the intervention and those who did not participate at the baseline physical activity score (p=0.209), BMI (p=0.071), corrected girths (arm: p=0.512; thigh: p=0.946; calf: p=0.297), waist girth (p=0.282), muscle mass (p=0.781), VO2 max. (p=0.144), handgrip (right arm: p=0.902; left arm: p=0.800), CMJ (p=0.950), 20-m sprint (p=0.818), curl-up (p=0.893), and push-up (p=0.339).

Levene's test for homogeneity of variances was performed, showing that all dependent variables were homogeneous: physical activity score (pre: p=0.739; post: p=0.074); body mass (pre: p=0.202; post: p=0.265); height (pre: p=0.858; post: p=0.800); BMI (pre: p=0.334; post: p=0.302); sitting height (pre: p=0.159; post: p=0.147); sum of 3 skinfolds (pre: p=0.115; post: p=0.492); corrected arm girth (pre: p=0.520; post: p=0.686); corrected thigh girth (pre: p=0.931; post: p=0.422); corrected calf girth (pre: p=0.274; post: p=0.429); waist girth (pre: p=0.082; post: p=0.354); hip girth (pre: p=0.169; post: p=0.453); waist/hip ratio (pre: p=0.788; post: p=0.177); muscle mass (pre: p=0.144; post: p=0.075); AMD (pre: p=0.193; post: p=0.053); VO2 max. (pre: p=0.532; post: p=0.198); handgrip right arm (pre: p=0.835; post: p=0.798); handgrip left arm (pre: p=0.648; post: p=0.434); sit-and-reach (pre: p=0.672; post: p=0.505); CMJ (pre: p=0.939; post: p=0.069); 20-m sprint (pre: p=0.999; post: p=0.052); curl-up (pre: p=0.818; post: p=0.058); and push-up (pre: p=0.417; post: p=0.942).

The differences between adolescents in the control and experimental groups after the intervention are shown in Table 2. After the intervention, the experimental group showed a higher level of physical activity (p<0.001), body mass (p<0.001),

Table 2. Differences pre to post test (intra-groups) for physical activity, physical fitness, adherence to Mediterranean diet, and anthropometric variables.

Variable	Group	Pre-intervention	Post-intervention	Diff. Pre-post	p	95% CI Diff.	ES
Physical activity	EG	2.63±0.67	2.80±0.60	-0.170±0.47	<0.001	-0.241; -0.098	0.052
	CG	2.72±0.68	2.70±0.74	0.014±0.67	0.753	-0.073; 0.101	0.001
Body mass	EG	55.47±12.81	56.39±12.64	-0.917±1.84	<0.001	-1.158; -0.677	0.126
	CG	52.47±10.65	53.39±10.57	-0.925±1.94	<0.001	-1.220; -0.630	0.089
Height	EG	162.91±9.12	163.65±9.03	-0.738±1.52	<0.001	-0.948; -0.528	0.109
	CG	160.87±8.75	161.52±8.70	-0.645±1.79	<0.001	-0.902; -0.388	0.059
BMI	EG	20.85±3.83	20.98±3.70	-0.124±0.70	0.009	-0.217; -0.031	0.017
	CG	20.19±3.33	20.43±3.22	-0.236±0.76	<0.001	-0.349; -0.122	0.041
Sitting height	EG	84.90±9.21	85.13±9.28	-0.234±11.32	0.829	-2.360; 1.892	0.001
	CG	82.17±14.99	81.95±17.07	0.222±22.36	0.829	-2.356; 2.799	0.001
Sum 3 skinfolds	EG	52.08±26.96	50.22±24.35	1.854±9.41	0.002	0.703; 3.006	0.025
	CG	44.87±23.71	44.31±22.85	0.554±8.28	0.445	-0.869; 1.977	0.002
Corrected arm girth	EG	20.90±2.79	21.31±2.70	-0.411±1.06	<0.001	-0.535; -0.287	0.099
	CG	20.73±2.69	21.12±2.62	-0.382±0.79	<0.001	-0.229; 0.535	0.059
Corrected thigh girth	EG	39.19±4.68	40.14±4.56	-0.944±1.76	<0.001	-1.233; -0.654	0.096
	CG	39.23±5.10	39.68±4.15	-0.451±2.84	0.013	-0.808; -0.094	0.016
Corrected calf girth	EG	28.95±3.46	29.32±2.85	-0.368±2.32	0.003	-0.609; -0.127	0.023
	CG	28.68±2.69	29.18±2.61	-0.497±0.84	0.001	-0.794; -0.199	0.027
Waist girth	EG	68.50±8.73	68.55±8.38	-0.044±2.11	0.759	-0.327; 0.239	0.001
	CG	67.49±7.03	67.75±7.13	-0.259±2.34	0.146	-0.608; 0.090	0.005
Hip girth	EG	89.41±9.15	90.35±8.68	-0.937±2.28	<0.001	-1.227; -0.646	0.094
	CG	86.22±7.69	87.50±7.59	-1.280±2.24	<0.001	-1.639; -0.922	0.113
Waist/hip ratio	EG	0.77±0.05	0.76±0.05	0.007±0.02	<0.001	0.005; 0.010	0.078
	CG	0.78±0.05	0.77±0.05	0.009±0.02	<0.001	0.005; 0.012	0.068

Muscle mass	EG	18.03±4.99	18.62±4.24	-0.590±1.82	<0.001	-0.835; -0.344	0.055
	CG	18.24±4.64	18.03±3.83	0.203±2.04	0.189	-0.100; 0.507	0.004
AMD	EG	6.85±2.44	6.83±2.56	0.021±2.35	0.899	-0.306; 0.348	0.001
	CG	5.82±2.54	5.75±2.84	0.062±2.84	0.759	-0.334; 0.458	0.001
VO2 max	EG	38.04±4.87	39.09±5.70	-1.050±0.20	<0.001	-1.445; -0.655	0.073
	CG	38.57±5.02	39.26±5.12	-0.686±0.25	0.006	-1.178; -0.194	0.021
Handgrip right arm	EG	24.49±7.63	25.97±8.27	-1.481±4.67	<0.001	-2.060; -0.902	0.060
	CG	24.39±7.24	25.27±8.49	-0.875±4.36	0.015	-1.577; -0.173	0.015
Handgrip left arm	EG	23.00±7.11	23.83±7.41	-0.830±3.77	<0.001	-1.284; -0.376	0.031
	CG	23.18±6.74	23.87±7.93	-0.688±3.23	0.014	-1.238; -0.137	0.015
Sit-and-reach	EG	14.56±8.00	16.06±8.44	-1.497±3.63	<0.001	-1.993; -1.002	0.083
	CG	12.70±7.48	13.76±8.10	-1.063±4.16	0.001	-1.664; -0.462	0.030
CMJ	EG	21.99±7.35	23.26±7.98	-1.262±6.97	0.015	-2.280; -0.245	0.015
	CG	22.04±7.55	22.53±9.42	-0.487±9.28	0.438	-1.720; 0.746	0.002
20-m sprint	EG	3.88±0.81	3.77±0.82	0.102±0.76	0.098	-0.019; 0.224	0.007
	CG	3.86±0.80	3.54±1.20	0.315±1.18	<0.001	0.168; 0.462	0.043
Curl-up	EG	20.43±11.49	24.39±10.67	-3.95±10.33	<0.001	-5.330; -2.577	0.075
	CG	20.33±11.31	21.94±11.93	-1.614±11.31	0.059	-3.293; 0.065	0.009
Push-up	EG	6.67±9.34	8.37±10.41	-1.700±5.94	<0.001	-2.519; -0.880	0.042
	CG	7.80±9.31	9.07±9.84	-1.270±6.95	0.014	-2.284; -0.256	0.016

EG: experimental group; CG: control group; BMI: body mass index; AMD: adherence to Mediterranean diet; VO2: maximum oxygen consumption; CMJ: countermovement jump.

height (p<0.001), corrected girths (p<0.001-0.003), hip girth (p<0.001), muscle mass (p<0.001) and better performance in the physical fitness tests (p<0.001-0.015), except in the 20-m sprint (p=0.098). Similarly, there was a significant decrease in the sum of three skinfolds (p=0.002) and waist/hip ratio (p<0.001). In the control group, the pre-post measurements showed significant differences in body mass (p<0.001), height (p<0.001), corrected girths (p<0.001-0.013), hip girth (p<0.001), waist/hip ratio (p<0. 001) and in all physical fitness tests (p<0.001-0.015), except in CMJ (p=0.438) and curl up (p=0.059), with higher values in all variables, except for the waist/hip ratio, after the intervention.

Table 3 shows the differences between the experimental and control groups in the pre-post change. The differences were significant in the level of physical activity (p=0.039), corrected thigh girth (p=0.034), muscle mass (p<0.001), VO2 max (p=0.043), and CMJ (p=0.034), with adolescents in the experimental group showing higher values in all variables after the intervention.

Table 3. Differences between groups in the pre-post-test change for physical activity, physical fitness, adherence to Mediterranean diet, and anthropometric variables.

Variable	Group	Diff. Pre-post	Diff. Post-pre EG – Diff. Post-pre CG	F	p	95% CI Diff.	ES
Physical activity score	EG	-0.170±0.47	-0.183	4.286	0.039	-0.296; -0.071	0.013
	CG	0.014±0.67					
Body mass	EG	-0.917±1.84	0.007	0.012	0.912	-0.373; 0.388	0.001
	CG	-0.925±1.94					
Height	EG	-0.738±1.52	-0.093	0.080	0.778	-0.426; 0.238	0.001
	CG	-0.645±1.79					
BMI	EG	-0.124±0.70	0.111	2.244	0.135	-0.035; 0.258	0.006
	CG	-0.236±0.76					
Sitting height	EG	-0.234±11.32	-0.456	1.440	0.231	-3.797; 2.886	0.004
	CG	0.222±22.36					
Sum 3 skinfolds	EG	1.854±9.41	1.301	0.882	0.348	-0.530; 3.131	0.003
	CG	0.554±8.28					
Corrected arm girth	EG	-0.411±1.06	-0.029	0.019	0.891	-0.226; 0.168	0.001
	CG	-0.382±0.79					
Corrected thigh girth	EG	-0.944±1.76	-0.493	4.528	0.034	-0.952; -0.033	0.013
	CG	-0.451±2.84					
Corrected calf girth	EG	-0.368±2.32	0.129	1.155	0.283	-0.254; 0.512	0.003
	CG	-0.497±0.84					

Waist girth	EG	-0.044±2.11	0.215	0.854	0.356	-0.235; 0.664	0.003
	CG	-0.259±2.34					
Hip girth	EG	-0.937±2.28	0.344	1.516	0.219	-0.118; 0.805	0.004
	CG	-1.280±2.24					
Waist/hip ratio	EG	0.007±0.02	-0.001	0.088	0.767	-0.005; 0.003	0.001
	CG	0.009±0.02					
Muscle mass	EG	-0.590±1.82	-0.793	12.736	<0.001	-1.184; -0.402	0.036
	CG	0.203±2.04					
AMD	EG	0.021±2.35	-0.041	0.507	0.477	-0.554; 0.472	0.001
	CG	0.062±2.84					
VO2 max	EG	-1.050±0.20	0.364	4.110	0.043	-1.338; 0.128	0.012
	CG	-0.686±0.25					
Handgrip right arm	EG	-1.481±4.67	-0.605	1.286	0.258	-1.515; 0.305	0.004
	CG	-0.875±4.36					
Handgrip left arm	EG	-0.830±3.77	-0.142	0.001	0.994	-0.856; 0.572	0.001
	CG	-0.688±3.23					
Sit-and-reach (cm)	EG	-1.497±3.63	-0.435	0.830	0.363	-1.214; 0.344	0.002
	CG	-1.063±4.16					
CMJ (cm)	EG	-1.262±6.97	-0.776	4.534	0.034	-2.374; 0.823	0.013
	CG	-0.487±9.28					
20-m sprint (s)	EG	0.102±0.76	-0.213	1.708	0.192	-0.404; -0.022	0.005
	CG	0.315±1.18					
Curl-up	EG	-3.95±10.33	-2.339	3.365	0.067	-4.510; -0.168	0.010
	CG	-1.614±11.31					
Push-up	EG	-1.700±5.94	-0.430	0.171	0.679	-1.733; 0.874	0.001
	CG	-1.270±6.95					

EG: experimental group; CG: control group; BMI: body mass index; AMD: adherence to Mediterranean diet; VO2: maximum oxygen consumption; CMJ: countermovement jump.

The pre- and post-intervention results according to the mobile application used by the adolescents are shown in Figure 2. All the mobile applications showed significant increases in body mass ($p<0.001$-0.009), height ($p<0.001$), corrected arm girth ($p<0.001$-0.003), corrected thigh girth ($p<0.001$-0.029), hip girth ($p<0.001$-0.029), waist/hip ratio ($p<0.001$-0.010), and VO2 max ($p<0.001$-0.011) after the intervention. In addition, no experimental group showed significant changes in sitting height, waist girth, AMD, CMJ, and 20-m sprint.

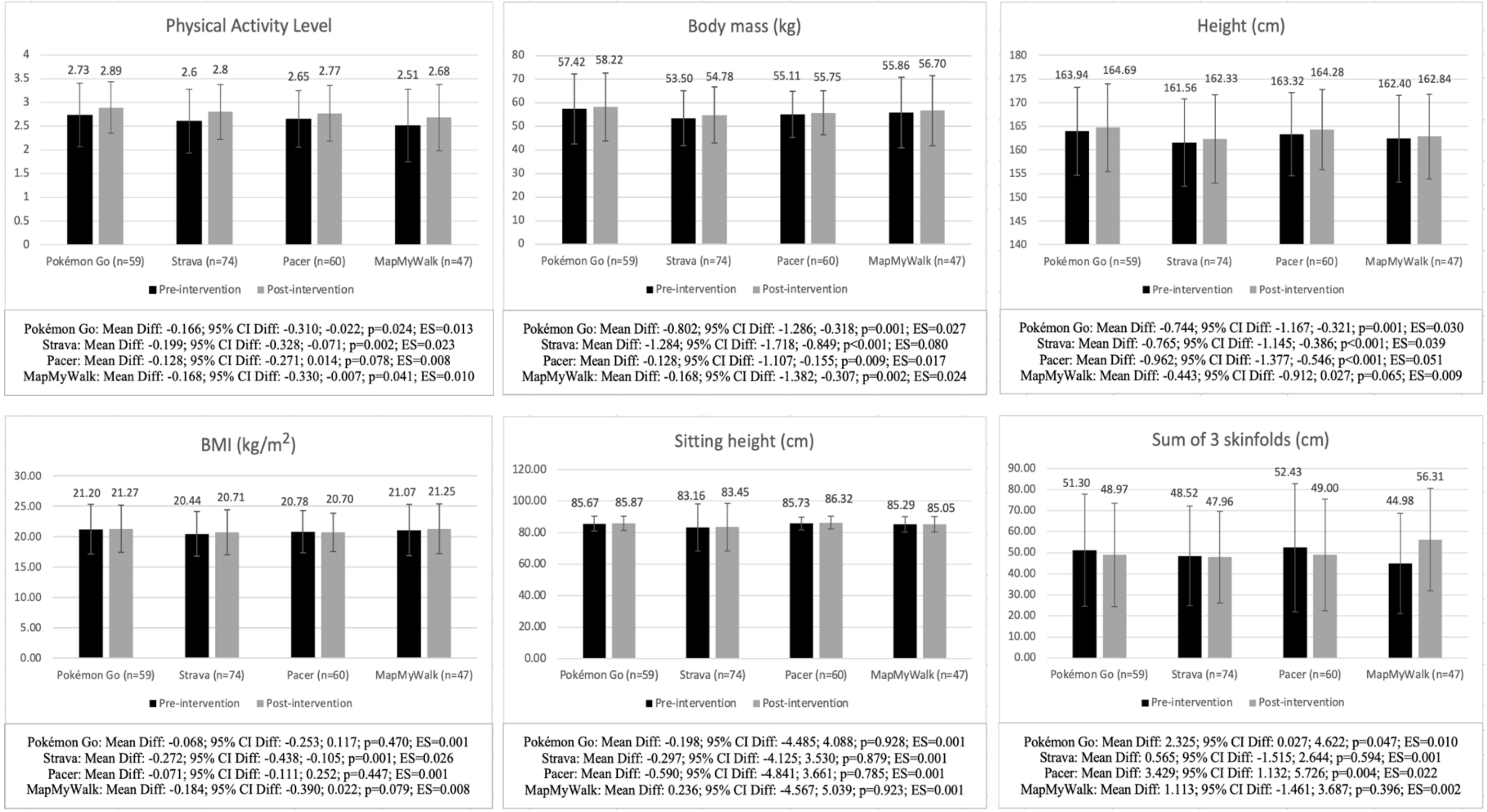
The level of physical activity increased significantly in all mobile applications groups ($p=0.002$-0.041), except for the Pacer group. Regarding muscle mass ($p=0.001$-0.038), hand grip strength ($p<0.001$-0.039), and sit-and-reach test ($p<0.001$-0.014), all the apps showed significant increases, except for Pokémon Go; the BMI did not show significant differences in any intervention group, except for Strava, where it increased ($p=0.001$); a significant decrease in the sum of 3 skinfolds, as well as an increase in corrected calf girth, was found in the Pokémon Go ($p=0.047$; $p=0.045$) and Pacer ($p=0.004$; $p=0.011$) groups. The curl up test score showed significant increases in the Strava ($p<0.001$) and MapMyWalk ($p=0.038$) groups, while in push-ups, only the Pokémon Go group showed a significant increase ($p<0.001$).

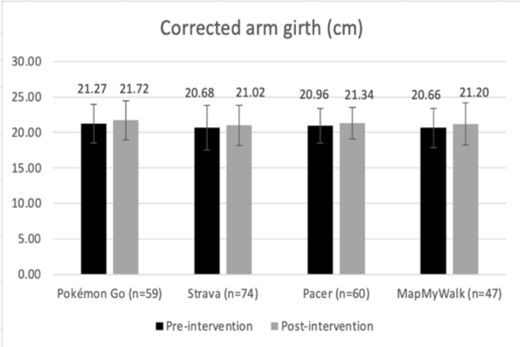
Table 4 shows the differences in the pre-post change between each one of the four experimental groups according to the mobile application used. The Strava group showed a significant increase in body mass with respect to the Pacer group ($p=0.043$), and in curl up with respect to the Pacer ($p=0.013$) and Pokémon Go ($p<0.001$) groups. The Pacer group significantly increased handgrip strength, as compared to the Pokémon Go group ($p=0.009$).

5.5. Discussion

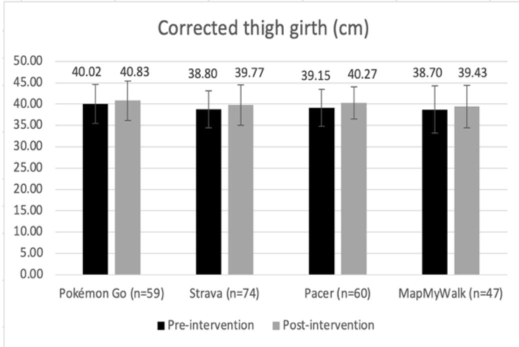
The present research was conducted to answer the research question of whether the mandatory use of the mobile application by students in compulsory secondary education would achieve a sufficient adherence to out of school time physical activity, for students in compulsory secondary education to obtain health benefits on their level of physical fitness and body composition, as previous research in this area had shown initial positive results, although these lost after a few weeks of intervention. The results obtained show that the mandatory use of the application led to its continuous use, with the study ending with a sample of

Figure 2. Differences pre to post test (intra-groups) in physical activity, physical fitness, adherence to Mediterranean diet, and anthropometric variables according to the mobile application used.

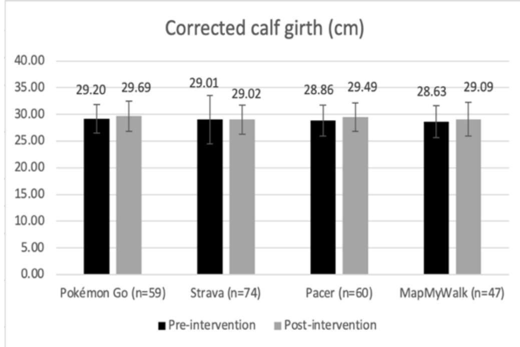




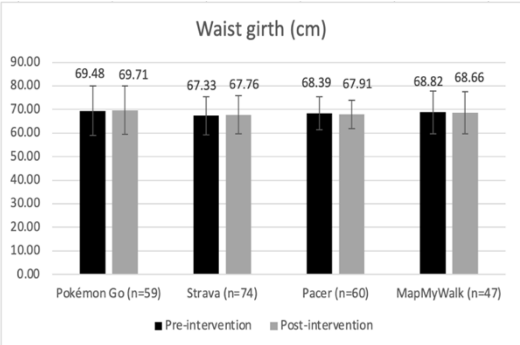
Pokémon Go: Mean Diff: -0.446; 95% CI Diff: -0.694; -0.199; p<0.001; ES=0.032
Strava: Mean Diff: -0.343; 95% CI Diff: -0.567; -0.119; p=0.003; ES=0.023
Pacer: Mean Diff: -0.386; 95% CI Diff: -0.633; -0.138; p=0.002; ES=0.024
MapMyWalk: Mean Diff: -0.536; 95% CI Diff: -0.813; -0.258; p<0.001; ES=0.036



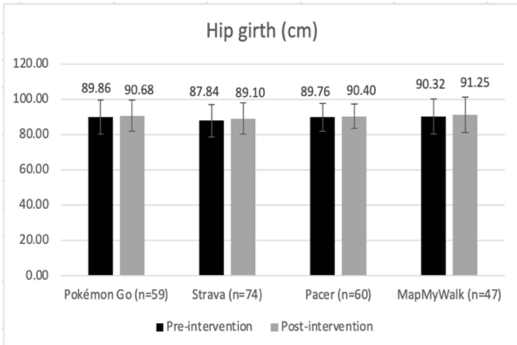
Pokémon Go: Mean Diff: -0.811; 95% CI Diff: -1.390; -0.232; p=0.006; ES=0.019
Strava: Mean Diff: -0.974; 95% CI Diff: -1.498; -0.449; p<0.001; ES=0.034
Pacer: Mean Diff: -1.123; 95% CI Diff: -1.702; -0.544; p<0.001; ES=0.036
MapMyWalk: Mean Diff: -0.724; 95% CI Diff: -1.373; -0.076; p=0.029; ES=0.012



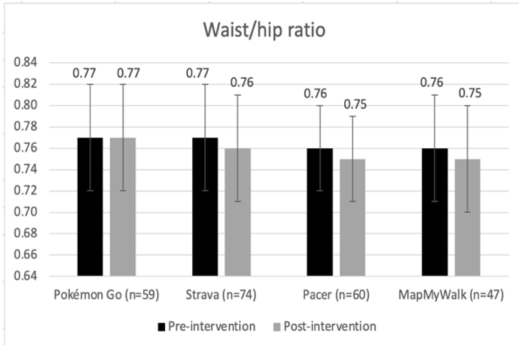
Pokémon Go: Mean Diff: -0.490; 95% CI Diff: -0.970; -0.010; p=0.045; ES=0.010
Strava: Mean Diff: -0.011; 95% CI Diff: -0.446; 0.423; p=0.960; ES=0.001
Pacer: Mean Diff: -0.626; 95% CI Diff: -1.106; -0.146; p=0.011; ES=0.017
MapMyWalk: Mean Diff: -0.458; 95% CI Diff: -0.996; 0.080; p=0.095; ES=0.007



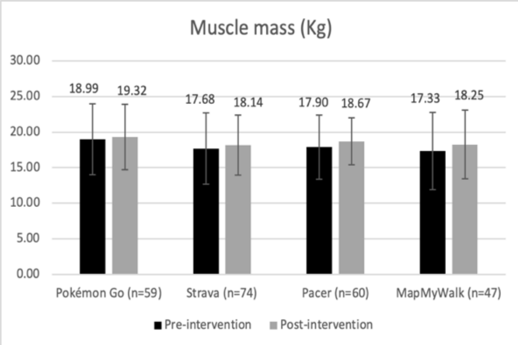
Pokémon Go: Mean Diff: -0.228; 95% CI Diff: -0.790; 0.334; p=0.425; ES=0.002
Strava: Mean Diff: -0.437; 95% CI Diff: -0.946; 0.071; p=0.092; ES=0.007
Pacer: Mean Diff: 0.485; 95% CI Diff: -0.076; 1.047; p=0.090; ES=0.007
MapMyWalk: Mean Diff: 0.165; 95% CI Diff: -0.465; 0.794; p=0.607; ES=0.001



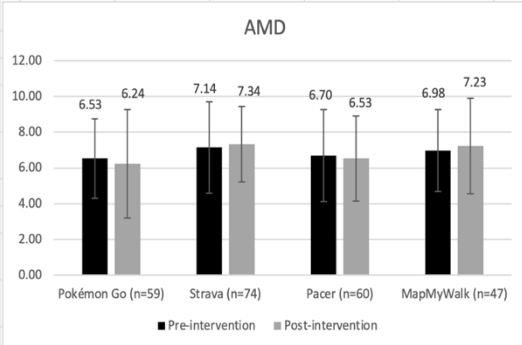
Pokémon Go: Mean Diff: -0.825; 95% CI Diff: 1.405; -0.246; p=0.005; ES=0.020
Strava: Mean Diff: -1.263; 95% CI Diff: -1.788; -0.739; p<0.001; ES=0.055
Pacer: Mean Diff: -0.647; 95% CI Diff: -1.227; -0.068; p=0.029; ES=0.012
MapMyWalk: Mean Diff: -0.923; 95% CI Diff: -1.572; -0.273; p=0.005; ES=0.020



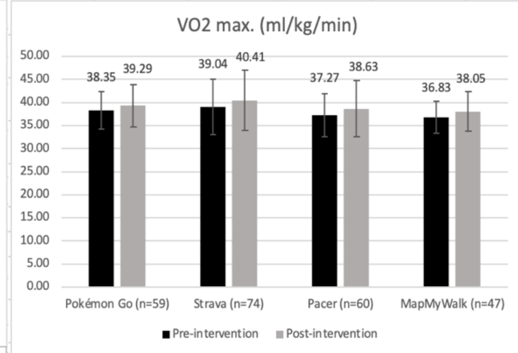
Pokémon Go: Mean Diff: 0.004; 95% CI Diff: -0.001; 0.010; p=0.088; ES=0.008
Strava: Mean Diff: 0.006; 95% CI Diff: 0.001; 0.011; p<0.010; ES=0.017
Pacer: Mean Diff: 0.011; 95% CI Diff: 0.006; 0.016; p<0.001; ES=0.042
MapMyWalk: Mean Diff: 0.009; 95% CI Diff: 0.004; 0.015; p=0.001; ES=0.027



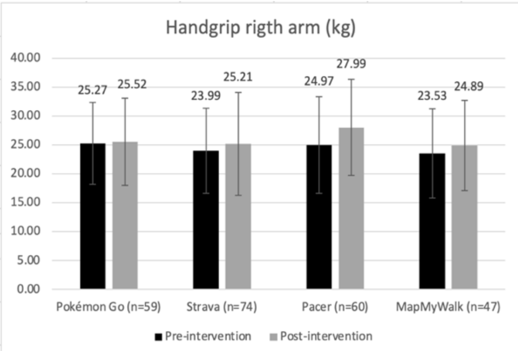
Pokémon Go: Mean Diff: -0.328; 95% CI Diff: -0.820; 0.165; p=0.192; ES=0.004
Strava: Mean Diff: -0.468; 95% CI Diff: -0.910; -0.026; p=0.038; ES=0.011
Pacer: Mean Diff: -0.762; 95% CI Diff: -1.251; -0.274; p=0.002; ES=0.024
MapMyWalk: Mean Diff: -0.918; 95% CI Diff: -1.465; -0.371; p=0.001; ES=0.028



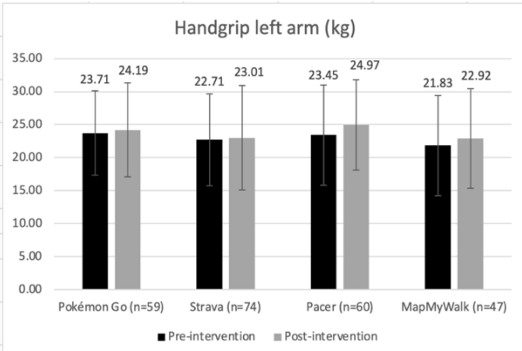
Pokémon Go: Mean Diff: 0.288; 95% CI Diff: -0.369; 0.945; p=0.389; ES=0.002
Strava: Mean Diff: -0.203; 95% CI Diff: -0.789; 0.384; p=0.497; ES=0.001
Pacer: Mean Diff: 0.167; 95% CI Diff: -0.485; 0.818; p=0.615; ES=0.001
MapMyWalk: Mean Diff: -0.255; 95% CI Diff: -0.991; 0.481; p=0.496; ES=0.001



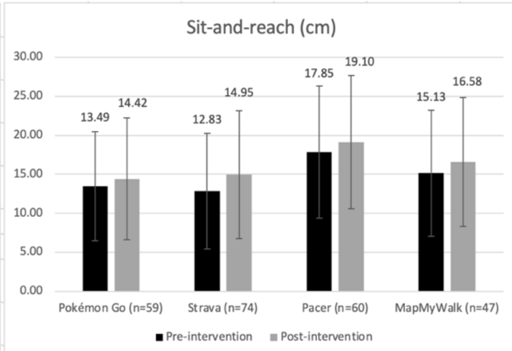
Pokémon Go: Mean Diff: -0.941; 95% CI Diff: -1.735; -0.147; p=0.002; ES=0.160
Strava: Mean Diff: -1.370; 95% CI Diff: -2.059; -0.680; p<0.001; ES=0.430
Pacer: Mean Diff: -1.362; 95% CI Diff: -2.156; -0.568; p=0.001; ES=0.320
MapMyWalk: Mean Diff: -1.221; 95% CI Diff: -1.126; 0.684; p=0.011; ES=0.100



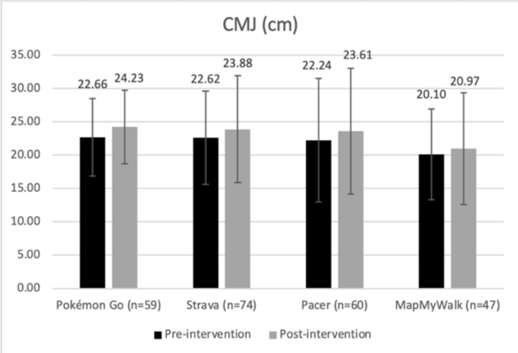
Pokémon Go: Mean Diff: -0.242; 95% CI Diff: -1.393; 0.908; p=0.679; ES=0.001
Strava: Mean Diff: -1.219; 95% CI Diff: -2.246; -0.191; p=0.020; ES=0.014
Pacer: Mean Diff: -3.018; 95% CI Diff: -4.160; -1.877; p<0.001; ES=0.064
MapMyWalk: Mean Diff: -1.362; 95% CI Diff: -2.651; -0.072; p=0.039; ES=0.011



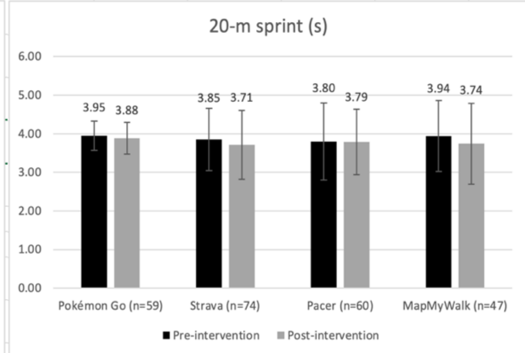
Pokémon Go: Mean Diff: -0.473; 95% CI Diff: -1.383; 0.438; p=0.308; ES=0.003
Strava: Mean Diff: -0.308; 95% CI Diff: -1.121; 0.505; p=0.457; ES=0.001
Pacer: Mean Diff: -1.515; 95% CI Diff: -2.418; -0.612; p=0.001; ES=0.027
MapMyWalk: Mean Diff: -1.089; 95% CI Diff: -2.110; -0.069; p=0.036; ES=0.011



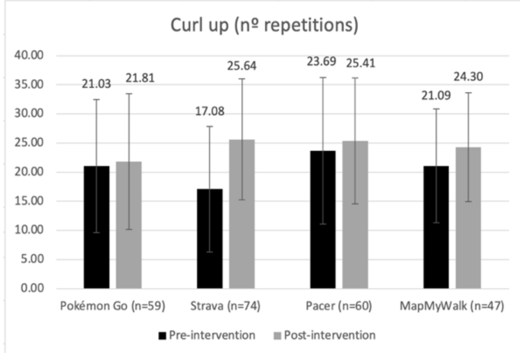
Pokémon Go: Mean Diff: -0.931; 95% CI Diff: -1.917; 0.056; p=0.064; ES=0.009
Strava: Mean Diff: -2.123; 95% CI Diff: -3.010; -1.236; p<0.001; ES=0.054
Pacer: Mean Diff: -1.250; 95% CI Diff: -2.245; -0.255; p=0.014; ES=0.015
MapMyWalk: Mean Diff: -1.446; 95% CI Diff: -2.563; -0.328; p=0.011; ES=0.016



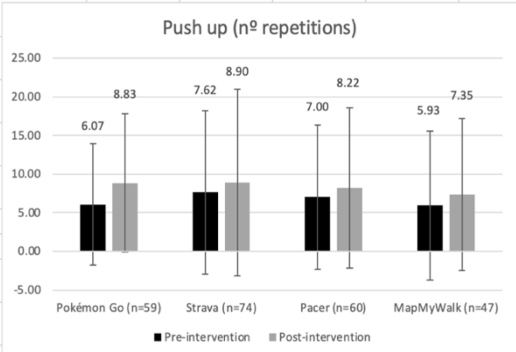
Pokémon Go: Mean Diff: -1.563; 95% CI Diff: -3.613; 0.487; p=0.135; ES=0.006
Strava: Mean Diff: -1.268; 95% CI Diff: -3.099; 0.562; p=0.174; ES=0.005
Pacer: Mean Diff: -1.365; 95% CI Diff: -3.398; 0.668; p=0.188; ES=0.004
MapMyWalk: Mean Diff: -0.866; 95% CI Diff: -3.163; 1.431; p=0.459; ES=0.001



Pokémon Go: Mean Diff: 0.071; 95% CI Diff: -0.174; 0.315; p=0.571; ES=0.001
Strava: Mean Diff: 0.139; 95% CI Diff: -0.079; 0.357; p=0.211; ES=0.004
Pacer: Mean Diff: 0.006; 95% CI Diff: -0.236; 0.248; p=0.961; ES=0.001
MapMyWalk: Mean Diff: 0.202; 95% CI Diff: -0.072; 0.476; p=0.149; ES=0.005



Pokémon Go: Mean Diff: -0.780; 95% CI Diff: -3.463; 1.904; p=0.568; ES=0.001
Strava: Mean Diff: -8.562; 95% CI Diff: -10.974; -6.149; p<0.001; ES=0.111
Pacer: Mean Diff: -1.712; 95% CI Diff: -4.395; 0.972; p=0.211; ES=0.004
MapMyWalk: Mean Diff: -3.217; 95% CI Diff: -6.257; -0.178; p=0.038; ES=0.011



Pokémon Go: Mean Diff: -2.763; 95% CI Diff: -4.392; -1.133; p=0.001; ES=0.028
Strava: Mean Diff: -1.278; 95% CI Diff: -2.753; 0.197; p=0.089; ES=0.008
Pacer: Mean Diff: -1.224; 95% CI Diff: -2.868; 0.419; p=0.144; ES=0.006
MapMyWalk: Mean Diff: -1.413; 95% CI Diff: -3.258; 0.432; p=0.133; ES=0.006

Table 4. Differences between apps in the pre-post-test change for physical activity, physical fitness, adherence to Mediterranean diet, and anthropometric variables.

Variable	Comparison Group	Diff. Pre-post	Diff. Post-pre EG – Diff. Post-pre CG	F	p	95% CI Diff.	ES
Body mass	Strava	-1.284	-0.926	2.148	0.043	-1.836; -0.017	0.025
	Pacer	-0.631					
Handgrip right arm	Pokémon Go	-0.242	2.363	3.812	0.009	0.377; 4.350	0.044
	Pacer	-3.018					
Curl-up	STRAVA	-8.562	-8.069	5.897	<0.001	-13.537; -2.600	0.066
	Pokémon Go	-0.780					
	STRAVA	-8.562	-6.257	5.897	0.013	-11.695; -0.818	0.066
	Pacer	-1.712					

CG: control group; BMI: body mass index; VO2: maximum oxygen consumption. Only those pairwise comparisons that were significant have been included in the table.

400 subjects, from the original 421, with only 21 subjects lost, and with this sample number being much higher than the samples from previous research, composed of 36-53 subjects by the time the studies ended (Direito et al., 2015a; Seah & Koh, 2021; Zhu & Dragon, 2016), with the exception of one study in which 138 adolescents finished the study (Gil-Espinosa et al., 2020). These results allow us to accept the first part of the first hypothesis, regarding the high number of adolescents who would complete the intervention, when it was defined as homework in physical education classes.

It should be noted that the comparative analysis of the control and experimental groups at baseline showed no significant differences in physical activity score, BMI, corrected girths, waist girth, muscle mass, VO2 max, handgrip, CMJ, 20-m sprint, curl-up, and push-up, but after the intervention, the changes were significantly higher in the intervention group compared to the control in physical activity score, corrected thigh girth, muscle mass, VO2 max, and CMJ, indicating that the regular and prolonged use of the mobile apps selected in the present study was useful for improving the level of physical activity, body composition, and physical fitness of adolescents.

The first objective of the present study was to determine the changes produced by a compulsory ten-week period of intervention with step tracker mobile applications on the level of physical activity, body composition, physical fitness, and AMD of adolescents aged twelve to sixteen years old. The experimental group showed a significant improvement in the level of physical activity, while the control group did not. In addition, a significantly greater difference was found in the change produced in the pre-post measurement of this variable in the experimental group with respect to the change produced in the control group. Previous research conducted in this area had not shown conclusive results, as some investigations showed significant increases in the level of physical activity (Khamzina et al., 2020; Lee et al., 2021; Schoeppe et al., 2016), while others found no improvements (Böhm et al., 2019). This could be because previous research using mobile apps had methodological limitations (invalid measuring instruments, heterogeneous outcome measures) and small sample sizes (n=42-300) (Böhm et al., 2019; Lee et al., 2021), making it difficult to extrapolate the results. The results obtained in the present study could indicate that mobile applications are useful for promoting physical activity in the adolescent population, which would refute previous results that showed no effects of the apps used after school hours (Direito et al., 2015a), but future research is still needed to corroborate them.

Regarding AMD, no significant differences were found in the experimental and the control groups. Previous research conducted with specific mobile applications for diet control showed significant results, favoring the consumption of fruits and vegetables (Elbert et al., 2016; Schoeppe et al., 2016), and decreasing the fat mass, weight, and body mass index in the intervention group (Lee et al., 2010). The absence of significant results in the present investigation could be due none of the selected applications including nutritional recommendations. So, if the aim is to establish a healthy lifestyle that includes physical activity and healthy eating, it seems necessary to use mobile applications that address both aspects, but this should be contrasted in future research to know the real effects of these applications.

The sum of 3 skinfolds showed a significant decrease in the experimental group after the intervention, but not in the control group. Previous research so far had determined changes in body composition through improvement in BMI (Shin et al., 2019), but the changes produced in the sum of skinfolds are unknown. These results could be because the regular practice of physical activity produces improvements in the body composition of adolescents (Bogataj et al., 2021; Smith et al., 2019), and after a period of ten weeks using mobile applications to promote the practice of physical activity, walking a minimum of 5000 steps daily three times per week, the improvements were significant in the sum of skinfolds.

Muscle mass increased significantly in the experimental group, while in the control group no significant changes were observed. Previous research conducted in overweight children showed similar results, with increases in muscle mass after the use of the app (De Freitas et al., 2021). However, both the experimental and control groups presented greater corrected thigh girth, but the change between pre and post measurements was significantly higher in the experimental group. The improvement in both groups could be because the students continued to attend school physical education classes and sports activities in which they were already participating, this being a factor to consider because previous research has shown different changes in the body composition of adolescents according to the physical education program carried out during the school year (Cohen et al., 2022). These results are relevant because the use of the mobile applications would produce a significantly greater improvement in the muscle mass of the lower limbs, although future research is needed to corroborate the changes produced in the muscle mass of the adolescents.

VO2 max showed a significant increase in the experimental and control groups, but the improvement was significantly higher in the experimental group at the end of the intervention. These results refute previous research in which no differences were observed in the cardiorespiratory capacity of adolescents after app use (Direito et al., 2015a). The increase in VO2 max in both groups in the present investigation could be because VO2 max improves during adolescence, regardless of the physical activity practiced (Kolunsarka et al., 2022). However, the improvement was significantly higher in the experimental group due to the fact that the group members used the mobile application for a long period of time, following the line of previous research in which intervention programs of long duration showed a remarkable effect on VO2 max (Kriemler et al., 2011). This could explain why adolescents who did not use the application showed a lower effect on this variable.

CMJ height was significantly higher only in the experimental group after the intervention. It should be noted that most previous interventions in adolescents analyzed the changes produced in cardiorespiratory fitness (Badawy & Kuhns, 2017; Goodyear et al., 2021), a few studies assessed changes in capacities such as muscular endurance (Schoeppe et al., 2016), but no previous research with mobile applications is known to have analyzed the modifications produced in jump height. The differences obtained in the present study could be due to the increase in muscle mass and corrected thigh girth observed in the intervention group, since they are factors that favor the production of lower limb strength (De Almeida-Neto et al., 2021; Figueiredo et al., 2020; Vuk et al., 2015).

Regarding the curl up test, the intervention group with mobile applications showed a significant increase in the score obtained. These results are similar to those obtained in previous research in which a six-week aerobic walking program showed significant improvements in abdominal endurance (Shnayderman & Katz-Leurer, 2013). This could be because the deep and superficial trunk musculature is active while walking (Lamoth et al., 2006), so increasing walking time with the use of mobile applications could favor the improvement of abdominal endurance.

According to the results obtained in the present investigation, the second part of the first hypothesis proposed, which indicated that the experimental group would show improvements in body composition, physical condition, and level of physical activity in comparison with the control group, can be confirmed.

The second objective of the present research was to compare the benefits obtained from the use of each of the mobile applications, on the level of physical activity, body composition, physical fitness, and AMD of adolescents. The level of activity showed a significant increase with the use of all the mobile applications, except for Pacer. Previous research that has compared the effects produced by the use of different mobile applications is scarce, and significant differences in the level of physical activity in any of the intervention groups were not found (Direito et al., 2015a). In the present study, the absence of significant differences with the use of the Pacer app is similar to previous research in which this particular app did not show significant results in terms of improved physical activity level, which could be explained by difficulties in handling the app or problems with the mobile device (De Barros Gonze et al., 2020).

The changes produced in body composition were significant with the use of all mobile applications, with a significant decrease in the sum of three skinfolds with the use of Pokémon Go and Pacer, as well as an increase in muscle mass with all applications except Pokémon Go. Previous studies showed improvements in body composition with the use of mobile apps (Likhitweerawong et al., 2021; Shin et al., 2019), but no previous research is known to have compared the effectiveness of different mobile apps in the same population. The results obtained could indicate that each mobile application is more effective in producing certain changes in body composition, because they use different behaviors change techniques (Bondaronek et al., 2018). If these findings were confirmed in future research, it would be necessary to analyze the mobile applications currently being used by adolescents to learn the most relevant aspects of each of them and use them in the areas where they are most effective.

Regarding physical fitness, there was a significant increase in VO2 max, handgrip strength, sit-and-reach, and curl up test with the use of all the mobile applications, except with Pokémon Go, where the changes were significant only in VO2 max. These results follow the line of previous research regarding the improvement in VO2 max, since significant improvements were found in this variable after the use of gamified and non-gamified mobile applications (Goodyear et al., 2021; Mora-Gonzalez et al., 2020). However, the absence of significant differences in the rest of the fitness variables with the use of Pokémon Go could be because it can be played in two different ways, intermittent and continuous (Beach et al., 2021). The form of play has been shown to be influential in increasing the level of physical activity, with the continuous form producing similar improvements in activity levels to traditional walking, while the intermittent form resulted in a reduced effect (Beach et al., 2021). This could be a possible explanation for the absence of significant differences in Pokémon Go on the physical fitness variables, since just as the form of gameplay influences the level of physical activity, it could do so on the fitness variables, but future research is needed to confirm this conclusion.

The results obtained when comparing the different mobile applications used lead to a partial rejection of the second initial hypothesis proposed, since it was indicated that no differences would be found in the variables analyzed between the different groups of mobile applications, but the results show that the level of physical activity, changes in body composition and improvements in physical condition were significantly different between the groups.

5.5.1. Practical implications

Regarding the practical implications derived from this study, the use of mobile applications promoted from the subject of physical education could be useful, in contrast to the results found in previous research, where no relationship was found between the use of these tools and the improvement of physical activity (Direito et al., 2015a; Zhu & Dragon, 2016). However, two aspects should be highlighted for this to be useful: firstly, the use of the applications should take place outside school hours, as the design and interface of current mobile applications greatly limit their use during class hours (Alonso-Fernández et al., 2022); and, secondly, their use should be mandatory for adolescents, through the integration of their use into the physical education subject as homework, with the help of physical education teachers. In this way, the difficulties found in previous research in relation to the lack of adherence and reduced use of mobile applications could be overcome, to therefore increase the level of physical activity of the adolescent population and achieve improvements in body composition and physical condition. Therefore, although future research is needed in this area, the use of mobile applications promoted as physical education "homework" may be a key aspect in improving the health status of the adolescent population, which especially necessary after the COVID-19 pandemic, with the step tracker apps being a very valuable educational resource, although its use should be centered on out-of-school hours.

5.5.2. Educational implications

These results are relevant for physical education teachers, who could promote the use of these tools in physical education classes, without the app used being excessively decisive, if it includes resources to facilitate behavioral change, as the differences between them are minimal. However, it should be noted that the results found may also be relevant for the Ministry and the Department of

Education, which could promote the inclusion of these applications on a regular basis, being considered as "homework" as in other subjects, given that the extracurricular work is crucial for integrating the contents worked on in the classroom, although in the field of physical education, this is forgotten.

5.6. Conclusion

To conclude, the results of the present study indicate that mobile applications used after school are useful tools for producing changes in the level of physical activity, body composition, and physical fitness of adolescents aged 12 to 16 years old. The mobile applications used in the present investigation do not seem effective in improving AMD in adolescents. It should be noted that depending on the mobile application used, different benefits on physical activity level, body composition, and physical fitness may occur, with the gamified mobile application used in the present research being useful for producing changes in physical activity and body composition, but not in physical fitness, with future research to discover the effectiveness of each application being necessary.

5.6.1. Limitations

The present study is not free of limitations. The sample was selected by convenience from the educational centers that could be accessed. Although the sample size at the beginning of the research was high, the sample in the intervention groups for certain applications was small, making statistical analysis difficult. The PAQ-A questionnaire, despite being valid and reliable for use in this population, is a self-report that considers physical activity performed in the last seven days, so this should be considered if an intervention of several weeks' duration is carried out. In addition, two relevant aspects that were not considered in the present research and with which one could more strongly attribute the changes produced in the adolescents to the mobile apps, were the adolescents' motivation and enjoyment of participating in the intervention, as this could be used to assess adherence and continuity in the use of the apps once it is no longer mandatory. Moreover, although starting to practice a new sport activity during the intervention was an exclusion criterion, special consideration should be given in future research to the adolescents who regularly exercise in the gym, since the changes in body composition and physical fitness obtained could be due to advances in this area. Furthermore, in the area of nutrition, more exhaustive monitoring should be carried out before starting the research, on the total daily energy expenditure or the caloric status of the adolescents, as this could hinder or facilitate the changes observed during the intervention.

5.6.2. Future studies

The results of the present research can be a first step for the development of future research from the Education and Information Technology communities. This is because the results obtained have shown improvements in the level of physical activity, body composition and physical fitness of adolescents using applications that were not specifically designed for adolescents. Therefore, this raises the possibility that a specific application could be designed with adolescents in mind, as in previous research with Healthy Jeart (Duarte-Hueros et al., 2020) and TRAINIME (Mokmin & Jamiat, 2021), and following the quality recommendations included in previous research on mobile apps (Gil-Espinosa et al., 2022). This app could be aimed at the field of physical education, including extracurricular "homework" along with educational content of interest to this population, which could facilitate obtaining more evident and significant results in terms of improving the level of physical activity, body composition and physical condition, and to improve the knowledge needed to maintain a healthy lifestyle.

In addition to the design of a mobile app aimed at increasing the practice of physical activity in the adolescent population, with useful educational resources that can be used in the physical education classroom for the knowledge of healthy lifestyle habits, another possible future line of research would be to analyze whether the changes produced at the levels of physical activity, physical condition and body composition differed among adolescents who covered a greater distance with the use of the application, thus being able to establish an optimal range and more precise recommendations for the appropriate use of these tools.

Vg – ESTUDIO 7: Influence of Pokémon Go playing style on physical activity and its effect on kinanthropometry variables and body composition in adolescents

ESTUDIO 7 – INFLUENCE OF POKÉMON GO PLAYING STYLE ON PHYSICAL ACTIVITY AND ITS EFFECT ON KINANTHROPOMETRY VARIABLES AND BODY COMPOSITION IN ADOLESCENTS

5.1. Abstract

Background: Pokémon Go is a mobile app that offers both continuous and intermittent (gamified) gameplay, but no previous research in adolescents is known to have addressed changes in physical activity and body composition according to playing style. For this reason, the aims of the present investigation were a) to establish the differences in the level of physical activity, and its influence on the kinanthropometric and body composition, of the adolescent population, considering their Pokémon Go playing style; and b) to analyze whether the practice of previous physical activity has an influence on the effects of the use of Pokémon Go on the level of physical activity and changes in kinanthropometric and body composition variables. **Methods**: A total of 94 adolescents (50 males and 44 females; mean age: 13.66±1.17 years-old) whose physical activity level and body composition were measured, participated in the investigation. Two groups of adolescents completed a 10-week intervention using Pokémon Go continuously (n=30) or intermittently (n=31), while the control group (n=33) did not use any after-school app. **Results**: The results showed that inactive adolescents in the continuous use group increased their physical activity between the pre- and post-test ($p=0.038$), but this did not occur in the active group. Regarding body composition variables, the increase in body mass ($p<0.001$) and BMI ($p=0.006$) in the control group was significantly higher than in the continuous use group of adolescents who were inactive, but not in the active group, while the decrease in fat mass ($p<0.001$-0.036) and sum of 3 skinfolds ($p<0.001$-0.003) was significantly higher in both Pokémon Go use groups as compared to the control group, regardless of the previous physical activity level. **Conclusions**: The continuous style of play seems to be more effective in increasing physical activity in adolescents, but the changes in body composition and kinanthropometric variables occur similarly with continuous and intermittent gameplay. Therefore, the playful use of Pokémon Go can be used in educational and health fields to produce changes in body composition in this population.

5.2. Introduction

The decrease in physical activity in the adolescent population in recent years (Pechtl et al., 2022) has had a negative impact on their body composition, as observed by the increase in the variables related to fat mass (Mateo-Orcajada, González-Gálvez, et al., 2022). In light of this situation, different types of interventions have been proposed in order to increase the practice of physical activity, and positively influence the body composition of adolescents, trying to reduce fat mass and increase muscle mass (Głąbska et al., 2019; Pfeiffer et al., 2019). Among the most innovative interventions in this population, those using electronic devices (Böhm et al., 2019; Wang et al., 2022) are particularly relevant, as these devices are fully integrated into the lives of adolescents (Biscond et al., 2022), with high usage times from early stages of life (Hirsh-Yechezkel et al., 2019). These interventions are characterized by the wide range of devices that can be used, including mobile applications (Gal et al., 2018), wearables (Gal et al., 2018), or internet websites (Rose et al., 2017), which have shown beneficial effects on the practice of physical activity and changes in body composition of adolescents (He et al., 2021; Lee et al., 2021; Schoeppe et al., 2016). In this sense, interventions with electronic devices have been shown to be useful, albeit modestly, in increasing physical activity and decreasing fat mass and body mass index (BMI).

More specifically, in recent years, mobile applications have gained special relevance due to the continuous development of smartphones for monitoring human movement (del Rosario et al., 2015), as well as the integration of these devices in the daily life of adolescents (Vaterlaus et al., 2021), which allows for greater adherence to interventions (Badawy & Kuhns, 2017). Moreover, their effectiveness in increasing physical activity and producing changes in the body composition of adolescents has made them highly useful devices for the fields of education and health (He et al., 2021; Lee et al., 2021; Schoeppe et al., 2016).

Among the most relevant mobile applications for the adolescent population, Pokémon Go is underlined, as it is a virtual reality game in which players must move in the real world to capture Pokémons (Kapoor et al., 2022). This application was a pioneer in the field of augmented reality, and is characterized by offering four areas of user experience: educational, entertainment, aesthetic, and evasion, and generating an environment in which users interact face-to-face in real life

(Aluri, 2017). On the other hand, Pokémon Go shows hedonic, emotional, and social benefits that facilitate users' permanence in the game (Rauschnabel et al., 2017). These aspects have allowed its use in areas such as education (Kot, 2021), tourism (Pamuru et al., 2021), or physical activity and health (Khamzina et al., 2020; Lee et al., 2021), thereby showing that this mobile application has a great potential to provide benefits. In this regard, previous research has shown that the use of Pokémon Go increased the physical activity of the players, by increasing the daily number of steps and the time spent in moderate intensity physical activity (Khamzina et al., 2020; Lee et al., 2021), ultimately resulting in a reduction of the fat mass in adolescents (Martínez-López et al., 2021; Mateo-Orcajada, Abenza-Cano, et al., 2023).

However, it is worth noting that Pokémon Go provides two gameplay options, continuous or intermittent, which have shown differences in their effectiveness in increasing the level of physical activity, with the continuous form being the most effective in this regard (Beach et al., 2021). This could be because in the continuous form of play, players do not allocate time on the gamified part of the application (catching Pokémons, or facing other players), while in the intermittent form, which is usually the most used, players make stops while using the application (Beach et al., 2021). However, the only study that has so far analyzed the different Pokémon playing styles did not include a control group, making the comparisons with a traditional walking group (Beach et al., 2021), so the effectiveness of the different Pokémon Go playing styles is still unknown.

In addition, little is known about the different forms of Pokémon Go gameplay in the adolescent population, as no previous research has been conducted in this population, despite the fact that adults have worse perceptions about the game's use (Madrigal-Pana et al., 2019). Therefore, the effects of the different forms of Pokémon Go gameplay on body composition in the adolescent population, as shown in previous research with continuous and intermittent exercise training programs (Koubaa et al., 2013; Steele et al., 2021), are unknown. Thus, the main aims of the present study were a) to establish the differences in the level of physical activity and its influence on the kinanthropometric and body composition of the adolescent population considering the Pokémon Go playing style; and b) to analyze whether the practice of previous physical activity has an influence on the effects of the use of Pokémon Go on the level of physical activity and changes in kinanthropometric and body composition variables.

Based on previous scientific literature (Beach et al., 2021) and the aims of the present research, the hypotheses of the present study are: (H1) the continuous style of Pokémon Go gameplay will increase the level of physical activity to a greater extent than the intermittent style, and changes in body composition will be more significant in the continuous use group as compared to the intermittent and control groups; and (H2) the changes in the level of physical activity and in the kinanthropometric and body composition variables will be significant in the group of adolescents who were previously inactive, but not in the group of active adolescents.

5.3. Methods

5.3.1. Design

The study design was longitudinal with a 10-week intervention, and followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al., 2011). The protocol was previously registered in ClinicalTrials.gov (code: NCT04860128). Non-probabilistic convenience sampling was used by choosing the adolescents from the two educational centers who were willing to participate in the study. The public schools with the largest number of students in compulsory secondary education in each of the localities in which the research was carried out were selected. If the selected centers did not wish to participate, the next public school with the largest number of students in compulsory secondary education was selected with the aim of obtaining a representative sample.

Schools that were willing to participate were visited to have a meeting with the management team. Once their approval was obtained, a meeting was held with the teachers responsible for the physical education subject, who arranged the meetings with the adolescents and their parents from each of the grades that would ultimately participate in the research. In each of the meetings, the aims of the research, the procedures, and the confidentiality of the data treatment were explained.

The institutional ethics committee of the Universidad Católica San Antonio approved the research design and protocol prior to initiation (code: CE022102), and the guidelines of the Declaration of Helsinki were followed.

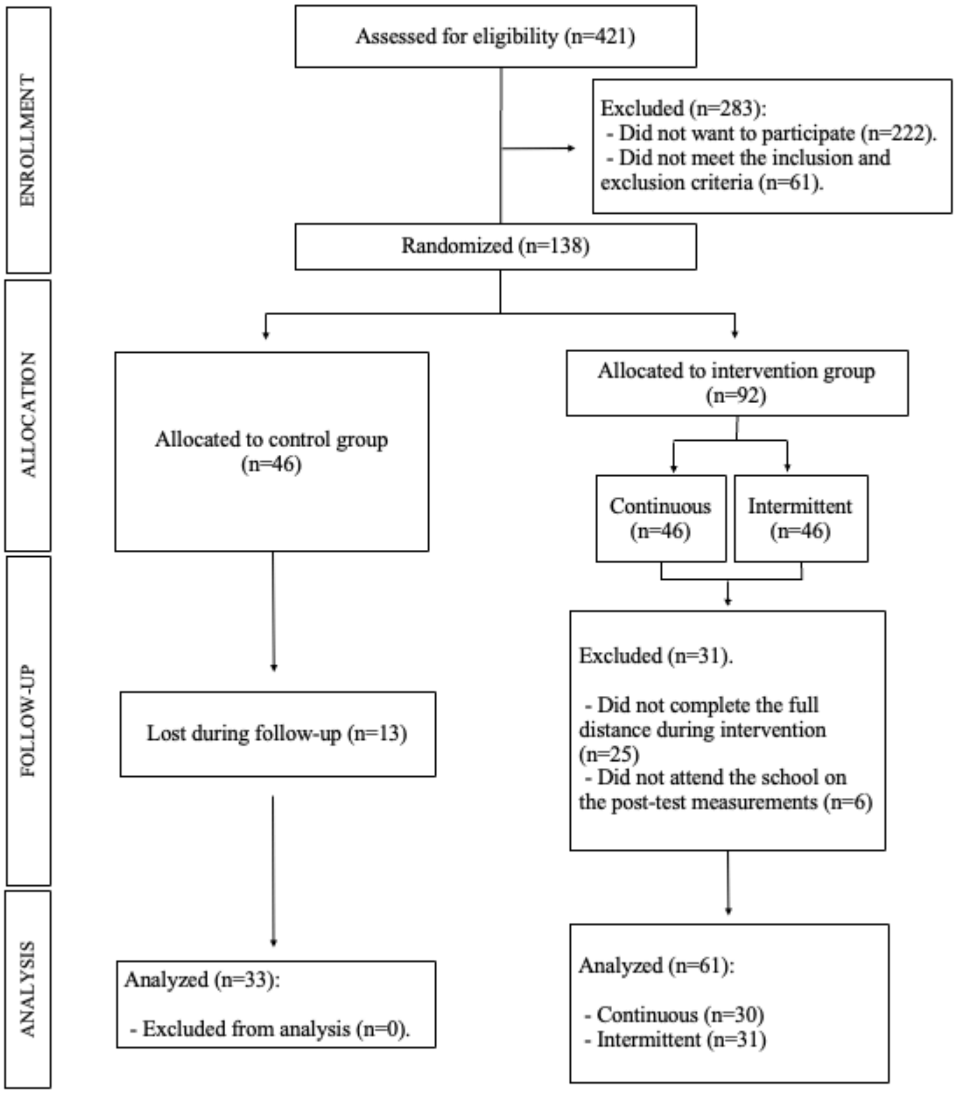
The independent variable of the study was the Pokémon Go playing style, defined as continuous, intermittent, or control; while the dependent variables were the level of physical activity, and the kinanthropometric and derived variables, including body mass, height, sitting height, BMI, sum of 3 skinfolds, corrected arm girth, corrected thigh girth, corrected calf girth, waist girth, hip girth, waist-to-hip ratio, muscle mass, and fat mass (in percentage).

5.3.2. Participants

The sample size calculation was performed using Rstudio statistical software (Rstudio Inc., v3.15.0, USA) and considering the standard deviations (SD) of previous research that had used Pokémon Go® in the adolescent population to increase the level of physical activity (SD= 1.57) (Ruiz-Ariza et al., 2018). Thus, for a 95% confidence interval (95% CI) and an estimated error (d) of 0.56, the minimum sample needed for conducting the study was 30 adolescents per group.

The sample selection flowchart is shown in Figure 1. The distribution in the experimental and control groups was randomized. A total of 94 adolescents ultimately participated in the research (50 males and 44 females; mean age: 13.66±1.17). The attrition rate was 31.88%, with 31 participants from the intervention groups (16 in the continuous and 15 in the intermittent) and 13 from the control group not completing the research. The participation of the adolescents was completely voluntary, and they provided an informed consent form to be signed by themselves and their parents prior to the start of the study. The inclusion criteria were a) age between 12 and 16 years; b) having their own mobile phone; c) having a mobile phone compatible with the latest version of Pokémon Go; d) participating in the pre- and post-test measurements; and e) completing the questionnaires and kinanthropometric measurements in their entirety. The exclusion criteria were a) attending less than 80% of the mandatory physical education sessions; b) stopping using the application during the 10 weeks or not completing the full distance marked; c) changing school during the intervention; d) starting or abandoning some type of regular physical activity during the intervention; and e) presenting some difficulty in practicing physical activity during the week prior to the measurement (measured through question nine of the Physical Activity Questionnaire for Adolescents).

Figure 1. Sample selection flowchart.



5.3.3. Instruments

5.3.3.1. ***Physical activity measurement***

Physical activity level was measured using the "Physical Activity Questionnaire for Adolescents" (PAQ-A) (Kowalski et al., 2004; Martínez-Gómez et al., 2009). The PAQ-A is composed of 9 items, the first eight of which are completed with a Likert scale of 1 to 5 points. The ninth item asked if whether during the previous week they experienced some difficulty in practicing regular physical activity and was answered dichotomously (yes or no). The arithmetic mean of the first eight items allowed us to obtain the final physical activity score (Benítez-Porres et al., 2016). According to the score obtained, adolescents with a value higher or lower than 2.75 were classified as active or inactive, respectively (Benítez-Porres et al., 2016). This questionnaire was previously validated and has an intraclass correlation coefficient of 0.71 for the final score of the questionnaire (Martínez-Gómez et al., 2009).

5.3.3.2. ***Kinanthropometric and derived variables measurement***

The measurement of kinanthropometric variables was composed of the following variables: three basic measurements (body mass, height, and sitting height), three skinfolds (triceps, thigh, and calf), and five girths (arm relaxed, waist, hips, thigh, and calf) (Esparza-Ros et al., 2019). From the measured kinanthropometrics variables, the following derived variables were calculated: BMI, muscle mass (Poortmans et al., 2005), fat mass (Slaughter et al., 1988), Σ3 skinfolds (triceps, thigh, and calf), waist-to-hip ratio (waist girth/hip girth), and corrected girths of the arm [arm relaxed girth – (π * triceps skinfold)], thigh [middle thigh girth – (π * thigh skinfold)], and calf [calf girth – (π * calf skinfold)].

All measurements were performed by anthropometrists (levels 2 to 4) accredited by the International Society for the Advancement of Kinanthropometry (ISAK) (Esparza-Ros et al., 2019). The measurements in the pre- and post-test were performed by the same anthropometrist on each participant, to try to reduce the inter-evaluator error.

The intra-evaluator and inter-evaluator technical error of measurement (TEM) was calculated in a subsample. Thus, the intra- and inter-evaluator error was 0.03% and 0.04% for basic measurements, 1.20% and 1.95% for skinfolds, and 0.05% and 0.07% for girths, respectively. In addition, the correlation coefficient of the anthropometrists with respect to a level 4 expert anthropometrist was 0.95 for basic measurements, 0.85 for skinfolds, and 0.88 for girths.

A skinfold caliper (Harpenden, Burgess Hill, UK) was used to measure skinfolds, with an accuracy of 0.2 mm; a Lufkin W606PM inextensible tape (Lufkin, Missouri) was used to measure girths, with an accuracy of 0.1 cm; for body mass, a TANITA BC 418-MA Segmental (TANITA, Tokyo) was used, with an accuracy of 100 g; and for height and sitting height, a SECA 213 stadiometer (SECA, Hamburg) was used, with an accuracy of 0.1 cm. All instruments were calibrated prior to use in pre- and post-test measurements.

5.3.4. Procedure

Following the protocol from previous research conducted with adolescents and mobile apps (Mateo-Orcajada, Abenza-Cano, et al., 2023), in both the pre- and post-test measurements, the PAQ-A questionnaire was completed first, and once completed, the anthropometric measurements were taken. The measurements were carried out in the indoor sports pavilions of the schools, using a separate space for the anthropometric measurements. All measurements were carried out during the physical education class hour, restricting food and drink intake one hour before the measurement; no vigorous exercise in the previous 24 hours; no physical activity prior to the assessments; and no large meals in the 24 hours prior to the measurement.

The Pokémon Go® intervention lasted 10 weeks, during which the adolescents had to use the application continuously or intermittently at least three times a week outside school hours. The choice of three days per week was due to the fact that it is the minimum established by the WHO (Chaput et al., 2020), while the ten-week duration is justified on the basis of previous studies, in which it was observed that long-term interventions with adolescents lead to a considerable loss of adherence and effectiveness, as compared to short (between 6-12 weeks) and medium-term interventions (between 12 and 26 weeks) (van de Kop et al., 2019). Due to the academic year of the compulsory secondary schools, a 10-week intervention was chosen.

Adolescents who used the app continuously were required to complete the required distance for that session without using the game, i.e., without making continuous stops to capture Pokémons or battle against other players. Thus, adolescents who used Pokémon Go continuously only used the app to record the minimum daily and weekly distance. In contrast, adolescents who used Pokémon Go intermittently were required to make stops to capture Pokémon and enjoy the virtual world experience but, as in the continuous mode, they had to complete the distance indicated for each session.

The adolescents had to complete a minimum of 5000 steps, or the equivalent of 3.19 km per day (Morency et al., 2007), which is the minimum distance for not being considered sedentary (Lubans et al., 2015). To this end, an intervention was proposed in which adolescents were required to walk 7,000 steps, or 4.57 km, each time they used the app during the first week, increasing to 12,520 steps, or 8.0 km, in the last week. The control group did not use any other mobile app and attended physical education class regularly, as did the experimental groups. A researcher, with the help of the physical education teachers, was responsible for verifying that the adolescents completed the required distance each week, excluding those who did not complete the minimum distance from the research.

5.3.5. Data analysis

The normality of the data was analyzed using the Kolmogorov-Smirnov test. As all variables followed normal distributions, parametric tests were used for their analysis. A one-way ANOVA and a MANOVA were performed to determine the homogeneity of the experimental and control groups at baseline. Two repeated measures ANOVA were performed; the first to analyze the differences in the study variables in each of the study groups between the pre- and post-test measurements, and the second to analyze these differences according to the previous level of physical activity. Subsequently, the Bonferroni post-hoc made it possible to determine the existence of significant differences between the differences in means (pre-post measurement) of each of the research groups in each study variable. The effect size was analyzed by partial eta squared ($\eta 2$) and was defined as small: ES≥ 0.10; moderate: ES ≥ 0.30; large: ≥ 1.2; or very large: ES ≥ 2.0, with an error of $p<0.05$ (Hopkins et al., 2009). A value $p<0.05$ was used to determine statistical significance. Statistical analysis was performed with the SPSS statistical package (v.25.0; SPSS Inc., IL).

5.4. Results

5.4.1. Baseline differences between continuous, intermittent and control groups

Prior to the analysis of the differences in the pre-post measurements between the groups, the baseline differences between the groups were analyzed for each of the variables. The analysis showed homogeneity in all variables between the three groups at baseline: physical activity (p=1.000); body mass (p=0.137-1.000); height (p=0.266-0.509); BMI (p=0.0139-1.000); sitting height (p=0.058-0.806); sum of 3 skinfolds (p=0.221-0.670); waist girth (p=0.224-0.565); hip girth (p=1.000); waist-to-hip ratio (p=0.150-0.875); corrected girths (p=0.828-1.000); fat mass (p=0.351-0.440); muscle mass (p=1.000).

Considering whether the adolescents were active or inactive before starting the research, homogeneity was also found in all variables: physical activity (active: p=1.000; inactive: p=0.659-1.000); body mass (active: p=0.429-1.000; inactive: p=0.102-1.000); height (active: p=0.165-1.000; inactive: p=0.062-1.000); BMI (active: p=0.772-1.000; inactive: p=0.064-1.000); sitting height (active: p=0.390-1.000; inactive: p=0.075-1.000); sum of 3 skinfolds (active: p=0.255-1.000; inactive: p=0.093-1.000); waist girth (active: p=0.466-1.000; inactive: p=0.223-1.000); hip girth (active: p=0.569-1.000; inactive: p=0.930-1.000); waist-to-hip ratio (active: p=0.263-1.000; inactive: p=0.562-1.000); corrected girths (active: p=0.239-1.000; inactive: p=0.434-1.000); fat mass (active: p=0.223-1.000; inactive: p=0.224-0.805); muscle mass (active: p=0.066-0.621; inactive: p=0.085-0.440).

5.4.2. Differences in pre-post physical activity and body composition measurements

Table 1 shows the differences between the pre- and post-test in the study variables in each of the research groups. Thus, the level of physical activity showed significant increases in the continuous intervention group (p=0.044; ES=0.036), but not in the intermittent group (p=0.068; ES=0.018).

Table 1. Differences in the study variables between pre- and post-test measurements in the continuous, intermittent and control groups.

		Descriptors (M±SD)				
Variable	Pokémon Go use	Pre-test	Post-test	Mean Diff.	p	η2
Physical activity	Continuous	2.80±0.61	3.04±0.53	-0.235	0.044	0.036
	Intermittent	2.76±0.72	2.96±0.65	-0.147	0.068	0.018
	Control Group	2.76±0.60	2.66±0.66	0.106	0.344	0.010
Body mass (kg)	Continuous	57.33±12.88	57.90±12.59	-0.567	0.022	0.057
	Intermittent	60.04±15.22	60.86±14.93	-0.827	0.001	0.121
	Control Group	58.78±11.14	60.29±11.02	-1.503	<0.001	0.326
Height (cm)	Continuous	161.98±8.05	162.71±7.96	-0.729	<0.001	0.222
	Intermittent	162.02±10.23	162.92±10.08	-0.902	<0.001	0.318
	Control Group	158.79±8.77	159.70±8.67	-0.915	<0.001	0.339
BMI (kg/m^2)	Continuous	21.85±4.63	21.86±4.42	-0.014	0.910	0.001
	Intermittent	21.62±3.51	21.69±3.49	-0.068	0.564	0.004
	Control Group	21.16±3.46	21.58±3.42	-0.421	<0.001	0.133
Sitting height (cm)	Continuous	84.82±4.10	85.03±3.91	-0.207	0.243	0.015
	Intermittent	86.21±5.11	86.48±4.84	-0.271	0.121	0.026
	Control Group	84.31±5.25	84.58±4.81	-0.270	0.111	0.028
Sum of 3 skinfolds (mm)	Continuous	51.20±24.26	46.16±21.79	5.042	<0.001	0.294
	Intermittent	49.23±20.24	45.19±17.61	4.044	<0.001	0.216
	Control Group	41.31±21.19	43.04±23.23	-1.726	0.030	0.051
Waist girth (cm)	Continuous	69.29±10.17	69.13±9.96	0.160	0.649	0.002
	Intermittent	72.43±9.67	72.35±9.54	0.080	0.817	0.001
	Control Group	69.07±7.92	69.89±8.27	-0.811	0.017	0.061

Hip girth (cm)	Continuous	90.86±10.12	91.40±9.77	-0.547	0.103	0.029
	Intermittent	90.80±8.52	91.43±8.08	-0.627	0.058	0.039
	Control Group	89.08±8.35	90.58±8.13	-1.499	<0.001	0.198
Waist-to-hip ratio	Continuous	0.78±0.05	0.78±0.05	0.006	0.131	0.025
	Intermittent	0.80±0.05	0.79±0.05	0.006	0.125	0.026
	Control Group	0.79±0.04	0.79±0.05	0.004	0.279	0.013
Corrected arm girth (cm)	Continuous	20.98±2.68	21.31±2.61	-0.329	0.008	0.074
	Intermittent	21.76±2.70	22.33±2.67	-0.574	<0.001	0.200
	Control Group	20.21±2.93	20.54±2.95	-0.322	0.007	0.077
Corrected thigh girth (cm)	Continuous	39.02±4.37	39.99±4.10	-0.970	0.122	0.026
	Intermittent	42.61±6.57	42.51±4.38	0.102	0.868	0.001
	Control Group	40.23±4.42	40.34±4.20	-0.107	0.857	0.001
Corrected calf girth (cm)	Continuous	28.23±3.01	28.81±2.95	-0.580	<0.001	0.231
	Intermittent	30.00±2.41	30.59±2.62	-0.582	<0.001	0.238
	Control Group	28.31±2.83	28.62±2.74	-0.312	0.004	0.087
Fat mass (%)	Continuous	24.36±12.59	22.87±12.77	1.497	<0.001	0.195
	Intermittent	22.29±8.50	20.73±7.65	1.560	<0.001	0.214
	Control Group	23.61±8.70	24.00±8.99	-0.388	0.206	0.018
Muscle mass (kg)	Continuous	17.79±4.23	18.49±4.20	-0.694	0.057	0.043
	Intermittent	18.33±5.23	18.71±5.17	-0.382	0.255	0.014
	Control Group	17.29±4.88	17.60±4.81	-0.310	0.340	0.010

Regarding the kinanthropometric and derived variables, body mass ($p<0.001$-0.022; ES=0.057-0.326) and height ($p<0.001$; ES=0.222-0.339) increased significantly in all groups, while BMI only increased in the control group ($p<0.001$; ES=0.133) (Table 1).

Regarding the girths, significant increases were found in all groups in corrected arm girth ($p<0.001$-0.008; ES=0.074-0.200) and corrected calf girth ($p<0.001$-0.004; ES=0.087-0.238), while waist girth ($p=0.017$; ES=0.061) and hip girth ($p<0.001$; ES=0.198) increased significantly only in the control group (Table 1).

However, the sum of 3 skinfolds (<0.001; ES=0.216-0.294) and fat mass percentage ($p<0.001$; ES=0.195-0.214) significantly decreased in the groups using Pokémon Go, but the sum of 3 skinfolds also increased significantly in the control group ($p=0.030$; ES=0.051) (Table 1). The effect size was small for all variables except for height and body mass in the intermittent and control groups.

5.4.3. Differences in pre-post physical activity and body composition measurement according to the previous practice of physical activity

Table 2 shows the differences in the study variables in the continuous, intermittent, and control groups according to their level of physical activity before the beginning of the study. With respect to the level of physical activity, a decrease was observed in the adolescents in the control group who were active before starting the study ($p=0.004$; ES=0.090), while the continuous group ($p=0.038$; ES=0.048) of adolescents who were inactive before starting the study showed a significant increase.

For body mass ($p<0.001$-0.049; ES=0.014-0.270) and height ($p<0.001$; ES=0.022-0.277), the differences were significant in all groups of both active and inactive adolescents. However, there were no significant differences in sitting height in any of the groups ($p=0.051$-0.769; ES=0.001-0.047), while for BMI, there was only an increase in the control group of adolescents who were inactive before the start of the study ($p=0.011$; ES=0.072).

The sum of 3 skinfolds ($p<0.001$-0.021; ES=0.059-0.207) and fat mass ($p<0.001$-0.018; ES=0.062-0.190) significantly decreased in all intervention groups, regardless of previous physical activity level, while a significant increase in both variables (sum of 3 skinfolds: $p=0.014$; ES=0.066; fat mass: $p=0.032$; ES=0.051) was only found in the control group of previously inactive adolescents.

Table 2. Differences in the study variables between pre- and post-test measurements in the continuous, intermittent and control groups according to the previous physical activity level.

Variable	Previous level of physical activity	Pokémon Go use	Pre-test	Post-test	Mean Diff.	p	η2
Physical activity	Active	Continuous	3.23±0.33	3.34±0.35	-0.110	0.453	0.006
		Intermittent	3.26±0.28	3.26±0.43	-0.010	0.946	0.001
		Control Group	3.17±0.35	2.75±0.82	0.418	0.004	0.090
	Inactive	Continuous	2.24±0.39	2.59±0.40	-0.352	0.038	0.048
		Intermittent	2.08±0.58	2.42±0.58	-0.336	0.057	0.044
		Control Group	2.27±0.46	2.54±0.37	-0.270	0.086	0.033
Body mass (kg)	Active	Continuous	53.48±12.23	54.82±12.41	-1.335	<0.001	0.179
		Intermittent	58.41±9.16	59.27±8.30	-0.853	0.004	0.091
		Control Group	52.06±11.79	53.32±11.88	-1.261	<0.001	0.180
	Inactive	Continuous	62.08±12.50	61.70±12.21	0.377	0.049	0.014
		Intermittent	62.28±21.22	63.08±21.23	-0.792	0.022	0.059
		Control Group	44.86±9.19	46.65±8.97	-1.793	<0.001	0.270
Height (cm)	Active	Continuous	161.19±7.04	162.28±6.89	-1.084	<0.001	0.277
		Intermittent	167.16±9.74	168.11±9.47	-0.942	<0.001	0.245
		Control Group	161.95±10.00	162.79±9.77	-0.844	<0.001	0.207
	Inactive	Continuous	162.96±9.34	163.25±9.39	-0.292	0.164	0.022
		Intermittent	164.43±11.06	165.28±11.04	-0.846	<0.001	0.159
		Control Group	154.99±5.10	155.99±5.39	-1.000	<0.001	0.234
BMI (kg/m^2)	Active	Continuous	20.46±3.62	20.76±3.72	-0.300	0.063	0.039
		Intermittent	20.94±2.50	20.98±2.23	-0.044	0.768	0.001
		Control Group	19.49±2.63	19.91±2.48	-0.417	0.007	0.081
	Inactive	Continuous	23.56±5.29	23.22±4.96	0.338	0.059	0.041
		Intermittent	22.56±4.49	22.66±4.64	-0.100	0.573	0.004
		Control Group	18.76±4.33	19.19±4.35	-0.427	0.011	0.072

Sitting height (cm)	Active	Continuous	83.68±3.75	83.91±3.58	-0.224	0.339	0.010
		Intermittent	86.44±4.87	86.51±4.49	-0.072	0.750	0.001
		Control Group	85.11±6.30	85.17±5.80	-0.067	0.769	0.001
	Inactive	Continuous	86.32±4.20	86.50±3.97	-0.185	0.490	0.005
		Intermittent	85.89±5.61	86.44±5.49	-0.546	0.053	0.046
		Control Group	81.16±2.36	81.67±2.20	-0.513	0.051	0.047
Sum of 3 skinfolds (mm)	Active	Continuous	50.77±29.94	46.40±26.28	4.363	<0.001	0.156
		Intermittent	46.28±14.82	41.41±11.95	4.863	<0.001	0.196
		Control Group	37.88±16.95	38.64±18.85	-0.767	0.468	0.006
	Inactive	Continuous	74.85±35.85	68.92±34.79	5.929	<0.001	0.207
		Intermittent	53.33±26.10	50.42±22.85	2.908	0.021	0.059
		Control Group	45.44±25.38	48.32±27.33	-2.877	0.014	0.066
Waist girth (cm)	Active	Continuous	67.05±9.25	67.50±9.39	-0.454	0.319	0.011
		Intermittent	71.37±5.29	70.79±4.65	0.579	0.191	0.019
		Control Group	67.00±6.17	67.43±7.24	-0.439	0.321	0.011
	Inactive	Continuous	72.22±10.94	71.26±10.65	0.964	0.066	0.038
		Intermittent	73.90±13.78	74.51±13.73	-0.611	0.241	0.016
		Control Group	62.77±9.30	64.02±9.27	-1.258	0.011	0.072
Hips girth (cm)	Active	Continuous	87.18±8.79	87.88±8.69	-0.700	0.113	0.028
		Intermittent	89.78±6.00	90.19±5.12	-0.411	0.336	0.011
		Control Group	85.97±7.67	86.95±7.64	-0.973	0.055	0.056
	Inactive	Continuous	95.67±10.00	96.02±9.44	-0.347	0.490	0.005
		Intermittent	92.21±11.26	93.13±10.97	-0.926	0.067	0.038
		Control Group	81.81±8.82	83.94±8.65	-2.131	<0.001	0.192
Waist-to-hip ratio	Active	Continuous	0.77±0.04	0.77±0.05	0.001	0.843	0.001
		Intermittent	0.80±0.03	0.79±0.03	0.010	0.055	0.041
		Control Group	0.77±0.04	0.78±0.05	0.004	0.409	0.008
	Inactive	Continuous	0.75±0.05	0.74±0.05	0.013	0.059	0.048
		Intermittent	0.80±0.06	0.80±0.07	0.001	0.914	0.001
		Control Group	0.78±0.04	0.76±0.05	0.004	0.479	0.006

Corrected arm girth (cm)	Active	Continuous	20.29±2.46	20.78±2.60	-0.491	0.003	0.094
		Intermittent	21.55±2.33	22.09±2.35	-0.534	0.001	0.115
		Control Group	21.34±3.29	21.76±3.27	-0.416	0.010	0.073
	Inactive	Continuous	21.89±2.78	22.01±2.55	-0.117	0.529	0.005
		Intermittent	22.04±3.21	22.67±3.13	-0.628	0.051	0.115
		Control Group	18.86±1.71	19.07±1.64	-0.211	0.226	0.017
Corrected thigh girth (cm)	Active	Continuous	38.87±4.36	39.76±4.20	-0.890	0.286	0.013
		Intermittent	42.93±7.96	42.12±3.53	0.809	0.318	0.011
		Control Group	40.27±4.53	40.24±4.42	0.038	0.962	0.001
	Inactive	Continuous	39.22±4.54	40.29±4.12	-1.075	0.260	0.014
		Intermittent	42.17±4.20	43.05±5.45	-0.878	0.357	0.010
		Control Group	35.78±2.83	36.06±2.53	-0.281	0.751	0.001
Corrected calf girth (cm)	Active	Continuous	28.49±2.90	29.00±2.70	-0.515	0.001	0.123
		Intermittent	30.17±2.40	30.60±2.48	-0.433	0.003	0.095
		Control Group	29.51±3.05	29.76±2.88	-0.249	0.085	0.033
	Inactive	Continuous	27.90±3.24	28.57±3.35	-0.663	<0.001	0.150
		Intermittent	29.77±2.51	30.56±2.90	-0.789	<0.001	0.200
		Control Group	26.87±1.73	27.26±1.87	-0.388	0.055	0.065
Fat mass (%)	Active	Continuous	22.61±11.56	21.33±11.40	1.278	0.003	0.096
		Intermittent	20.80±6.30	18.95±5.15	1.854	<0.001	0.190
		Control Group	17.27±7.48	17.17±7.81	0.099	0.809	0.001
	Inactive	Continuous	31.28±12.59	29.49±13.41	1.783	<0.001	0.136
		Intermittent	24.36±10.79	23.20±9.86	1.153	0.018	0.062
		Control Group	20.23±9.99	21.20±10.06	-0.971	0.032	0.051
Muscle mass (kg)	Active	Continuous	17.53±4.05	18.28±4.15	-0.755	0.108	0.029
		Intermittent	21.75±4.71	21.67±3.69	0.084	0.849	0.001
		Control Group	19.81±5.03	20.11±4.95	-0.298	0.498	0.005
	Inactive	Continuous	18.12±4.58	18.74±4.42	-0.619	0.233	0.016
		Intermittent	20.75±6.03	21.78±6.90	-1.026	0.051	0.044
		Control Group	14.26±2.39	14.58±2.28	-0.324	0.501	0.005

Regarding girths, a significant increase in waist (p=0.011; ES=0.072) and hip girths (p<0.001; ES=0.192) was only observed in the control groups of adolescents who were inactive before the start. However, the corrected arm girth only increased significantly in the active adolescent groups (p=0.001-0.010; ES=0.073-0.115), whereas the corrected calf girth increased in the continuous and intermittent groups of active (p=0.001-0.003; ES=0.095-0.123) and inactive (p<0.001; ES=0.150-0.200) adolescents.

5.4.4. Differences in the changes between pre-and post-test measurements in the physical activity and body composition variables between the different groups

The differences in the changes found in the study variables between the different groups studied are shown in Table 3. The increase in body mass (p=0.018; ES=0.087) and BMI (p=0.048; ES=0.075) was greater in the control group with respect to the continuous use group.

The decreases in the sum of 3 skinfolds and fat mass were significantly higher in both intervention groups with respect to the control group (p<0.001; ES=0.220-0.320), but there were no differences between the two intervention groups (p=1.000; ES=0.220-0.320).

The rest of the variables did not show significant differences in the changes between the pre- and post-test (p=0.066-1.000; ES=0.001-0.065). The effect size was small for all variables except for the sum of 3 skinfolds.

5.4.5. Differences in the changes between pre-and post-test measurements in the study variables between the different groups according to the previous level of physical activity

The differences in the changes found in the study variables according to the previous level of physical activity are shown in Table 4. Body mass and BMI showed significant changes when comparing the inactive adolescents in the continuous and the control group (body mass: p<0.001; ES=0.201; BMI: p=0.006; ES=0.104), with the values of these variables decreasing in the continuous group and increasing in the control group after the intervention.

Table 3. Differences in the change produced in the study variables between pre- and post-test measurements between the different groups.

Variable	Comparison groups	Mean Diff.	p	95% CI	η2
Physical activity	Continuous-Intermittent	-0.038	1.000	-0.485; 0.321	0.049
	Continuous-Control	-0.341	0.130	-0.730; 0.064	
	Intermittent-Control	-0.303	0.259	-0.641; 0.139	
Body mass (kg)	Continuous-Intermittent	0.260	1.000	-0.564; 1.085	0.087
	Continuous-Control	0.936	0.018	0.123; 1.748	
	Intermittent-Control	0.676	0.125	-0.123; 1.474	
Height (cm)	Continuous-Intermittent	0.172	1.000	-0.316; 0.660	0.012
	Continuous-Control	0.186	1.000	-0.295; 0.666	
	Intermittent-Control	0.014	1.000	-0.459; 0.486	
BMI (kg/m²)	Continuous-Intermittent	0.054	1.000	-0.357; 0.465	0.075
	Continuous-Control	0.407	0.048	0.003; 0.812	
	Intermittent-Control	0.353	0.098	-0.044; 0.751	
Sitting height (cm)	Continuous-Intermittent	0.057	1.000	-0.553; 0.667	0.001
	Continuous-Control	0.056	1.000	-0.545; 0.657	
	Intermittent-Control	-0.001	1.000	-0.592; 0.589	
Sum of 3 skinfolds (mm)	Continuous-Intermittent	1.085	1.000	-1.755; 3.925	0.320
	Continuous-Control	6.856	<0.001	4.057; 9.654	
	Intermittent-Control	5.770	<0.001	3.021; 8.520	
Waist girth (cm)	Continuous-Intermittent	0.226	1.000	-0.961; 1.412	0.065
	Continuous-Control	1.117	0.066	-0.052; 2.286	
	Intermittent-Control	0.892	0.184	-0.257; 2.041	
Hips girth (cm)	Continuous-Intermittent	0.150	1.000	-0.993; 1.293	0.061
	Continuous-Control	1.022	0.088	-0.105; 2.148	
	Intermittent-Control	0.872	0.173	-0.235; 1.978	

	Continuous-Intermittent	0.001	1.000	-0.014; 0.015	
Waist-to-hip ratio	Continuous-Control	0.003	1.000	-0.011; 0.017	0.003
	Intermittent-Control	0.002	1.000	-0.012; 0.016	
	Continuous-Intermittent	0.263	0.399	-0.160; 0.686	
Corrected arm girth (cm)	Continuous-Control	0.011	1.000	-0.405; 0.428	0.033
	Intermittent-Control	-0.251	0.413	-0.661; 0.158	
	Continuous-Intermittent	-1.066	0.692	-3.220; 1.089	
Corrected thigh girth (cm)	Continuous-Control	-0.857	0.983	-2.979; 1.266	0.018
	Intermittent-Control	0.209	1.000	-1.877; 2.295	
	Continuous-Intermittent	0.020	1.000	-0.364; 0.404	
Corrected calf girth (cm)	Continuous-Control	-0.250	0.330	-0.629; 0.128	0.042
	Intermittent-Control	-0.270	0.238	-0.642; 0.101	
	Continuous-Intermittent	-0.066	1.000	-1.173; 1.041	
Fat mass (%)	Continuous-Control	1.881	<0.001	0.791; 2.972	0.220
	Intermittent-Control	1.948	<0.001	0.876; 3.020	
	Continuous-Intermittent	-0.312	1.000	-1.481; 0.857	
Muscle mass (kg)	Continuous-Control	-0.384	1.000	-1.536; 0.768	0.008
	Intermittent-Control	-0.072	1.000	-1.204; 1.060	

In addition, significant changes were found when comparing both intervention groups with the control group, in the variables sum of 3 skinfolds and fat mass, independently of the previous level of physical activity. Thus, the active adolescents in the continuous and intermittent groups decreased their sum of 3 skinfolds ($p=0.003$; $p=0.001$; $ES=0.167$) and fat mass ($p=0.036$; $p=0.010$; $ES=0.098$) to a greater extent than the control group. Similarly, adolescents who were inactive in the continuous and intermittent groups decreased their sum of 3 skinfolds ($p<0.001$; $p=0.003$; $ES=0.245$) and fat mass ($p<0.001$; $p=0.005$; $ES=0.184$) to a greater extent than the control group.

5.5. Discussion

The present research was conducted to discover whether different ways of playing Pokémon Go had different effects on the level of physical activity and changes in body composition in the adolescent population, and whether the previous level of physical activity was a conditioning factor in these changes. The results showed that the level of physical activity increased significantly only in inactive adolescents who used the continuous gameplay style of Pokémon Go. In addition, fat mass decreased, and lower limb muscle mass increased in adolescents who used Pokémon Go, regardless of gameplay style and whether they were active or inactive prior to the start of the research.

According to the aims of the present study, the results found showed a significant increase in the practice of physical activity pre- and post-test in the continuous Pokémon Go group, but it only occurred in adolescents who were inactive before starting the intervention. However, when comparing the change in the level of physical activity pre- and post-test, no significant differences were found neither between the intervention groups, nor in the changes found with respect to the control group. Previous research found significant changes in the level of physical activity of adolescents with the use of this mobile application; however, the changes occurred in light intensity physical activity (Lee et al., 2021), which could explain why in the present study the adolescents who were inactive before the start of the investigation were the only ones who reported changes, as the adolescents who were active before the start of the study perhaps did not perceive an increase in physical practice with the changes in light-intensity physical

Table 4. Differences in the change produced in the study variables between pre- and post-test measurements between the different groups according to the previous physical activity level.

Variable	Previous level of physical activity	Comparison groups	Mean Diff.	p	95% CI	η2
Physical activity	Active	Continuous-Intermittent	-0.117	1.000	-0.624; 0.389	0.083
		Continuous-Control	-0.545	0.051	-1.051; -0.038	
		Intermittent-Control	-0.427	0.110	-0.919; 0.064	
	Inactive	Continuous-Intermittent	-0.018	1.000	-0.596; 0.561	0.002
		Continuous-Control	-0.083	1.000	-0.642; 0.476	
		Intermittent-Control	-0.065	1.000	-0.624; 0.493	
Body mass (kg)	Active	Continuous-Intermittent	-0.482	0.768	-1.510; 0.546	0.018
		Continuous-Control	-0.073	1.000	-1.101; 0.955	
		Intermittent-Control	0.408	0.961	-0.589; 1.406	
	Inactive	Continuous-Intermittent	1.169	0.051	-0.004; 2.343	0.201
		Continuous-Control	2.170	<0.001	1.037; 3.304	
		Intermittent-Control	1.001	0.102	-0.133; 2.135	
Height (cm)	Active	Continuous-Intermittent	-0.143	1.000	-0.773; 0.488	0.010
		Continuous-Control	-0.240	1.000	-0.870; 0.391	
		Intermittent-Control	-0.097	1.000	-0.709; 0.514	
	Inactive	Continuous-Intermittent	0.554	0.191	-0.166; 1.274	0.071
		Continuous-Control	0.708	0.055	0.012; 1.403	
		Intermittent-Control	0.154	1.000	-0.542; 0.849	
BMI (kg/m²)	Active	Continuous-Intermittent	-0.256	0.738	-0.790; 0.279	0.036
		Continuous-Control	0.117	1.000	-0.417; 0.651	
		Intermittent-Control	0.372	0.249	-0.146; 0.890	
	Inactive	Continuous-Intermittent	0.438	0.248	-0.171; 1.048	0.104
		Continuous-Control	0.765	0.006	0.176; 1.354	
		Intermittent-Control	0.327	0.538	-0.262; 0.916	

Sitting height (cm)	Active	Continuous-Intermittent	-0.165	1.000	-0.974; 0.644	0.004
		Continuous-Control	-0.171	1.000	-0.980; 0.638	
		Intermittent-Control	-0.006	1.000	-0.791; 0.780	
	Inactive	Continuous-Intermittent	0.362	1.000	-0.562; 1.285	0.013
		Continuous-Control	0.329	1.000	-0.564; 1.221	
		Intermittent-Control	-0.033	1.000	-0.925; 0.860	
Sum of 3 skinfolds (mm)	Active	Continuous-Intermittent	-0.385	1.000	-4.144; 3.373	0.167
		Continuous-Control	5.245	0.003	1.487; 9.004	
		Intermittent-Control	5.631	0.001	1.984; 9.277	
	Inactive	Continuous-Intermittent	3.022	0.268	-1.269; 7.312	0.245
		Continuous-Control	8.808	<0.001	4.663; 12.953	
		Intermittent-Control	5.786	0.003	1.641; 9.932	
Waist girth (cm)	Active	Continuous-Intermittent	-0.808	0.609	-2.347; 0.730	0.034
		Continuous-Control	0.211	1.000	-1.328; 1.749	
		Intermittent-Control	1.019	0.298	-0.474; 2.511	
	Inactive	Continuous-Intermittent	1.575	0.094	-0.182; 3.331	0.109
		Continuous-Control	2.222	0.056	0.525; 3.918	
		Intermittent-Control	0.647	1.000	-1.049; 2.344	
Hips girth (cm)	Active	Continuous-Intermittent	-0.173	1.000	-1.685; 1.338	0.010
		Continuous-Control	0.388	1.000	-1.123; 1.900	
		Intermittent-Control	0.562	1.000	-0.905; 2.028	
	Inactive	Continuous-Intermittent	0.581	1.000	-1.145; 2.306	0.077
		Continuous-Control	1.785	0.052	0.117; 3.452	
		Intermittent-Control	1.204	0.244	-0.463; 2.871	
Waist-to-hip ratio	Active	Continuous-Intermittent	-0.009	0.833	-0.028; 0.011	0.015
		Continuous-Control	-0.003	1.000	-0.022; 0.017	
		Intermittent-Control	0.006	1.000	-0.013; 0.025	
	Inactive	Continuous-Intermittent	0.013	0.459	-0.009; 0.035	0.025
		Continuous-Control	0.010	0.793	-0.012; 0.031	
		Intermittent-Control	-0.003	1.000	-0.025; 0.018	

Corrected arm girth (cm)	Active	Continuous-Intermittent	0.067	1.000	-0.497; 0.630	0.003
		Continuous-Control	-0.054	1.000	-0.617; 0.510	
		Intermittent-Control	-0.121	1.000	-0.667; 0.426	
	Inactive	Continuous-Intermittent	0.510	0.168	-0.133; 1.153	0.047
		Continuous-Control	0.094	1.000	-0.527; 0.716	
		Intermittent-Control	-0.416	0.318	-1.037; 0.206	
Corrected thigh girth (cm)	Active	Continuous-Intermittent	-1.684	0.473	-4.569; 1.201	0.023
		Continuous-Control	-0.912	1.000	-3.797; 1.973	
		Intermittent-Control	0.772	1.000	-2.027; 3.570	
	Inactive	Continuous-Intermittent	-0.196	1.000	-3.489; 3.097	0.005
		Continuous-Control	-0.793	1.000	-3.974; 2.389	
		Intermittent-Control	-0.596	1.000	-3.778; 2.585	
Corrected calf girth (cm)	Active	Continuous-Intermittent	-0.048	1.000	-0.557; 0.461	0.016
		Continuous-Control	-0.232	0.805	-0.742; 0.277	
		Intermittent-Control	-0.184	1.000	-0.678; 0.310	
	Inactive	Continuous-Intermittent	0.127	1.000	-0.454; 0.708	0.036
		Continuous-Control	-0.274	0.709	-0.836; 0.287	
		Intermittent-Control	-0.401	0.254	-0.963; 0.160	
Fat mass (%)	Active	Continuous-Intermittent	-0.595	0.966	-2.052; 0.863	0.098
		Continuous-Control	1.160	0.036	-0.297; 2.618	
		Intermittent-Control	1.755	0.010	0.341; 3.169	
	Inactive	Continuous-Intermittent	0.629	1.000	-1.034; 2.293	0.184
		Continuous-Control	2.754	<0.001	1.146; 4.361	
		Intermittent-Control	2.124	0.005	0.517; 3.732	
Muscle mass (kg)	Active	Continuous-Intermittent	-0.839	0.577	-2.397; 0.720	0.019
		Continuous-Control	-0.457	1.000	-2.016; 1.101	
		Intermittent-Control	0.381	1.000	-1.130; 1.893	
	Inactive	Continuous-Intermittent	0.408	1.000	-1.372; 2.187	0.011
		Continuous-Control	-0.295	1.000	-2.013; 1.424	
		Intermittent-Control	-0.702	0.964	-2.421; 1.017	

activity, as the questionnaire used did not allow the evaluation of the different intensities of physical activity. In addition, the only study that analyzed the different ways to play playing Pokémon Go showed that the continuous group more closely resembled traditional walking, but did not compare the results with a control group, as in the case of the present study, with these results being novel (Beach et al., 2021). Furthermore, physical activity was measured using a questionnaire, which, although valid and reliable (Kowalski et al., 2004; Martínez-Gómez et al., 2009), may make it difficult for adolescents who played Pokémon Go (intermittently) to discriminate between increases in daily physical activity, as shown in previous research with young people, in which there was a perception that to achieve health benefits, strenuous effort, exertion, and sweat was necessary (Sleap & Wormald, 2001). Thus, future research should use objective methods such as accelerometry to measure the level of physical activity, which would make it possible to determine variations in the number of steps and light, moderate, and vigorous intensity physical activity.

Regarding kinanthropometric variables and body composition, body mass and height increased in all groups, regardless of the previous level of physical activity, while BMI significantly increased only in the control group of previously inactive adolescents. In addition, the control group showed a greater change between pre- and post-test measurements in body mass and BMI than the continuous use group, but this only occurred in the inactive adolescent group. Previous research has analyzed differences in kinanthropometric and derived variables as a function of Pokémon Go use, although without considering different playing styles, and the results were similar to those from the present study, with a significant increase in body mass and height in all the groups (Mateo-Orcajada, Abenza-Cano, et al., 2023). Previous research has also shown that players of Pokémon Go in the continuous mode presented a greater similarity with traditional walking (Beach et al., 2021), with interventions using continuous walking, such as active commuting to school, being useful for decreasing BMI in the adolescent population (Martin-Moraleda et al., 2022). This could be the explanation for the fact that the continuous use of Pokémon Go group showed the least increase in body mass and BMI as compared to the control group of inactive adolescents. The lack of differences between the continuous group and the control in adolescents who were active before baseline could be due to the fact that regular physical activity would prevent significant changes in body composition (Mateo-Orcajada, González-Gálvez, et al., 2022), regardless of the Pokémon Go intervention. However, BMI does not show the composition of muscle and fat mass of the adolescents (Micozzi & Albanes, 1988), so that a higher BMI would not necessarily indicate a less healthy body composition. In addition, the present research did not considered other behaviors that may influence body composition and kinanthropometric variables of adolescents, such as diet or energy intake (Mateo-Orcajada, Abenza-Cano, et al., 2022), which could have influenced the results found.

Similarly, the corrected girths increased in all the groups analyzed, without significant differences between them. More specifically, the corrected arm girth significantly increased in all groups of previously active adolescents, whereas the corrected calf girth increased in the continuous and intermittent groups of previously active and inactive adolescents, but not in the control groups. The results obtained are similar to those from previous studies, in which a significant increase was observed in corrected girths in the groups that used mobile applications to encourage aerobic physical activity, and in the control group (Mateo-Orcajada, Abenza-Cano, et al., 2023). The increase in corrected calf girth in all intervention groups, but not in the control groups, could be due to the fact that the increased walking time with the use of Pokémon Go could stimulate the development of muscle mass in the lower limbs, which would be similar to other research developed with continuous and intermittent aerobic work (Yin et al., 2020). Nevertheless, given the influence of hormonal changes that occur at age at peak height velocity (APHV) on muscle development (Clark & Rogol, 1996; Handelsman, 2017), future studies must analyze the influence of maturation on the changes in these variables.

In addition, it is worth noting the increase in waist girth, hips girth, sum of 3 skinfolds and fat mass in the control group of previously inactive adolescents, as compared to the intervention groups. Furthermore, there was a significant decrease in fat mass and sum of 3 skinfolds in all intervention groups, with the change being significant with respect to the control group, regardless of the level of previous physical activity. No significant differences were found between the continuous and intermittent playing styles. These results are similar to those from previous research, in which the use of Pokémon Go led to a significant decrease in the sum of 3 skinfolds and prevented a significant increase in waist girth (Mateo-Orcajada, Abenza-Cano, et al., 2023). A possible explanation for these results would be that the increase in physical activity performed, although not significant with respect to the control group, was sufficient to begin to produce small changes in the variables related to fat accumulation in the adolescent population. This has been shown in previous research, in which regular aerobic physical activity programs resulted in a decrease in waist and hip girths (Carson et al., 2013; Tercedor et al., 2017), as these are the trunk areas in which a large part of the adipose mass tends to accumulate (Moreno et al., 2007).

Similarly, the decrease in fat mass and sum of skinfolds could be due to the fact that the increase in physical activity with the use of Pokémon Go could promote greater energy expenditure, regardless of whether the application is used intermittently or continuously, this being fundamental for the loss of fat mass (Papadopoulou et al., 2020). These results are especially relevant, as they would show that continuous and intermittent use (based on gamification) are equally effective for fat mass reduction in adolescents. This is fundamental, as the extra motivation offered by gamified strategies lead to a greater adherence to the programs, as shown in previous interventions with other electronic devices (Ryan et al., 2017). However, future research is needed to provide more scientific evidence in this area and to confirm whether Pokémon Go can be used as a complementary tool in educational and health fields to promote fat loss in the adolescent population.

According to the hypotheses proposed for the present investigation, H1, which stated that the continuous style of Pokémon Go gameplay would increase the level of physical activity to a greater extent than the intermittent style, and that changes in body composition would be more significant in the continuous use group as compared to the intermittent and control groups, must be partially rejected. This is because, although the increase in physical activity practiced was only significant in the continuous use group, the changes in body composition were significant in the intermittent and continuous groups with respect to the control group, and without differences observed between the two intervention groups. In addition, H2 must be refuted, as the changes produced in the variables of fat mass and muscle mass were significant in the intervention groups of previously active and inactive adolescents.

The present study is not free of limitations. First, the sample size, although homogeneous between groups, was small, so that future research should be carried out with a larger sample that is representative of the adolescent population. Second, the use of questionnaires to measure physical activity, although valid and reliable, could be limiting the information obtained in terms of the intensity of physical activity performed or the number of steps, so it would be appropriate for future research to carry out an objective measurement of this variable. Third, it is not known whether the changes in the level of physical activity were due to the exclusive use of Pokémon Go or other means, as this was not measured. Fourth, other behaviors that could influence changes in body composition and kinanthropometric variables, such as diet or caloric intake, were not recorded. Fifth, although the results were significant, the effect sizes were small for practically all the variables analyzed.

Future research should consider using steps or distance completed with Pokémon Go as an addition to physical activity measurement questionnaires to obtain further information on the level of physical activity of adolescents. Furthermore, just as the previous level of physical activity was considered in the present investigation, future research could consider BMI to discover whether this is a determining variable in terms of the changes that may be produced by the use of Pokémon Go, on the body composition of the adolescent population. In addition, other behaviors that could influence body composition and kinanthropometric variables, such as diet or caloric intake, should be considered in future research.

5.6. Conclusions

It can be concluded that continuous Pokémon Go gameplay appears to increase the physical activity of inactive adolescents. In addition, fat mass seemed to decrease and lower limb muscle mass increase in adolescents using Pokémon Go, regardless of whether it was used continuously or intermittently, and regardless of the adolescents' previous level of physical activity. However, body mass and BMI appeared to decrease with continuous Pokémon Go use, but only in inactive adolescents. These results suggest that the use of Pokémon Go from an educational or health care fields could provide significant benefits for decreasing fat mass and increasing lower limb muscle mass, regardless of the adolescents' previous level of physical activity.

VI – CONCLUSIONES

VI - CONCLUSIONES

6.1. CONCLUSIONES GENERALES

En respuesta al primer objetivo general, se concluye que el nivel de actividad física de la población adolescente es la variable más relevante a tener en cuenta en las diferencias halladas en las variables cineantropométricas, en la composición corporal, la condición física y en el uso de las nuevas tecnologías, mientras que la AMD, el estado de peso y el estado psicológico, a pesar de ser relevantes, parecen ejercer un papel secundario.

Respecto al segundo objetivo general, se puede concluir que una intervención de diez semanas con aplicaciones móviles promovida desde la materia de educación física y utilizada en horario extraescolar permite aumentar el nivel de actividad física realizado por la población adolescente, produciendo cambios significativos en las variables cineantropométricas, de composición corporal y de condición física.

6.2. CONCLUSIONES ESPECÍFICAS

En respuesta a los objetivos específicos 1 y 2 se puede concluir que los adolescentes activos tienen menor grasa, mayores valores de masa muscular y altura, mayor AMD, mayor fuerza, velocidad y aptitud cardiorrespiratorio que los adolescentes sedentarios. La masa corporal, el IMC, la masa muscular, el perímetro de la cadera, la relación cintura/cadera, la relación cintura/talla, la AMD, y el VO2 máx. se consideraron resultados primarios para distinguir entre los grupos de adolescentes activos y sedentarios. La comparación entre adolescentes con diferente estado de peso mostró resultados superiores en las variables antropométricas y un menor rendimiento en las pruebas de aptitud física, excepto en la fuerza de prensión manual, en los adolescentes con sobrepeso u obesidad, independientemente de que fueran activos o sedentarios. Además, los adolescentes más activos dentro del mismo grupo de estado de peso tenían mayor masa muscular, rendimiento físico y AMD que los adolescentes más sedentarios, de acuerdo con el paradigma "fat but fit".

En respuesta a los objetivos específicos 3 y 4 se puede concluir que una mayor AMD no parece producir efectos beneficiosos en la población adolescente. Así, sólo el nivel de actividad física presentó diferencias significativas en función de la AMD de los adolescentes, mientras que no hubo diferencias significativas en las variables cinantropométricas y de condición física de los adolescentes en función de su AMD cuando se consideró toda la muestra. Considerando el sexo de los adolescentes, se observó que los varones con mejor AMD tenían mayor nivel de actividad física y mayor masa muscular, pero también presentaban mayor masa grasa, masa corporal e IMC. En cuanto a las mujeres con mejor AMD, sólo presentaban un mayor nivel de actividad física y un mayor VO2 máximo. Además, al considerar conjuntamente el IMC y el sexo, no se pudo confirmar la opinión del paradigma "fat but healthy diet". Esto se debe a que los varones obesos y con sobrepeso con AMD óptima presentaban mayor masa corporal, suma de tres pliegues cutáneos y perímetro de cintura, y no practicaban más actividad física que los varones con sobrepeso y peor AMD. Además, no se encontraron diferencias en las variables cineantropométricas y de condición física en las mujeres de ninguno de los grupos de estado de peso. Por lo tanto, el paradigma "fat but healthy diet" no puede confirmarse en la presente investigación.

En respuesta a los objetivos específicos 5 y 6 se puede concluir que los adolescentes en los percentiles más altos (50-75 y 75-100) de satisfacción de las necesidades psicológicas básicas presentaron mejores niveles de actividad física, AMD, variables cinantropométricas y derivadas, y aptitud física. Además, cabe destacar que los adolescentes que tenían todas las necesidades psicológicas básicas satisfechas mostraron mayores niveles de actividad física, AMD, mejores variables cinantropométricas y derivadas, y mejor forma física, siendo la competencia la más relevante. Además, cuando no todas las necesidades psicológicas básicas estaban satisfechas, la satisfacción de la competencia sola o junto con la autonomía o la relación social reportaron los mayores beneficios.

En respuesta a los objetivos específicos 7 y 8 puede concluirse que el uso problemático de internet y del teléfono móvil podría tener efectos diferentes en los adolescentes de ambos sexos, viéndose las mujeres más afectadas en términos de nivel de actividad física, AMD y estado psicológico (satisfacción vital y competencia), mientras que los varones se ven afectados en términos de AMD, estado físico y estado psicológico (satisfacción vital y relación). El uso problemático de internet en las mujeres condujo a un menor nivel de actividad física, AMD, satisfacción vital y competencia en comparación con las chicas que no presentaban un uso problemático o cuyos problemas era ocasionales. En los varones, el uso problemático de internet condujo a una menor satisfacción vital, pero a puntuaciones más altas en prensión manual y CMJ. En cuanto al uso problemático del teléfono móvil, las mujeres mostraron peor AMD y satisfacción vital, mientras que los varones mostraron menor satisfacción vital y relación, pero mayores puntuaciones en CMJ. Además, los adolescentes sin problemas en la utilización de internet ni del móvil mostraron puntuaciones más altas en AMD y satisfacción vital que los que presentaban problemas ocasionales o un uso problemático de internet, del móvil o de ambos. Sin embargo, en futuras investigaciones debería prestarse especial atención a los adolescentes con uso problemático del teléfono móvil, ya que parecen estar más afectados en su estado psicológico que el resto de los grupos.

Para dar respuesta a los objetivos específicos 9, 10, 11 y 12 se puede concluir que las diferencias entre chicos activos y sedentarios, y chicas activas y sedentarias no fueron significativas en las variables antropométricas mientras que, en las variables de aptitud física y psicológica, las diferencias fueron significativas entre las chicas activas y sedentarias en todas las variables. Sin embargo, en la comparación entre chicos activos y sedentarios, sólo se encontraron diferencias significativas en competencia, autonomía y VO2 máx. Cuando se comparan hombres y mujeres con el mismo nivel de actividad física (chicos activos-chicas activas, chicos sedentarios-chicas sedentarias), es importante señalar que, en las variables psicológicas, sólo se encontraron diferencias entre chicos sedentarios y chicas sedentarias, con una puntuación más baja en las chicas. En cuanto a la comparación entre varones y mujeres con distinto nivel de actividad física (chicos activos-chicas sedentarias, chicas activas-chicos sedentarios), las diferencias fueron aún más evidentes en todas las variables analizadas entre chicos activos y chicas sedentarias, aunque no se encontraron diferencias entre las chicas activas y los chicos sedentarios en masa grasa o satisfacción vital.

En cuanto a la AMD, no se encontraron diferencias entre los chicos con pobre y óptima adherencia a la dieta mediterránea, ni entre las chicas con pobre y óptima adherencia a la dieta mediterránea en las variables antropométricas y de aptitud física, aunque sí en las variables psicológicas, puntuando más alto los chicos y chicas con adherencia óptima a la dieta mediterránea. En la comparación entre chicos y chicas con pobre adherencia a la dieta mediterránea y chicos y chicas con óptima adherencia a la dieta mediterránea, las diferencias fueron significativas en las variables antropométricas y de aptitud física en ambos grupos, pero sólo en las variables psicológicas entre los chicos y chicas con óptima adherencia a la dieta mediterránea. Otro aspecto novedoso es que, en las variables psicológicas, la comparación entre chicas con pobre adherencia y chicos con óptima adherencia a la dieta mediterránea hubo diferencias significativas, con valores más altos en los chicos con adherencia óptima, aunque no se encontraron diferencias entre los chicos con pobre adherencia y las chicas con óptima adherencia.

Según el estado de peso, los chicos y chicas con sobrepeso/obesidad mostraron puntuaciones más altas en las variables antropométricas, y menor rendimiento en capacidad cardiorrespiratoria y CMJ. Sin embargo, sólo los chicos con sobrepeso/obesidad mostraron mayor rendimiento en fuerza de prensión manual, mientras que los chicos con normopeso lo hicieron en el sprint de 20 m. No hubo diferencias significativas en las variables psicológicas entre los chicos con normopeso y sobrepeso/obesidad, ni entre las chicas normopeso y sobrepeso/obesidad. Al comparar varones y mujeres con el mismo estado de peso (chicos normopeso-chicas normopeso y chicos sobrepeso/obesidad-chicas sobrepeso/obesidad), las diferencias fueron más evidentes en las variables antropométricas y de aptitud física entre géneros mientras que, en las variables psicológicas, las chicas con normopeso y sobrepeso/obesidad mostraron valores más bajos que los varones. En cuanto a la comparación entre chicas normopeso y los chicos con sobrepeso/obesidad, y los chicos normopeso con las chicas con sobrepeso/obesidad, las variables psicológicas no mostraron diferencias significativas mientras que, en la aptitud física, cabe destacar que no hubo diferencias entre las chicas normopeso y los chicos con sobrepeso/obesidad en el CMJ. En cuanto a las variables antropométricas, los chicos con sobrepeso/obesidad mostraron puntuaciones superiores a las chicas normopeso en todas las variables analizadas, siendo similar en las chicas con sobrepeso/obesidad con respecto a los chicos normopeso, excepto en masa muscular, en la que los chicos normopeso obtuvieron valores superiores, y en perímetros corregidos, en los que no hubo diferencias entre chicas con sobrepeso/obesidad y los chicos normopeso.

Respecto a los objetivos específicos 13 y 14 se puede concluir que las aplicaciones móviles utilizadas en horario extraescolar son herramientas útiles para producir cambios en el nivel de actividad física, la composición corporal y la forma física de los adolescentes de 12 a 16 años. Las aplicaciones móviles utilizadas en la presente investigación no parecen eficaces para mejorar la AMD en los adolescentes. Cabe destacar que dependiendo de la aplicación móvil utilizada, se pueden producir diferentes beneficios sobre el nivel de actividad física, la composición corporal y la forma física, siendo la aplicación móvil gamificada utilizada en la presente investigación útil para producir cambios en la actividad física y la composición corporal, pero no en la forma física, siendo necesarias futuras investigaciones para descubrir la eficacia de cada aplicación.

Y, para dar respuesta a los objetivos específicos 15 y 16, puede concluirse que la forma de juego continua de Pokémon Go parece aumentar la actividad física de los adolescentes inactivos. Además, la masa grasa parecía disminuir y la masa muscular de las extremidades inferiores aumentar en los adolescentes que utilizaban Pokémon Go, independientemente de si se utilizaba la forma de juego continua o intermitente, e independientemente del nivel previo de actividad física de los adolescentes. Sin embargo, la masa corporal y el IMC parecían disminuir con la forma de juego continua de Pokémon Go, pero solo en los adolescentes inactivos.

6.3. GENERAL CONCLUSIONS

In response to the first general aim, we conclude that the level of physical activity of the adolescent population is the most relevant variable to be considered in the differences found in the kinanthropometric variables, body composition, fitness, and the use of new technologies, while AMD, weight status and psychological state, although relevant, seem to play a secondary role.

Regarding the second general aim, it can be concluded that a ten-week intervention with mobile applications promoted by the physical education subject and used after school allows increasing the level of physical activity performed by the adolescent population, producing significant changes in kinanthropometric variables, body composition and fitness.

6.4. SPECIFIC CONCLUSIONS

In response to specific objectives 1 and 2 it can be concluded that active adolescents have lower fat mass, higher values of muscle mass and height, greater AMD, greater strength, speed, and cardiorespiratory fitness than sedentary adolescents. Body mass, BMI, muscle mass, hip girth, waist-to-hip ratio, waist-to-height ratio, AMD, and VO2 max were considered as primary outcomes to distinguish between active and sedentary groups of adolescents. The comparison between adolescents with different weight status showed higher results in anthropometric variables and lower performance in physical fitness tests, except for handgrip strength, in overweight or obese adolescents, regardless of whether they are active or sedentary. In addition, the more active adolescents within the same weight status group had greater muscle mass, physical performance, and AMD diet than the more sedentary adolescents, in accordance with the "fat but fit" paradigm.

In response to specific objectives 3 and 4 it can be concluded that greater AMD does not seem to produce beneficial effects in the adolescent population. Thus, only the level of physical activity showed significant differences as a function of the adolescents' AMD, while there were no significant differences in the kinanthropometrics variables and the physical condition variables of the adolescents according to their AMD when considering the whole sample. Considering the gender of the adolescents, it was observed that the males with better AMD had a higher level of physical activity and a greater muscle mass, but also showed a greater fat mass, body mass, and BMI. As for the females with better AMD, they presented only a higher level of physical activity and higher VO2 max. In addition, when considering BMI and gender together, the view of the "fat but healthy diet" paradigm could not be confirmed. This is because overweight and obese males with optimal AMD showed greater body mass, sum of three skinfolds, and waist circumference, and they did not practice more physical activity than overweight males with worse AMD. In addition, no differences were found in the kinanthropometric and physical condition variables in the females in any of the weight status groups. Therefore, the fat but healthy diet paradigm cannot be confirmed in the present research.

In response to specific objectives 5 and 6 it can be concluded that adolescents in the highest percentiles (50-75 and 75-100) of BPNs satisfaction had better levels of physical activity, AMD, kinanthropometric and derived variables, and physical fitness. Furthermore, it is noteworthy that adolescents who had all BPNs satisfied showed higher levels of physical activity, AMD, better kinanthropometric and derived variables, and better physical fitness, with competence being the most relevant; when not all BPNs were satisfied, satisfaction of competence alone or together with autonomy or relatedness reported the greatest benefits.

In response to specific objectives 7 and 8 it can be concluded that problematic internet and mobile phone use could have different effects on adolescent males and females, with females being more affected in terms of physical activity level, AMD, and psychological state (life satisfaction and competence), while males are affected in terms of AMD, physical condition, and psychological state (life satisfaction and relatedness). Problematic internet use in females led to a lower level of physical activity, AMD, life satisfaction, and competence compared to girls with non-problematic use and occasional problems. In males, problematic internet use led to lower life satisfaction, but higher handgrip and CMJ scores. In terms of problematic mobile phone use, females showed worse AMD and life satisfaction, while males showed lower life satisfaction and relatedness, but higher CMJ scores. In addition, adolescents with non-problematic use with both internet and mobile phones showed higher AMD and life satisfaction scores than those who presented occasional problems or problematic use of the internet, mobile phone, or both. However, special attention should be paid in future research to adolescents with problematic use of mobile phones, as they seem to be more affected in their psychological state than the rest of the groups.

In response to the specific objectives 9, 10, 11 and 12, it can be concluded that the differences between active and sedentary males and active and sedentary females were not significant in the anthropometric variables, while in the physical fitness and psychological variables, the differences were significant between active females and sedentary females in all variables, while for the comparison between actives males and sedentary males, significant differences were only found in competence, autonomy, and VO_2 max. When comparing males and females with the same level of physical activity (active males-active females, sedentary males-sedentary females), it is important to note that in the psychological variables, differences were only found between sedentary males and sedentary females, with sedentary females scoring lower. Regarding the comparison between males and females with different levels of physical activity (actives males-sedentary females, active females-sedentary males), the differences were even more evident in all the variables analyzed between actives males and sedentary females, although no differences were found between active females and sedentary males in fat mass or life satisfaction.

Regarding AMD, no differences were found between males with optimal adherence and males with poor adherence and between females with optimal adherence and females with poor adherence in the anthropometric and physical fitness variables, although differences were found in the psychological variables, with males and females with optimal adherence scoring higher. In the comparison between males and females with poor adherence and males and females with optimal adherence, the differences were significant in the anthropometric and physical fitness variables in both groups but only in the psychological variables between males with optimal adherence and females with optimal adherence. Another novel aspect is that in the psychological variables, the comparison between females with poor adherence and males with optimal adherence showed significant differences, with higher values in males with optimal adherence, although no differences were found between males with poor adherence and females with optimal adherence.

According to weight status, the overweight/obese males and females showed higher scores in the anthropometric variables, and lower performance in cardiorespiratory capacity and CMJ. However, only the overweight/obese males showed higher performance in handgrip, while the normalweight males did so in the 20-m sprint. There were no significant differences in psychological variables between normalweight and overweight/obese males nor between normalweight and overweight/obese females. When comparing males and females with the same weight status (normalweight males-normalweight females and overweight/obese males-overweight/obese females), differences were more evident in anthropometric and physical fitness variables between genders, while in psychological variables, overweight/obese and normalweight females showed lower values than males. As for the comparison between normalweight females and overweight/obese males, and normalweight males and overweight/obese females, the psychological variables showed no significant differences, while in physical fitness, it is noteworthy that there were no differences between normalweight females and overweight/obese males in the CMJ. Regarding the anthropometric variables, the overweight/obese males showed higher scores than the normalweight females in all the variables analyzed, with this being similar in the overweight/obese females with respect to the normalweight males, except in muscle mass, in which the normalweight males obtained higher values, and in corrected girths, in which there were no differences between overweight/obese females and normalweight males.

With respect to the specific objectives 13 and 14, it can be concluded that mobile applications used after school are useful tools for producing changes in the level of physical activity, body composition, and physical fitness of adolescents aged 12 to 16 years old. The mobile applications used in the present investigation do not seem effective in improving AMD in adolescents. It should be noted that depending on the mobile application used, different benefits on physical activity level, body composition, and physical fitness may occur, with the gamified mobile application used in the present research being useful for producing changes in physical activity and body composition, but not in physical fitness, with future research to discover the effectiveness of each application being necessary.

And, in response to specific objectives 15 and 16, it can be concluded that continuous Pokémon Go gameplay appears to increase the physical activity of inactive adolescents. In addition, fat mass seemed to decrease and lower limb muscle mass increase in adolescents using Pokémon Go, regardless of whether it was used continuously or intermittently, and regardless of the adolescents' previous level of physical activity. However, body mass and BMI appeared to decrease with continuous Pokémon Go use, but only in inactive adolescents. These results suggest that the use of Pokémon Go from an educational or health care fields could provide significant benefits for decreasing fat mass and increasing lower limb muscle mass, regardless of the adolescents' previous level of physical activity.

VII – APLICACIONES PRÁCTICAS

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Las siguientes aplicaciones prácticas se extraen de los artículos incluidos en el apartado de métodos, resultados y discusión de la presente tesis doctoral. Del primer estudio resalta la importancia de la práctica de actividad física para un adecuado desarrollo de la composición corporal, las capacidades físicas y la AMD durante la adolescencia. Además, atendiendo a las reducidas horas de educación física semanales disponibles en España en Educación Secundaria Obligatoria, es necesario concienciar a todos los agentes implicados en el desarrollo de los adolescentes (profesores, entrenadores, progenitores, los propios estudiantes) de la importancia de la actividad física y la influencia en la salud en etapas posteriores. También es necesario otorgar mayor relevancia a la actividad física en horario extraescolar, ya que permitirá incrementar las horas semanales de práctica, facilitando el acceso a un estilo de vida activo a los adolescentes que pueda ser mantenido en el tiempo. Ambas estrategias pueden adquirir especial relevancia, principalmente en los adolescentes con sobrepeso y obesidad, ya que son menos activos, y los beneficios de comenzar a practicar actividad física serían relevantes en la condición física y la composición corporal (paradigma fat but fit).

Respecto al segundo estudio, se observó que la AMD no parece ser tan determinante para las variables antropométricas y la condición física de los adolescente, pero sí que parece un elemento clave para la adopción de otros hábitos de vida saludables en los chicos y chicas, incluido un mayor nivel de práctica de actividad física. Además, la presente tesis otorga relevancia al género y al IMC en el estudio de la AMD, ya que las necesidades cambian entre los grupos analizados. En este sentido, especial relevancia debe ser puesta en los chicos con sobrepeso, ya que la AMD óptima no parece ser tan relevante en las variables cineantropométricas y en la práctica de actividad física, adquiriendo mayor relevancia otros hábitos saludables, aunque son necesarias investigaciones futuras para corroborarlo. En el caso de las chicas, la AMD tampoco parece ser relevante en la mejora de la condición física ni en los cambios en la composición corporal.

Otro aspecto relevante de este segundo estudio es que no se puede confirmar el paradigma “fat but healthy diet”, ya que los cambios fueron significativos en la actividad física, las variables cineantropométricas y la condición física en función de la AMD únicamente en los chicos con bajo peso y normopeso. Además, en el grupo con sobrepeso, los chicos con óptima AMD mostraron peor composición corporal y condición física. Por tanto, la AMD no parece un factor suficientemente determinante para compensar un estado de peso inadecuado y deben seguir explorándose los hábitos saludables que son más determinantes.

Atendiendo al tercer estudio, se establece la relevancia de las necesidades psicológicas básicas en el desarrollo saludable de la población adolescente, más allá del ámbito deportivo donde esta relación había sido ampliamente estudiada. La satisfacción de las necesidades psicológicas básicas puede ser determinante en la adopción de hábitos de vida saludables, siendo esto fundamental en una sociedad en la que la población adolescente ha reducido considerablemente su práctica de actividad física y su adherencia a patrones nutricionales adecuados. Por tanto, esta investigación es de relevancia para los profesionales que trabajan con adolescentes ya que no se conocía si la satisfacción individual de una de las necesidades psicológicas básicas era suficiente para obtener beneficios, o era necesaria la satisfacción conjunta de todas las necesidades psicológicas básicas. En este sentido, los resultados muestran la importancia de la satisfacción conjunta de las necesidades psicológicas básicas, aportando conocimiento valioso sobre la interacción entre estas variables psicológicas y el bienestar adolescente.

El cuarto estudio permite conocer que el uso problemático u ocasional de internet y el teléfono móvil puede influir en el estado de salud de los adolescentes, afectando principalmente al nivel de práctica de actividad física, el estado psicológico y la AMD de las chicas, así como al estado psicológico y la condición física de los chicos. Además, el uso problemático del teléfono móvil parece ser especialmente negativo sobre el estado psicológico de los adolescentes, ya que puede estar relacionado con puntuaciones más bajas en autonomía y relación social. Por tanto, los programas destinados a la mejora de la salud de los adolescentes desde un punto de vista global deben considerar el nivel de uso problemático de internet y el teléfono móvil.

El quinto estudio permite conocer que, aunque la práctica de actividad física es fundamental para toda la población adolescente, en las chicas es aún más relevante para conseguir mejoras en la condición física y el estado psicológico. Esto se debe a que permite reducir las diferencias halladas entre chicos y chicas adolescentes, pudiendo incluso compensar las diferencias en función del género en la acumulación de masa grasa y la satisfacción con la vida. Al considerar la AMD, las diferencias solo estuvieron presentes entre los chicos y chicas con baja AMD, pero no con óptima AMD, lo que es determinante en la promoción de hábitos saludables en esta población ya que las diferencias psicológicas entre géneros desaparecen cuando se alcanza una óptima AMD. Respecto al estado de peso, tanto las chicas con normopeso como las chicas con sobrepeso mostraron puntuaciones más bajas en las variables psicológicas que los chicos, pero no se hallaron diferencias al comparar las chicas con normopeso y las chicas con sobrepeso por lo que las diferencias podrían no ser únicamente a causa del estado de peso. Por tanto, este quinto estudio muestra que, aunque la AMD y el mantenimiento de un estado de peso saludable son relevantes para la población adolescente, la actividad física ejerce un papel aún más decisivo. Por tanto, los programas destinados a la adquisición de hábitos saludables en jóvenes deben considerar la práctica de actividad física como eslabón principal, ya que parece facilitar la adquisición del resto de hábitos saludables, aumentando los beneficios obtenidos.

Del sexto estudio se extraen implicaciones prácticas sociales y educativas. Respecto a las sociales, el uso de las aplicaciones móviles promovido desde la materia de educación física podría ser útil para aumentar la actividad física de los adolescente siempre y cuando estas se utilizasen en horario extraescolar, ya que su diseño e interfaz limitan enormemente su uso en horario lectivo. Además, su uso debería ser obligatorio para los adolescentes mediante la integración en la asignatura de educación física como deberes, y con la ayuda de los docentes de la materia. Así, se superarían las dificultades encontradas en investigaciones previas en relación a la falta de adherencia y el uso reducido de las aplicaciones móviles, para aumentar de esta forma el nivel de actividad física y conseguir mejoras en la composición corporal y la condición física. Por tanto, aunque son necesarias investigaciones futuras, el uso de aplicaciones móviles promovidas como "deberes" de educación física puede ser clave en la mejora del estado de salud de la población adolescente, especialmente necesario tras la pandemia de Covid-19, convirtiéndose las aplicaciones móviles de seguimiento de pasos en un recurso educativo muy valioso, aunque su uso debería centrarse en horario extraescolar.

En cuanto a las implicaciones educativas, este sexto estudio es relevante para el profesorado de educación física, ya que serían los encargados de promover el uso de estas herramientas en las clases de educación física. Además, los resultados hallados pueden ser relevantes para el Ministerio y la Consejería de Educación, que podrían promover la inclusión de estas aplicaciones de forma habitual, siendo consideradas como “deberes” al igual que en otras materias, dado que el trabajo extraescolar es crucial para la integración de los contenidos trabajados en el aula, aunque esto se olvide en el ámbito de la educación física.

Finalmente, los resultados hallados en el séptimo estudio sugieren que el uso de Pokémon Go desde un ámbito educativo o sanitario podría aportar beneficios significativos para disminuir la masa grasa y aumentar la masa muscular de las extremidades inferiores, independientemente del nivel de actividad física previa de los adolescentes y del estilo de juego que se utilice.

VIII - LIMITACIONES Y FUTURAS LÍNEAS DE INVESTIGACIÓN

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Las limitaciones halladas en los artículos de revisión sistemática incluidos en la justificación de la presente tesis doctoral fueron:

a) Los protocolos usados para evaluar la condición física, la composición corporal y las variables antropométricas eran diferentes entre los estudios.

b) Los tamaños muestrales utilizados en algunos artículos eran pequeños, lo que hacía difícil la comparación e interpretación final de los resultados estadísticos.

c) Las muestras presentaban gran heterogeneidad en cuanto a chicos y chicas, y algunos estudios únicamente incluyeron participantes de un sexo, lo que hacía difícil establecer conclusiones para la totalidad de la población adolescente.

d) Se incluyeron únicamente artículos científicos en inglés y español, excluyendo la producción científica en otros idiomas, así como los meeting abstracts, conferences, etc.

e) La selección de artículos que dividían la muestra entre adolescentes activos y sedentarios excluyó numerosos artículos que comparaban adolescentes que practicaban deportes específicos con aquellos que no lo hacían.

f) La inclusión de muestras pertenecientes a diferentes países implicó la comparación de adolescentes con diferente etnia, clase social y costumbres que no fueron consideradas, lo que podría influir en los resultados obtenidos.

g) La falta de concordancia en las variables medidas y los métodos utilizados dificultó la realización de metaanálisis con los resultados obtenidos.

Estas limitaciones representan las brechas de conocimiento existentes en la literatura científica que dieron origen a la presente tesis doctoral. A pesar de que los estudios realizados consideraron estas limitaciones, en la presente tesis doctoral también se hallaron las siguientes limitaciones:

a) Los estudios transversales no permiten establecer la relación causal entre las variables analizadas.

b) A pesar de que se eligieron centros educativos de diferentes áreas geográficas de la Región de Murcia, la muestra fue seleccionada por conveniencia en los centros educativos a los que se tuvo acceso tras la pandemia de Covid-19.

c) El cuestionario de actividad física (PAQ-A) que permite clasificar a los adolescentes en activos y sedentarios, a pesar de estar validado en español, representa una medida subjetiva del nivel de actividad física. Por tanto, investigaciones futuras deberían incluir la medida objetiva del nivel de actividad física practicado.

d) La utilización del cuestionario KIDMED para la medida de la AMD supone un riesgo debido a la subjetividad y a la falta de precisión que puede presentar al ser cumplimentado por parte de los adolescentes. Además, este cuestionario permite conocer el nivel de AMD, pero no el tipo de comida ingerida ni las cantidades.

e) La escala de necesidades psicológicas básicas, a diferencia de otras escalas psicológicas, no presenta una clasificación que permita determinar el grado de satisfacción de los adolescentes, por lo que se tuvieron que establecer percentiles de acuerdo a la puntuación de los adolescentes de la propia muestra.

f) En el ámbito psicológico, únicamente se ha valorado a los adolescentes por medio de cuestionarios, siendo las entrevistas y los auto-registros instrumentos muy valiosos para completar la información en este ámbito.

g) La clasificación de los adolescentes en bajo peso, normopeso y sobrepeso/obesidad de acuerdo a las directrices de la OMS debe ser tenido en cuenta ya que existen directrices de otras organizaciones internacionales que podrían dificultar la comparación de resultados.

h) El IMC no permite diferenciar entre los componentes de la composición corporal como el tejido adiposo o muscular.

i) Los adolescentes de doce a dieciséis años se encuentran en la pubertad, por lo que el proceso de maduración biológica debe ser tenido en cuenta en los cambios físicos, principalmente en el desarrollo de la fuerza, potencia y la capacidad cardiorrespiratoria. En el caso concreto de las chicas, no se ha tenido en cuenta a las que se encuentran en proceso menstrual y las que aún no han pasado por este, siendo este un factor determinante que podría influir en los resultados.

j) Cuando se considera de forma conjunta el nivel de actividad física, la AMD, el género, o el nivel de uso de internet y el teléfono móvil de los adolescentes, el tamaño muestral de algunos grupos es muy reducido.

k) Aunque en los estudios de intervención la muestra inicial era grande, la muestra fue reducida en algunos grupos cuando se compararon las diferentes aplicaciones móviles utilizadas, dificultando el análisis estadístico.

l) No se consideraron aspectos tales como la motivación o el disfrute de los adolescentes que participaron en la intervención, siendo estos aspectos determinantes en la adherencia y la continuidad en el uso de las aplicaciones, sobre todo si el uso de estas deja de ser obligatorio y promocionado desde la materia de educación física.

m) Aunque comenzar o abandonar la práctica deportiva regular durante la investigación fue un criterio de exclusión, no se tuvo en cuenta si los adolescentes que asistían regularmente al gimnasio o realizaban ejercicios de fuerza progresaron en los mismos, lo que podría influir en los cambios en la composición corporal y el rendimiento físico.

n) Los tamaños del efecto de la mayoría de los cambios medidos fueron reducidos, lo que debe ser tenido en cuenta en la extrapolación de los resultados.

En base a las limitaciones halladas en los estudios transversales y longitudinales de la presente tesis doctoral, las investigaciones futuras que se realicen con aplicaciones móviles en adolescentes deberían considerar los siguientes aspectos:

a) Incluir la medida objetiva del nivel de actividad física, ya que aportaría mayor información sobre el comportamiento físico de los adolescentes. Además, la información nutricional debería ser medida con mayor exhaustividad y con instrumentos que permitan conocer realmente la ingesta de los adolescentes. Esto es de gran relevancia por la importancia que ha mostrado la AMD en el desarrollo adolescente.

b) Investigaciones futuras en adolescentes deberían considerar la realización de entrevistas o grupos de discusión que permitan evaluar el estado psicológico de forma más rigurosa.

c) Tal como se ha realizado en los estudios que componen la presente tesis doctoral, la medida de la composición corporal debe complementarse con mediciones antropométricas que permitan analizar la evolución de los diferentes tejidos (muscular y graso) en la población adolescente.

d) La etapa del proceso madurativo en que se encuentra cada adolescente debe ser tenida en cuenta, ya que es fundamental en la interpretación de los cambios físicos, psicológicos y de comportamiento durante la adolescencia. En el caso concreto de las chicas, el ciclo menstrual debe tenerse en cuenta ya que supone cambios hormonales, físicos y psicológicos que pueden condicionar los resultados hallados durante la intervención.

e) Investigaciones futuras deberían considerar tamaños muestrales superiores, principalmente para cada uno de los grupos de intervención si se utilizan diferentes aplicaciones móviles. Así, la muerte experimental no afectará de forma significativa a los análisis estadísticos que puedan realizarse, resultando en grupos de análisis más homogéneos.

f) Los cambios en las variables psicológicas tales como la satisfacción de las necesidades psicológicas básicas, la satisfacción con la vida, la motivación y el disfrute de los adolescentes con el uso de las aplicaciones móviles debe ser tenida en cuenta en futuros estudios, principalmente si se incluyen aplicaciones gamificadas, ya que esto podría influir en la efectividad de la intervención.

g) La distancia recorrida con el uso de las aplicaciones móviles debe ser tenida en cuenta en futuras investigaciones, ya que podría ser determinante en los cambios sobre la composición corporal y la condición física. En el caso concreto de Pokémon Go, estudios futuros deberían hacer uso de la distancia recorrida con la aplicación, ya que puede ser una medida objetiva de la actividad física que complemente otras medidas objetivas y subjetivas de esta variable, aunque sería necesario comprobar su validez y fiabilidad. De este modo, las recomendaciones sobre el volumen y la intensidad óptimos de actividad física a realizar con las aplicaciones móviles podría ser establecido con mayor precisión y fiabilidad.

h) Los resultados hallados en los estudios de intervención se han conseguido mediante aplicaciones móviles que no estaban diseñadas exclusivamente para adolescentes. Por tanto, investigaciones futuras deberían centrarse en el diseño de una aplicación móvil que incluya aspectos de interés para los adolescentes, con tareas que promuevan la actividad física y recursos educativos que aumenten el conocimiento sobre un estilo de vida saludable, aumentando la tasa de participación y la adherencia a la misma.

i) Si se diseña una aplicación móvil específica para adolescentes, debería testarse su uso en el ámbito escolar y extraescolar (deberes), ya que los beneficios podrían ser mucho más amplios si se combinan ambos. Esto permitiría aumentar la adherencia mediante el uso cotidiano de la misma, así como combatir la inactividad física de la población adolescente y mejorar la composición corporal y la condición física a través de la instauración y mantenimiento de un estilo de vida saludable.

IX - REFERENCIAS BIBLIOGRÁFICAS

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X – ANEXOS

X - ANEXOS

ANEXO 1. APROBACIÓN DEL COMITÉ DE ÉTICA

UCAM
UNIVERSIDAD CATÓLICA SAN ANTONIO

COMITÉ DE ÉTICA DE LA UCAM

DATOS DEL PROYECTO

Título:	"Las nuevas tecnologías como herramienta para la promoción de la salud en escolares de Educación Secundaria Obligatoria de la CARM: efectos de las aplicaciones tecnológicas deportivas sobre la salud física y psicológica de los adolescentes"	
Investigador Principal	**Nombre**	**Correo-e**
Dra.	Lucía Abenza Cano	labenza@ucam.edu

INFORME DEL COMITÉ

Fecha	**26/02/2021**	**Código**	**CE022102**

Tipo de Experimentación

Investigación experimental clínica con seres humanos	
Investigación experimental no clínica con seres humanos	
Utilización de tejidos humanos procedentes de pacientes, personas sanas, tejidos embrionarios o fetales	
Utilización de tejidos humanos, tejidos embrionarios o fetales procedentes de bancos de muestras o tejidos	
Investigación observacional, psicológica o comportamental en humanos	X
Uso de datos personales, información genética, etc.	X
Experimentación animal	
Utilización de agentes biológicos de riesgo para la salud humana, animal o las plantas	
Uso de organismos modificados genéticamente (OMGs)	

Comentarios Respecto al Tipo de Experimentación
Nada Obsta

Comentarios Respecto a la Metodología de Experimentación
Nada Obsta

UNIVERSIDAD CATÓLICA SAN ANTONIO • COMITÉ DE ÉTICA •

Universidad Católica San Antonio. Vicerrectorado de Investigación. Salida nº 7798 01/03/2021 17:48:04

UCAM
UNIVERSIDAD CATÓLICA
SAN ANTONIO

COMITÉ DE ÉTICA DE LA UCAM

Sugerencias al Investigador

A la vista de la solicitud de informe adjunto por el Investigador y de las recomendaciones anteriormente expuestas el dictamen del Comité es:

Emitir Informe Favorable	X
Emitir Informe Desfavorable	
Emitir Informe Favorable condicionado a Subsanación	

MOTIVACIÓN
Incrementará conocimientos en su área

Vº Bº El Presidente,

Fdo.: José Alberto Cánovas Sánchez

El Secretario,

UNIVERSIDAD CATÓLICA SAN ANTONIO
COMITÉ DE ÉTICA

Fdo.: José Alarcón Teruel

ANEXO 2. CONSENTIMIENTO INFORMADO FASE 1

UCAM
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SAN ANTONIO

CONSENTIMIENTO INFORMADO

Yo, ……………………………………………………………., con DNI ……………………………

Padre/madre o tutor/a legal de ………………………………………………………..

DECLARO:

Haber sido informado/a del estudio y procedimientos del proyecto de investigación financiado por la Fundación Séneca de la Región de Murcia y aprobado por el comité de ética de la Universidad Católica San Antonio de Murcia (Código: CE022102), titulado: “Las nuevas tecnologías como herramienta para la promoción de la salud en escolares de Educación Secundaria Obligatoria de la CARM: efectos de las aplicaciones tecnológicas deportivas sobre la salud física y psicológica de los adolescentes” y de los procedimientos de la investigación.

Los investigadores que van a acceder a los datos personales y a los resultados obtenidos son: D. Adrián Mateo Orcajada, Dra. Lucía Abenza Cano, y Dra. Raquel Vaquero Cristóbal, todos ellos personal docente e investigador de la UCAM.

Asimismo, he podido hacer preguntas del estudio, comprendiendo que nos presentamos de forma voluntaria al mismo y que en cualquier momento puedo abandonarlo sin que me suponga perjuicio de ningún tipo.

CONSIENTO:

1. Que mi hijo/a cumplimente los cuestionarios sobre contenido relacionado con la actividad física practicada, uso de las nuevas tecnologías, el dolor lumbar, la dieta mediterránea, el desarrollo cognitivo, la satisfacción con la vida y la satisfacción de las necesidades psicológicas básicas.
2. Que mi hijo/a realice las pruebas de condición física estipuladas en la investigación sobre fuerza, resistencia, flexibilidad y velocidad.
3. Que se lleven a cabo las mediciones antropométricas estipuladas, siguiendo el protocolo establecido por la International Society for the Advancement in Kinanthropometry (ISAK)
4. El uso de los datos obtenidos según lo indicado en el párrafo siguiente: En cumplimiento del Reglamento (UE) 2016/679 del Parlamento Europeo y del Consejo, de 27 de abril de 2016, Real Decreto-Ley 5/2018, de 27 de julio y Ley Orgánica 15/1999, de 13 de diciembre, de Protección de Datos de Carácter Personal, le comunicamos que la información que ha facilitado y la obtenida como consecuencia de las exploraciones a las que se va a someter pasará a formar parte del fichero automatizado INVESOCIAL, cuyo titular es la FUNDACIÓN UNIVERSITARIA SAN ANTONIO, con la finalidad de INVESTIGACIÓN Y DOCENCIA EN LAS ÁREAS DE CONOCIMIENTO CIENCIAS SOCIALES, JURÍDICAS, DE LA EMPRESA Y DE LA COMUNICACIÓN. Tiene derecho a acceder a esta información y cancelarla o rectificarla, dirigiéndose al domicilio de la entidad, en Avda. de los Jerónimos de Guadalupe 30107 (Murcia). Esta entidad le garantiza la adopción de las medidas oportunas para asegurar el tratamiento confidencial de dichos datos.

En ……………., a …. de …………….. 202...

El padre, madre o tutor/a del alumno, El investigador principal

Fdo: ………………..……… Fdo:………………………… Fdo: ……..…….……………

ANEXO 3. CONSENTIMIENTO INFORMADO FASE 2

UCAM
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SAN ANTONIO

CONSENTIMIENTO INFORMADO

Yo, …………………………………………………………., con DNI ………………………….……

Padre/madre o tutor/a legal de ………………………………………………………..

DECLARO:

Haber sido informado/a del estudio y procedimientos del proyecto de investigación financiado por la Fundación Séneca de la Región de Murcia y aprobado por el comité de ética de la Universidad Católica San Antonio de Murcia (Código: CE022102), titulado: "Las nuevas tecnologías como herramienta para la promoción de la salud en escolares de Educación Secundaria Obligatoria de la CARM: efectos de las aplicaciones tecnológicas deportivas sobre la salud física y psicológica de los adolescentes" y de los procedimientos de la investigación.

Los investigadores que van a acceder a los datos personales y a los resultados obtenidos son: D. Adrián Mateo Orcajada, Dra. Lucía Abenza Cano, y Dra. Raquel Vaquero Cristóbal, todos ellos personal docente e investigador de la UCAM.

Asimismo, he podido hacer preguntas del estudio, comprendiendo que nos presentamos de forma voluntaria al mismo y que en cualquier momento puedo abandonarlo sin que me suponga perjuicio de ningún tipo.

CONSIENTO:

1. Que mi hijo/a cumplimente los cuestionarios sobre contenido relacionado con la actividad física practicada, uso de las nuevas tecnologías, el dolor lumbar, la dieta mediterránea, el desarrollo cognitivo, la satisfacción con la vida y la satisfacción de las necesidades psicológicas básicas.
2. Que mi hijo/a realice las pruebas de condición física estipuladas en la investigación sobre fuerza, resistencia, flexibilidad y velocidad.
3. Que se lleven a cabo las mediciones antropométricas estipuladas, siguiendo el protocolo establecido por la International Society for the Advancement in Kinanthropometry (ISAK)
4. Que mi hijo utilice las aplicaciones móviles correspondientes para fomentar el incremento de la actividad física.
5. El uso de los datos obtenidos según lo indicado en el párrafo siguiente: En cumplimiento del Reglamento (UE) 2016/679 del Parlamento Europeo y del Consejo, de 27 de abril de 2016, Real Decreto-Ley 5/2018, de 27 de julio y Ley Orgánica 15/1999, de 13 de diciembre, de Protección de Datos de Carácter Personal, le comunicamos que la información que ha facilitado y la obtenida como consecuencia de las exploraciones a las que se va a someter pasará a formar parte del fichero automatizado INVESOCIAL, cuyo titular es la FUNDACIÓN UNIVERSITARIA SAN ANTONIO, con la finalidad de INVESTIGACIÓN Y DOCENCIA EN LAS ÁREAS DE CONOCIMIENTO CIENCIAS SOCIALES, JURÍDICAS, DE LA EMPRESA Y DE LA COMUNICACIÓN. Tiene derecho a acceder a esta información y cancelarla o rectificarla, dirigiéndose al domicilio de la entidad, en Avda. de los Jerónimos de Guadalupe 30107 (Murcia). Esta entidad le garantiza la adopción de las medidas oportunas para asegurar el tratamiento confidencial de dichos datos.

En ……………., a …. de …………….. 202...

El padre, madre o tutor/a del alumno, El investigador principal

Fdo: ……………….……… Fdo:…………………….……… Fdo: ……..……..……………

ANEXO 4. REVOCACIÓN CONSENTIMIENTO INFORMADO

UCAM
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SAN ANTONIO

REVOCACIÓN CONSENTIMIENTO INFORMADO

Yo, ……………………………………………………………., con DNI …………………………..……

Padre/madre o tutor/a legal de ………………………………………………………..

REVOCO MI CONSENTIMIENTO PARA PARTICIPAR EN EL PROYECTO

Proyecto titulado: "Las nuevas tecnologías como herramienta para la promoción de la salud en escolares de Educación Secundaria Obligatoria de la CARM: efectos de las aplicaciones tecnológicas deportivas sobre la salud física y psicológica de los adolescentes".

En ……………., a …. de …………….. 202...

El padre, madre o tutor/a del alumno, El investigador principal

Fdo: …………………………………. Fdo: …………………………………

ANEXO 5. HOJA INFORMATIVA PROGENITORES Y ESTUDIANTES

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LAS NUEVAS TECNOLOGÍAS COMO HERRAMIENTAS PARA LA PROMOCIÓN DE LA SALUD EN ESCOLARES DE EDUCACIÓN SECUNDARIA OBLIGATORIA DE LA CARM: EFECTOS DE LAS APLICACIONES TECNOLÓGICAS DEPORTIVAS SOBRE LA SALUD FÍSICA Y PSICOLÓGICA DE LOS ADOLESCENTES

Estimado padre, madre o tutor/a legal,

Le informamos de que desde el Campus de Murcia de la Universidad Católica de Murcia (UCAM), en colaboración con la Facultad de Deporte, con la financiación de la Fundación Séneca de la Región de Murcia, y con la aprobación del comité de ética institucional de la universidad (Código: CE022102), se requieren voluntarios para un estudio acerca de la influencia de las aplicaciones tecnológicas deportivas en el incremento de la práctica deportiva de los adolescentes en tiempos de la COVID-19.

El foco del presente estudio se encuentra en los hábitos de vida de los escolares. El proyecto consistirá en la cumplimentación por parte del alumno de cuestionarios relacionados con la actividad física practicada, uso de las nuevas tecnologías, el dolor lumbar, la dieta mediterránea, el desarrollo cognitivo, la satisfacción con la vida y la satisfacción de las necesidades psicológicas básicas. Estos deben ser completados de forma anónima con la mayor sinceridad posible. Tras su cumplimentación el alumno debe entregarlos a los investigadores de la UCAM presentes en la toma de datos.

Además, el alumno llevará a cabo las siguientes pruebas física: 20 m shuttle-run test o course navette (resistencia), curl up (abdominales), push up (flexiones), handgrip (fuerza del tren superior), counter movement jump o salto con contramovimiento (fuerza del tren inferior), sit and reach (flexibilidad) y sprint de 20 metros (velocidad).

Se incluirá también una valoración antropométrica de los alumnos, que incluirá peso, talla, talla sentado, pliegues del tríceps, muslo y pierna, y perímetros de la cintura, cadera, brazo relajado, muslo y pierna, siguiendo el protocolo establecido por la International Society for the Advancement in Kinanthropometry (ISAK).

Tras las mediciones se llevará a cabo una fase de intervención en la que los alumnos deben utilizar durante 10-12 semanas una aplicación móvil de actividad física. Una vez finalizada la intervención se llevarán a cabo dos nuevas tomas de datos en la que se analizarán los cambios en la composición corporal y la condición física de los adolescentes provocados por el uso de las aplicaciones móviles, así como la adherencia a estas.

El tratamiento de los datos será confidencial y totalmente anónimo por parte de los investigadores pertenecientes a la UCAM, cumpliendo la legislación vigente a nivel de España y Europa.

Cabe destacar que se llevarán a cabo todos los protocolos higiénico-sanitarios estipulados para hacer frente a la COVID-19. Se procederá a desinfectar todo el material utilizado cada vez que un alumno realice su intervención. Se mantendrá la distancia de seguridad en todo momento. Y los integrantes del equipo investigador llevarán mascarilla en todo momento, sin excepción.

Tras la participación en el estudio, los alumnos obtendrán información antropométrica (masa corporal, talla, pliegues y perímetros) derivada de la evaluación cineantropométrica, así como un análisis de la condición física obtenido de las pruebas físicas realizadas. De igual forma, se aportarán aplicaciones tecnológicas deportivas que pueden ser de utilidad para el incremento de la práctica deportiva y el establecimiento de hábitos de vida saludables.

Es necesario que aporte el consentimiento informado para que los datos de su hijo/a o tutorizado/a puedan ser utilizados en la presente investigación. Tiene una copia en la parte posterior de esta misma hoja para que la devuelva firmada.

Muchas gracias por su colaboración. Un cordial saludo.

Atentamente,

El investigador principal.

Consentimiento informado

ANEXO 6. HOJA INFORMATIVA CENTRO EDUCATIVO

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LAS NUEVAS TECNOLOGÍAS COMO HERRAMIENTAS PARA LA PROMOCIÓN DE LA SALUD EN ESCOLARES DE EDUCACIÓN SECUNDARIA OBLIGATORIA DE LA CARM: EFECTOS DE LAS APLICACIONES TECNOLÓGICAS DEPORTIVAS SOBRE LA SALUD FÍSICA Y PSICOLÓGICA DE LOS ADOLESCENTES

Estimado,

Le informamos de que desde el Campus de Murcia de la Universidad Católica de Murcia (UCAM), en colaboración con la Facultad de Deporte, con la financiación de la Fundación Séneca de la Región de Murcia, y con la aprobación del comité de ética institucional de la universidad (Código: CE022102), se va a llevar a cabo un estudio acerca de la influencia de las aplicaciones tecnológicas deportivas en el incremento de la práctica deportiva de los adolescentes en tiempos de la COVID-19.

Con la realización del presente estudio se determinará la influencia del uso de las nuevas tecnologías sobre los niveles de práctica deportiva, hábitos sedentarios, condición física, composición corporal, hábitos alimentarios, desarrollo cognitivo, satisfacción de las necesidades psicológicas básicas, satisfacción con la vida y dolor lumbar de los escolares, así como analizar los efectos de un programa de actividad físico-deportiva que integre las nuevas tecnologías por medio de aplicaciones móviles relacionadas con el ejercicio físico sobre la actividad física, los hábitos sedentarios, la condición física, la composición corporal, la satisfacción de las necesidades psicológicas básicas y la satisfacción con la vida de los escolares, y finalmente, analizará la adherencia que este tipo de programas generan a medio plazo en los adolescentes en función de la edad y el género.

Para llevar a cabo la investigación, se realizará una primera toma de datos en la que se incluirán variables personales por medio de **cuestionarios** (CERI y CERM, Escala de satisfacción con la vida, PAQ-A, Escala PANASN, Escala de satisfacción de las necesidades psicológicas básicas, Trail Making A-B, Nordic Questionnaire y KITMED), medidas de **composición corporal** (que consistirá en la medición de peso, talla, pliegues cutáneos y perímetros, siguiendo el protocolo establecido por la International Society for the Advancement in Kinanthropometry) y finalmente, se llevarán a cabo las **pruebas físicas** (Test Course Navette, test de fuerza de prensión manual, test de salto con contramovimiento, test de extensibilidad isquiosural, curl up, push up y sprint de 20 metros) para determinar la condición física de los sujetos.

Una vez obtenidos los datos de las mediciones, se llevará a cabo la intervención mediante el uso de aplicaciones tecnológicas deportivas que pretenden fomentar la práctica deportiva y los hábitos saludables de los adolescentes para determinar si existen diferencias en el incremento de la actividad física, en función de la aplicación utilizada (aplicaciones móviles disponibles para IOS y Android que favorezcan la práctica de actividad física). Los adolescentes usarán las aplicaciones móviles durante un **periodo de 10-12 semanas** aproximadamente. De forma semanal, deberán aportar **un registro** del tiempo de uso, así como de las variables más relevantes que aporte cada aplicación (por ejemplo: distancia recorrida, tiempo en movimiento, etc).

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Una vez finalizada la intervención se llevará a cabo una segunda toma de datos en la que se incluirán los mismos cuestionarios, variables de composición corporal y de condición física. Tras finalizar esta segunda toma de datos, se realizará una tercera toma de datos a las 10-12 semanas con el objetivo de determinar la adherencia de los adolescentes a las aplicaciones móviles y la continuidad de los efectos conseguidos durante la intervención.

Tras la participación en el estudio, los alumnos obtendrán información sobre las modificaciones producidas en su composición corporal (masa corporal, talla, pliegues y perímetros), derivada de la evaluación cineantropométrica, así como en la condición física por el uso de las aplicaciones móviles. De esta forma, se aportarán aplicaciones tecnológicas deportivas que pueden ser de utilidad para el incremento de la práctica deportiva y el establecimiento de hábitos de vida saludables. Asimismo, el centro educativo obtendrá un informe detallado de las variables medidas durante la intervención.

Con respecto a los datos personales, solo los miembros del equipo de investigación tendrán acceso a los mismos. Estos datos no serán públicos en ningún caso y se utilizarán únicamente para los fines de la investigación.

Cabe destacar que se llevarán a cabo todos los protocolos higiénico-sanitarios estipulados para hacer frente a la COVID-19. Se procederá a desinfectar todo el material utilizado cada vez que un alumno realice su intervención. Se mantendrá la distancia de seguridad en todo momento. Y los integrantes del equipo investigador llevarán mascarilla en todo momento, sin excepción.

Para consultar cualquier duda o pregunta que pueda surgir pueden ponerse en contacto con el equipo de investigación a través del correo electrónico:

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ANEXO 7. CUESTIONARIO SOCIODEMOGRÁFICO

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TOMA DE DATOS CUESTIONARIOS

A continuación, se presentan una serie de cuestionarios anónimos que debe rellenar en su totalidad. Los cuestionarios son totalmente anónimos. Si tiene alguna duda, puede consultar a cualquiera de los investigadores. Se pretende analizar diferentes aspectos de la práctica de actividad física en adolescentes de 12 a 16 años. Marque las respuestas deseadas mediante una X o un círculo según corresponda. Por favor, responda con sinceridad. Gracias.

Los cuestionarios utilizados forman parte de la toma de datos del proyecto titulado: "Las nuevas tecnologías como herramienta para la promoción de la salud en escolares de Educación Secundaria Obligatoria de la CARM: efectos de las aplicaciones tecnológicas deportivas sobre la salud física y psicológica de los adolescentes".

CUESTIONARIO DE VARIABLES SOCIODEMOGRÁFICAS

1. Código de Colegio: ………………. Nombre alumno/a: ……………………………………….
2. Código de Participante: …………………..
3. Fecha (¿qué día es hoy?): …………..………….. Fecha de nacimiento: ………………………….
4. Curso (1º, 2º, 3º o 4º ESO): ……………………
5. Sexo: Masculino ☐ Femenino ☐

ANEXO 8. CUESTIONARIO DE ACTIVIDAD FÍSICA PARA ADOLESCENTES (PAQ-A)

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CUESTIONARIO DE ACTIVIDAD FÍSICA PARA ADOLESCENTES (PAQ-A)

Se pretende conocer tu nivel de actividad física de los últimos 7 días (ultima semana). Esto incluye actividades como deportes, educación física o danza que te hacen sudar o sentirte cansado.

Recuerda: no hay preguntas buenas o malas, esto NO es un examen. Por tanto, contesta de la forma más honesta y sincera posible.

1. Actividad física en tu tiempo libre: ¿Has hecho alguna de estas actividades en los últimos 7 días (última semana)? Si la respuesta es sí, indica cuántas veces la has hecho (marca una sola X por actividad en la casilla correspondiente).

	No	1-2 días	3-4 días	5-6 días	7 o más días
Saltar a la comba					
Patinar					
Jugar a juegos como el pilla-pilla					
Montar en bicicleta					
Caminar (como ejercicio)					
Correr/footing					
Aeróbic/Spinning					
Natación					
Bailar/Danza					
Bádminton					
Rugby					
Montar en monopatín					
Fútbol/Fútbol sala					
Voleibol					
Hockey					
Baloncesto					
Esquiar					
Otros deportes de raqueta					
Balonmano					
Atletismo					
Musculación/Pesas					
Artes marciales (judo, karate, …)					

2. En los últimos 7 días, durante las clases de educación física, ¿cuántas veces estuviste muy activo durante las clases jugando intensamente, corriendo, saltando o haciendo lanzamientos? (Señala solo una).

- No hice/hago educación física………………… ☐
- Casi Nunca…………………………………….. ☐
- Algunas veces………………………………….. ☐
- A menudo……………………………………… ☐
- Siempre………………………………………… ☐

3. En los últimos 7 días, ¿qué hiciste normalmente a la hora de la comida (antes y después de comer)? (Señala solo una).

- Estar sentado (hablar, leer, trabajo de clase)…… ☐
- Estar o pasear por los alrededores……………… ☐
- Correr o jugar un poco………………………….. ☐
- Correr y jugar bastante………………………….. ☐
- Correr y jugar intensamente todo el tiempo…….. ☐

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4. En los últimos 7 días, inmediatamente después de la escuela hasta las 6 de la tarde, ¿cuántos días jugaste algún juego, hiciste deporte o bailes en los que estuvieras muy activo? (Señala solo una).

Ninguno………………………………………… ☐
1 vez en la última semana……………………… ☐
2-3 veces en la última semana………………….. ☐
4 veces en la última semana……………………. ☐
5 veces o más en la última semana……………... ☐

5. En los últimos 7 días, ¿cuántos días a partir de la media tarde (entre las 6 de la tarde y las 10 de la noche) hiciste deportes, baile o jugaste a juegos en los que estuvieras muy activo? (Señala solo una).

Ninguno………………………………………… ☐
1 vez en la última semana……………………… ☐
2-3 veces en la última semana………………….. ☐
4 veces en la última semana……………………. ☐
5 veces o más en la última semana……………... ☐

6. El último fin de semana, ¿cuántas veces hiciste deportes, baile o jugar a juegos en los que estuviste muy activo? (Señala solo una).

Ninguno………………………………………… ☐
1 vez en la última semana……………………… ☐
2-3 veces en la última semana………………….. ☐
4 veces en la última semana……………………. ☐
5 veces o más en la última semana……………... ☐

7. ¿Cuál de las siguientes frases describe mejor tu última semana? Lee las cinco antes de decidir cuál te describe mejor. (Señala solo una).

Todo o la mayoría de mi tiempo libre lo dediqué a actividades de poco esfuerzo físico……………. ☐
Algunas veces (1 o 2 veces) hice actividades físicas en mi tiempo libre …………………………….. ☐
A menudo (3-4 veces a la semana) hice actividad física en mi tiempo libre………............................ ☐
Bastante a menudo (5-6 veces en la última semana) hice actividad física …………………………... ☐
Muy a menudo (7 o más veces en la última semana) hice actividad física ………….......................... ☐

8. Señala con qué frecuencia hiciste actividad física para cada día de la semana (como hacer deporte, jugar, bailar o cualquier otra actividad física) (Marque con una sola X en cada día).

	Ninguna	Poca	Normal	Bastante	Mucha
Lunes					
Martes					
Miércoles					
Jueves					
Viernes					
Sábado					
Domingo					

9. ¿Estuviste enfermo esta última semana o algo impidió que hicieras normalmente actividades físicas?

Sí…………………………………………….. ☐
No…………………………………………….. ☐

ANEXO 9. ESCALA DE SATISFACCIÓN CON LA VIDA

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ESCALA DE SATISFACCIÓN CON LA VIDA

Por favor, indica tu grado de acuerdo con cada frase rodeando con un círculo el número apropiado (solo uno por afirmación). Por favor, sé sincero con tu respuesta.

	Muy en desacuerdo		Neutro		Muy de acuerdo
En la mayoría de los aspectos de mi vida es como yo quiero que sea	1	2	3	4	5
Las circunstancias de mi vida son muy buenas	1	2	3	4	5
Estoy satisfecho con mi vida	1	2	3	4	5
Hasta ahora he conseguido de la vida las cosas que considero importantes	1	2	3	4	5
Si pudiera vivir mi vida otra vez no cambiaría casi nada	1	2	3	4	5

ANEXO 10. ESCALA DE SATISFACCIÓN DE LAS NECESIDADES PSICOLÓGICAS BÁSICAS

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ESCALA DE SATISFACCIÓN DE LAS NECESIDADES PSICOLÓGICAS BÁSICAS

Por favor, indica tu grado de acuerdo con cada frase rodeando con un círculo el número apropiado (solo uno por afirmación). Por favor, sé sincero con tu respuesta.

Cuando practico deporte…	Falso	Bastante Falso	Algo Falso	Algo verdadero	Bastante verdadero	Verdadero
Yo creo que puedo completar los ejercicios que son un reto personal	1	2	3	4	5	6
Siento que puedo hacer ejercicios a mi manera	1	2	3	4	5	6
Me siento atado a mis compañeros de ejercicios porque ellos me aceptan por quién soy	1	2	3	4	5	6
Tengo confianza para hacer los ejercicios más desafiantes	1	2	3	4	5	6
Creo que puedo tomar decisiones respecto a mi programa de ejercicios	1	2	3	4	5	6
Me siento como si tuviese una obligación común con la gente que es importante para mí cuando hacemos ejercicio juntos	1	2	3	4	5	6
Tengo confianza en mi habilidad personal de completar los ejercicios de mayor reto	1	2	3	4	5	6
Creo que yo estoy a cargo de las decisiones en mi programa de ejercicios	1	2	3	4	5	6
Creo que soy capaz de completar los ejercicios que me ofrecen el mayor reto personal	1	2	3	4	5	6
Siento una camaradería con mis compañeros porque hacemos ejercicios por la misma razón	1	2	3	4	5	6
Me siento capaz de completar los ejercicios más desafiantes	1	2	3	4	5	6
Creo que tengo voz en los ejercicios que hago	1	2	3	4	5	6
Me siento cercano a mis compañeros de ejercicios porque ellos saben lo difícil que pueden ser los ejercicios	1	2	3	4	5	6
Estoy contento en la manera en que puedo completar los ejercicios desafiantes	1	2	3	4	5	6
Creo que puedo escoger los ejercicios en que participo	1	2	3	4	5	6
Me siento relacionado con los que me relaciono cuando hacemos ejercicio juntos	1	2	3	4	5	6
Creo que soy el que decide los ejercicios que hago	1	2	3	4	5	6
Creo que me llevo bien con los que me relaciono cuando hacemos ejercicio juntos	1	2	3	4	5	6

ANEXO 11. CUESTIONARIO KIDMED DE ADHERENCIA A LA DIETA MEDITERRÁNEA

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CUESTIONARIO KIDMED (ADHERENCIA A LA DIETA MEDITERRÁNEA)

Por favor, marque con una X aquellas conductas que realiza habitualmente (puede marcar varias opciones). En caso de no realizar la afirmación, deje el espacio en blanco. Sé sincero con tu respuesta. Gracias.

	Es cierto
Toma una fruta o un zumo natural todos los días	
Toma una 2ª pieza de fruta todos los días	
Toma verduras frescas (ensaladas) o cocinadas regularmente una vez al día	
Toma verduras frescas o cocinadas de forma regular más de una vez al día	
Consume pescado con regularidad (por lo menos 2-3 veces a la semana)	
Acude una vez o más a la semana a un centro de comida rápida (fast-food) tipo hamburguesería	
Le gustan las legumbres y las toma más de 1 vez a la semana	
Toma pasta o arroz casi a diario (5 o más días a la semana)	
Desayuna un cereal o derivado (pan, etc.)	
Toma frutos secos con regularidad (al menos 2-3 veces a la semana)	
Se utiliza aceite de oliva en casa	
No desayuna	
Desayuna un lácteo (yogurt, leche, etc.)	
Desayuna bollería industrial, galletas o pastelitos	
Toma 2 yogures y/o 40 gramos de queso cada día	
Toma golosinas y/o caramelos varias veces al día	

ANEXO 12. CUESTIONARIOS CERI Y CERM SOBRE LA USABILIDAD DE INTERNET Y EL MÓVIL

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CUESTIONARIO CERI Y CERM SOBRE LA USABILIDAD DE INTERNET Y EL MÓVIL

A continuación, encontrarás una serie de afirmaciones sobre tu uso de internet y del teléfono móvil. Lea atentamente cada frase e indique la respuesta que más se aproxime a tu realidad. (Marque solo una respuesta en cada pregunta). Conteste con total sinceridad. Gracias.

CERI: Uso de internet	Casi nunca	Algunas veces	Bastantes veces	Casi siempre
¿Con qué frecuencia haces nuevas amistades con personas conectadas a internet?	1	2	3	4
¿Con qué frecuencia abandonas las cosas que estás haciendo para estar más tiempo conectado a la red?	1	2	3	4
¿Piensas que tu rendimiento académico o laboral se ha visto afectado negativamente por el uso de la red?	1	2	3	4
Cuando tienes problemas, ¿conectarte a Internet te ayuda a evadirte de ellos?	1	2	3	4
	Casi nunca	Algunas veces	Bastantes veces	Casi siempre
¿Con qué frecuencia anticipas tu próxima conexión a la red?	1	2	3	4
¿Piensas que la vida sin Internet es aburrida, vacía y triste?	1	2	3	4
¿Te enfadas o te irritas cuando alguien te molesta mientras estas conectado?	1	2	3	4
¿Cuándo no estás conectado a Internet, te sientes agitado o preocupado?	1	2	3	4
¿Cuándo navegas por Internet, te pasa el tiempo sin darte cuenta?	1	2	3	4
¿Te resulta más fácil o cómodo relacionarte con la gente a través de Internet que en persona?	1	2	3	4

CERM: Uso del teléfono móvil	Casi nunca	Algunas veces	Bastantes veces	Casi siempre
¿Has tenido el riesgo de perder una relación importante, un trabajo o una oportunidad académica por el uso del móvil?	1	2	3	4
¿Piensas que tu rendimiento académico o laboral se ha visto afectado negativamente por el uso del móvil?	1	2	3	4
¿Hasta qué punto te sientes inquieto cuando no recibes mensajes o llamadas?	1	2	3	4
¿Sufres alteraciones de sueño debido a aspectos relacionados con el móvil?	1	2	3	4
¿Sientes la necesidad de invertir cada vez más tiempo en el móvil para sentirte satisfecho?	1	2	3	4
¿Piensas que la vida sin el móvil es aburrida, vacía y triste?	1	2	3	4
¿Te enfadas o te irritas cuando alguien te molesta mientras utilizas el móvil?	1	2	3	4
¿Dejas de salir con tus amigos por pasar más tiempo utilizando el móvil?	1	2	3	4
Cuando te aburres, ¿utilizas el móvil como una forma de distracción?	1	2	3	4
¿Con qué frecuencia dices cosas por el móvil que no dirías en persona?	1	2	3	4

ANEXO 13. HOJA DE REGISTRO VALORACIÓN ANTROPOMÉTRICA

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SERÁ SUPERVISADO POR LOS INVESTIGADORES. NO COMPLETAR

BIOIMPEDANCIA

Masa corporal (kg): ………………………..

IMC: ………………….

% grasa total: ………………….

% grasa brazo derecho: ………………….

% grasa brazo izquierdo: ………………….

% grasa tronco: ………………….

% grasa pierna derecha: ………………….

% grasa pierna izquierda: ………………….

% agua corporal: ………………….

Masa muscular (kg): ………………….

Complexión física: ………………….

Masa ósea (kg): ………………….

ANTROPOMETRÍA

Variable	First measure	Second measure	Third measure	Mean/Median
Masa corporal (kg)				
Talla (cm)				
Talla sentado (cm)				
PL Tríceps (mm)				
PL Muslo (mm)				
PL Pierna (mm)				
PR Brazo relajado				
PR Cintura				
PR Caderas				
PR Muslo medio				
PR Pierna				

ANEXO 14. HOJA DE REGISTRO TEST DE CONDICIÓN FÍSICA

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TOMA DE DATOS VARIABLES FÍSICAS

Prueba	Medida 1	Medida 2
20 m shuttle run test (km/h)		
Handgrip derecha (kg)		
Handgrip izquierda (kg)		
Sit and reach (cm)		
CMJ (cm)		
Sprint 20 m (s)		
Curl up		
Push up		

ANEXO 15. MOBILE APPLICATION RATING SCALE: USER VERSION (uMARS)

	Totalmente en desacuerdo	En desacuerdo	Ni de acuerdo, ni desacuerdo	De acuerdo	Totalmente de acuerdo	La aplicación no aporta nada de información
1. Es divertido/entretenido utilizar la aplicación. Tiene componentes que la hacen más divertida que otras aplicaciones similares.	1	2	3	4	5	
2. Es interesante utilizar la aplicación. Presenta la información de forma interesante en comparación con otras aplicaciones similares.	1	2	3	4	5	
3. Permite personalizar los ajustes y preferencias que le gustaría (por ejemplo, el sonido, el contenido o las notificaciones).	1	2	3	4	5	
4. Permite la entrada del usuario, proporciona información, contiene avisos (recordatorios, opciones para compartir los registros realizados, notificaciones).	1	2	3	4	5	
5. El contenido de la aplicación es apropiado (imágenes, lenguaje, diseño).	1	2	3	4	5	
6. Las características y los botones de la aplicación funcionan con velocidad/precisión.	1	2	3	4	5	
7. Utilizar la aplicación es fácil. Las indicaciones dentro de la aplicación son muy útiles.	1	2	3	4	5	
8. Es sencillo acceder de una pantalla a otra dentro de la aplicación, ya que las diferentes pantallas tienen conexión.	1	2	3	4	5	
9. Los toques o gestos a utilizar para pasar de una pantalla a otra tienen sentido.	1	2	3	4	5	
10. La disposición y el tamaño de los botones, iconos, menús y contenidos dentro de la aplicación es adecuado.	1	2	3	4	5	
11. La calidad de los gráficos utilizados para los botones, iconos, menús y el contenido es apropiado.	1	2	3	4	5	
12. La aplicación es muy atractiva visualmente.	1	2	3	4	5	
13. El contenido/la información de la aplicación es correcto, está bien escrito y es relevante.	1	2	3	4	5	6
14. La información aportada por la aplicación es muy completa.	1	2	3	4	5	6
15. La explicación de los conceptos mediante imágenes, gráficos, vídeos, es clara y correcta.	1	2	3	4	5	6
16. La información que aporta la aplicación proviene de una fuente creíble.	1	2	3	4	5	6
17. Recomendaría la aplicación a otra gente que podría beneficiarse de ella.	1	2	3	4	5	
18. Cuántas veces crees que usarás la aplicación en los próximos 12 meses?	Ninguna	1-2	3-10	10-50	>50	
19. Pagaría por utilizar esta aplicación.	1	2	3	4	5	
20. Valore del 1 al 5 la aplicación.	La peor que he usado	2	Ni buena ni mala	4	De las mejores que he usado	
21. La aplicación ha aumentado mi conciencia sobre la importancia de los comportamientos saludables.	1	2	3	4	5	
22. La aplicación ha aumentado mi conocimiento sobre los comportamientos saludables.	1	2	3	4	5	
23. Usar la aplicación ha cambiado mi actitud hacia la mejora de los comportamientos saludables.	1	2	3	4	5	
24. La aplicación ha aumentado mis intenciones/motivación para abordar los comportamientos saludables.	1	2	3	4	5	
25. La aplicación me ha animado a buscar más ayuda para abordar los comportamientos saludables (si es que lo necesito). (ej. Buscar entrenador, nutricionista).	1	2	3	4	5	
26. Usar la aplicación aumentaría mis comportamientos saludables.	1	2	3	4	5	

ANEXO 16. ARTÍCULOS CIENTÍFICOS PUBLICADOS

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EMPIRICAL RESEARCH

Differences in Physical Fitness and Body Composition Between Active and Sedentary Adolescents: A Systematic Review and Meta-Analysis

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Abstract
Previous research analyzing the differences in physical fitness and body composition between active and sedentary adolescents aged 12–16 has not provided conclusive results. For this reason, a systematic review with meta-analysis was conducted to provide an overview of the results obtained to date. The objectives of this systematic review and meta-analysis were to investigate the differences in the physical fitness and body composition of adolescents who engaged in daily physical activity and those who were inactive. A search in PubMed, EBSCO, and Web of Sciences databases was performed. A total of 13,884 articles were reviewed and 11 were included in the meta-analysis. In the physical fitness performance, significantly higher values in cardiorespiratory fitness, hamstring and lower back flexibility, sit-ups and upper limb resistance were found in active compared to the inactive participants. In body composition, the inactive group showed significantly higher values in variables related to body fat, mainly in body fat percentage, fat mass and fat mass index compared to the active group. The results revealed that maintaining an active lifestyle through physical activity is a determining factor in improving the physical fitness and body composition of adolescents aged 12–16 years. The study design of the systematic review was previously registered in PROSPERO with code CRD42021241975. https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=241975.

Keywords Adolescents · Anthropometry · Body composition · Physical activity · Physical condition · Physical fitness

Introduction

The benefits of physical activity for different population groups have been reported in numerous studies that point out its importance for improving physical fitness and maintaining fat mass at optimal levels (Amatriain-Fernández et al. 2020). However, the research conducted so far in adolescents aged 12–16 years does not provide conclusive results when comparing the physical fitness and body composition of active and sedentary adolescents, since the differences between the two groups are small and studies use different methodologies that make comparison difficult. Due to this lack of information and the limitations found in the scientific literature, it is difficult to draw conclusions on the importance of daily physical activity for the prevention of overweight, obesity and associated pathologies in this population. To address these shortcomings, the present investigation consists of a systematic review with a meta-analysis of the scientific literature existing to date, comparing the physical capacities (upper body strength, lower body strength, cardiorespiratory capacity) and body composition (fat mass, fat-free mass, weight) of active and sedentary adolescents aged 12–16 years, with the aim at investigating the existing differences in these parameters.

Lifestyle and Health Risks

Sedentary lifestyles are positively associated with the risk of chronic diseases during adolescence and later stages, so that adolescents who do not engage in physical activity have a greater risk of developing cardiovascular diseases (Zheng et al. 2020), metabolic syndrome (Renninger et al. 2020), and

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REVIEW ARTICLE

WILEY

Mobile application interventions to increase physical activity and their effect on kinanthropometrics, body composition and fitness variables in adolescent aged 12–16 years old: An umbrella review

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Abstract

Background: The aims of the present umbrella review were (a) to summarize the available evidence on the effectiveness of mobile applications aimed at increasing physical activity; (b) to analyse the effect of an increase in physical activity on kinanthropometric variables, body composition and physical fitness of adolescents aged 12–16 years old; and (c) to determine the strengths and limitations of the interventions carried out with adolescents aged 12–16 years old through the use of mobile applications, to provide recommendations for future research.

Methods: The most relevant inclusion criteria were (a) adolescents aged 12–16 years old; (b) interventions carried out only with mobile apps; (c) pre-post measurements; (d) participants without illnesses or injuries; and (e) interventions lasting more than 8 weeks. The databases used to identify the systematic reviews were the Web of Science, Google Scholar, PubMed and Scopus. Two reviewers independently used the AMSTAR-2 scale to measure the methodological quality of the included reviews and also carried out an analysis of external validity, with a third reviewer participating in the cases in which consensus was not reached.

Results: A total of 12 systematic reviews were included (these included a total of 273 articles that used electronic devices, of which 22 studies exclusively used mobile applications with adolescents aged 12–16). Regarding physical activity and its effect on body composition, kinanthropometric variables and physical fitness, no significant differences were found for any of the variables analysed, and the results were not sufficiently consistent to determine the influence of these interventions.

Conclusions: It is important to highlight that the scientific research conducted so far showed that mobile applications were not effective in increasing physical activity and changing the kinanthropometric variables, body composition or physical fitness of adolescents. Thus, future research with stronger methodological rigour and larger samples is needed to provide stronger evidence.

KEYWORDS
adolescents, body composition, new technologies, physical activity, youth

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Article

Physical, Psychological, and Body Composition Differences between Active and Sedentary Adolescents According to the "Fat but Fit" Paradigm

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Abstract: The practice of physical activity during adolescence is essential for the proper development of the population. In recent decades, the relevance of physical activity has been increasing, due to the development of the "fat but fit" paradigm. This paradigm shows that adolescents with a high level of physical fitness are healthier than adolescents with poorer physical fitness, regardless of their weight, giving importance to sports practice over other aspects. However, few previous studies have analyzed the differences in physical and body composition between active and sedentary adolescents in this paradigm. For this reason, the objectives of the present study were to establish the differences in body composition, physical performance, and adherence to the Mediterranean diet between active and sedentary adolescents; and to analyze the differences between active and sedentary adolescents according to the "fat but fit" paradigm. The sample consisted of 791 adolescent whose body composition, level of physical activity, adherence to the Mediterranean diet, and physical fitness were measured. It was found significant between active and sedentary adolescents in most of the anthropometric, AMD, and physical fitness variables, with a significant effect of the covariates gender, age, BMI, and biological maturation on the model. The binary logistic regression analysis performed shows that anthropometric variables, AMD, and VO2 max can be considered as primary outcomes to distinguish between active and sedentary groups of adolescents. Furthermore, the results showed that the active adolescents, regardless of their weight status, had lower fat mass and greater muscle mass, as well as a higher performance in the physical fitness tests, and greater adherence to the Mediterranean diet than the sedentary adolescents. To conclude, the practice of physical activity is a determinant for the improvement of body composition, physical performance, and adherence to the Mediterranean diet of the adolescent population, regardless of their gender, age, weight, or maturity status.

Keywords: adolescent health; anthropometric measurement; nutritional habits; physical activity; weight status

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1. Introduction

The practice of physical activity during adolescence is fundamental for the prevention and treatment of different chronic diseases [1], among which obesity [2], hypertension [3], diabetes [4], or metabolic syndrome [5] stand out. Despite its relevance, the level of physical practice is annually reduced by 3.4% in boys and 5.3% in girls from the age of nine [6]. The decrease in the level of daily physical activity and the adoption of sedentary behaviors are related to lower adherence to the Mediterranean diet (AMD) [7], lower performance on physical fitness tests [8], and higher percentage of fat mass [9]. This forms a serious problem for the health of the adolescent population because in recent years there has been a decline in physical capacities, mainly affecting strength [10] and cardiorespiratory capacity [11,12], as well as an increased number of diseases related to poor nutrition [13] and accumulation of fat mass [14].

nutrients MDPI

Article

Differences in Kinanthropometric Variables and Physical Fitness of Adolescents with Different Adherence to the Mediterranean Diet and Weight Status: "Fat but Healthy Diet" Paradigm

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Abstract: The present investigation provides a new paradigm, the fat but healthy diet, through which to analyze the importance of adherence to the Mediterranean diet (AMD) in the adolescent population. To this end, the objectives were to analyze the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in males and females with different AMD and to determine the existing differences in physical fitness, level of physical activity, and kinanthropometric variables in adolescents with different body mass index and AMD. The sample consisted of 791 adolescent males and females whose AMD, level of physical activity, kinanthropometric variables, and physical condition were measured. The results showed that when analyzing the whole sample, the differences were only significant in the level of physical activity among adolescents with different AMD. However, when considering the gender of the adolescents, the males also showed differences in the kinanthropometric variables, while the females did so in the fitness variables. In addition, when considering gender and body mass index, the results showed that overweight males with better AMD showed less physical activity and higher body mass, sum of three skinfolds, and waist circumference, and females did not show differences in any variable. Therefore, the benefits of AMD in anthropometric variables and physical fitness of adolescents are questioned, and the fat but healthy diet paradigm cannot be confirmed in the present research.

Keywords: body weight; dietary pattern; gender differences; physical activity; physical condition; youth

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1. Introduction

In the adolescent population, nutritional habits are one of the most important factors for the establishment of healthy lifestyles [1,2]. Thus, a correct diet facilitates the prevention of chronic diseases such as obesity [3], contributes to better glycemic control [4], and has a fundamental anti-inflammatory and antioxidant effect in this population [5].

In recent decades, the adherence to the Mediterranean diet (AMD) of adolescents has been used in Europe as a criterion for assessing their diet because it is one of the healthiest dietary patterns known to date [6,7]. Previous research conducted in adolescents has tried to establish differences in AMD according to gender [8,9] and to analyze the relationship between AMD and other determinant variables for health such as body composition [10,11], level of physical activity [11,12], or physical fitness [13].

Regarding some components of physical fitness and physical activity levels of adolescents according to AMD, the results found were very disparate. Some of the results found in previous research were: (1) higher values in handgrip strength and vertical jump in males with a higher AMD but not in females [13]; (2) a higher performance in cardiorespiratory endurance tests in males and females with moderate-high AMD [10,13]; (3) a higher level of physical activity in adolescents with a higher AMD [12]; or (4) absence of significant differences in the level of physical activity and physical fitness among adolescents with different AMD [11].

behavioral sciences

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Article

The Role of Basic Psychological Needs in the Adoption of Healthy Habits by Adolescents

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Abstract: Previous research in this field has not examined the significance of each of the basic psychological needs (BPNs) on changes in the physical activity level, adherence to the Mediterranean diet (AMD), kinanthropometric and derived variables, and the physical fitness of adolescents. Therefore, the purpose of this study was (a) to examine the variances in physical activity, AMD, and kinanthropometric and derived variables, as well as fitness levels, among adolescents with varying degrees of satisfaction regarding each of the BPNs and (b) to assess the differences in the study variables among adolescents based on whether the BPNs are satisfied individually or jointly. The sample consisted of 791 adolescents (404 males and 387 females; average age: 14.39 ± 1.26 years old). The findings indicated that adolescents in the highest percentiles (75–100) of competence, autonomy, or relatedness showed higher scores in physical activity and AMD and better kinanthropometric and physical fitness variables than adolescents in the lowest percentiles (0–25). Adolescents who showed joint satisfaction of all BPNs showed the best results on all variables analyzed. In addition, it should be noted that competence played the most relevant role.

Keywords: autonomy; adherence to Mediterranean diet; competence; physical activity level; relatedness

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1. Introduction

Self-determination theory (SDT) defines autonomy, competence, and relatedness as the three basic psychological needs (BPNs) [1]. Satisfaction of BPNs in adolescents is necessary to achieve well-being and decrease vulnerability to the development of any psychopathology [2]. Adolescents who have all BPNs satisfied together seem to show adequate health status, although individual satisfaction of each BPN has also been shown to influence psychological and behavioral development. [3]. Thus, the results found in previous research showed that the joint satisfaction of the BPNs was related to autonomous motivation, favoring enjoyment and less pressure, with relatedness being the most determinant BPN in this relationship. Competence predicted controlled motivation positively, while autonomy and relatedness predicted it negatively; in addition, competence was negatively related to the feeling of pressure [3].

In addition, it should be noted that in previous cross-sectional research, the authors showed the relationship between LBW and certain healthy lifestyle habits, such as the practice of physical activity [4] or adherence to an optimal nutritional pattern [5]. Thus, with respect to the practice of physical activity, adolescents who had more barriers to physical activity practice showed higher BPN frustration [4]. Similarly, the BPNs were significantly related to adherence to an optimal nutritional pattern, specifically adherence to the Mediterranean diet (AMD), with the AMD score being higher in adolescents who had greater satisfaction of the BPNs, although it is unknown whether the differences were

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Article

The Degree of Problematic Technology Use Negatively Affects Physical Activity Level, Adherence to Mediterranean Diet and Psychological State of Adolescents

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Abstract: The previous scientific literature has shown how detrimental addictive internet and mobile phone use can be for the adolescent population. However, little is known about their influence on the physical activity, kinanthropometry and body composition, nutrition patterns, psychological state, and physical fitness of this population. For this reason, the objectives of this research were (a) to determine the differences in the physical activity level, kinanthropometric and body composition variables, adherence to Mediterranean diet (AMD), psychological state, and physical fitness according to gender and different levels of problematic use of the internet and mobile phones; and (b) to establish the differences in the physical activity level, kinanthropometric and body composition variables, AMD, psychological state, and physical fitness among adolescents when considering problematic use of the internet and mobile phones in combination. The sample consisted of 791 adolescent males and females between 12 and 16 years of age (1st to 4th course) from four compulsory secondary schools (404 males and 387 females; mean age: 14.39 ± 1.26 years-old; mean height: 163.47 ± 8.94 cm; mean body mass: 57.32 ± 13.35 kg; mean BMI: 21.36 ± 3.96 kg/m^2). The physical activity level (baseline score: 2.64 ± 0.67), kinanthropometric variables and body composition, AMD (baseline score: 6.48 ± 2.48), psychological state (baseline life satisfaction: 17.73 ± 4.83; competence: 26.48 ± 7.54; autonomy: 25.37 ± 6.73; relatedness: 24.45 ± 6.54), and physical condition variables were measured. The results showed that adolescent males and females with problematic internet and/or mobile phone use presented a worse psychological state, but it is especially relevant to highlight that females also had a lower level of physical activity and AMD, with problematic mobile phone use being especially relevant, mainly in the psychological state of adolescents. In conclusion, problematic use of the internet and mobile phones can have detrimental effects on the level of physical activity, AMD, and psychological state of adolescents, with the differences found in females being particularly relevant.

Keywords: basic psychological needs; life satisfaction; new technologies; physical activity; physical fitness; youth

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Citation: Mateo-Orcajada, A.; Vaquero-Cristóbal, R.; Albaladejo-Saura, M.D.; Abenza-Cano, L. The Degree of Problematic Technology Use Negatively Affects Physical Activity Level, Adherence to Mediterranean Diet and Psychological State of Adolescents. *Healthcare* **2023**, *11*, 1706. https://doi.org/10.3390/healthcare11121706

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1. Introduction

The COVID-19 pandemic exacerbated the excessive use of mobile phones in the adolescent population [1]. Scientific research conducted during and after the pandemic found that a percentage of nearly 90% of adolescents used mobile phones on a regular basis. Along with the increase in the use of these devices, problematic use of the internet and mobile phones also increased, understood as a pattern of interaction with the mobile phone and the internet that is characterized by repetitive use of the mobile phone and internet to engage in negative health behaviors [2,3]. This includes the inability to regulate mobile phone and internet use, leading to associated negative consequences in daily life, including technological dependence, as well as social, behavioral, and affective problems [2,3]. This

children

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Article

The Importance of Healthy Habits to Compensate for Differences between Adolescent Males and Females in Anthropometric, Psychological and Physical Fitness Variables

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Abstract: Adolescence is a crucial stage in human development, and differences in psychological, physical and body composition variables between males and females have been amply demonstrated. However, the role played by certain healthy habits, such as the practice of physical activity, adherence to the Mediterranean diet (AMD) or the maintenance of an adequate weight status, in compensating for the differences found between males and females in these variables, is not well known. For this reason, the study aimed to analyze whether the practice of physical activity, optimal AMD, and adequate weight status can compensate for the differences between adolescent males and females in anthropometric variables, psychological state, and physical fitness. The sample was composed of 791 adolescents (404 males and 387 females) aged twelve to sixteen years old, whose anthropometric, psychological (autonomy, competence, relatedness, and life satisfaction), and physical fitness variables (cardiorespiratory fitness, upper strength and explosive lower limb power, hamstring and lower back flexibility, and speed) were measured. All measurements were carried out in a single day using the sports pavilion of the four participating schools. The most novel results of this research show that the practice of physical activity was determinant mainly in females, as it reduced the differences found in comparison with males in psychological ($p < 0.001$–0.045) and anthropometric variables ($p < 0.001$). Regarding weight status and AMD, these were still relevant for the adolescent population, mainly the achievement of optimal AMD, but males continued to present higher values in physical fitness tests ($p < 0.001$) and lower values in fat accumulation ($p < 0.001$), regardless of weight status or AMD. Thus, physical activity seems to be the most determining factor that compensates for the differences between adolescent boys and girls.

Keywords: adolescents; basic psychological needs; body composition; life satisfaction; Mediterranean diet; physical activity; physical fitness; gender differences

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Citation: Mateo-Orcajada, A.; Abenza-Cano, L.; Cano-Martínez, A.; Vaquero-Cristóbal, R. The Importance of Healthy Habits to Compensate for Differences between Adolescent Males and Females in Anthropometric, Psychological and Physical Fitness Variables. *Children* **2022**, *9*, 1926. https://doi.org/10.3390/children9121926

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1. Introduction

Adolescence is a fundamental stage in the development of individuals and is characterized by physical, hormonal, and cognitive changes before reaching adulthood [1,2]. However, the timing of the onset of physical, hormonal, and cognitive changes differs between males and females, with females developing the earliest [3,4]. Moreover, the changes between males and females at this stage do not only differ in the time at which they occur, as hormonal differences during puberty are notable depending on the sex [2,5], giving rise to a phenomenon known as sexual dimorphism [6]. These differences in the maturation process between males and females during adolescence lead to changes in their behaviors related to physical activity [7], nutritional habits [8], and weight status [9], as well as in personal variables such as the anthropometry and derived variables [10], psychological state [11], or physical fitness [12].

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Mandatory after-school use of step tracker apps improves physical activity, body composition and fitness of adolescents

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Abstract
Previous scientific research on the use of mobile applications to increase physical activity level and improve health among adolescents does not provide conclusive results, one of the main reasons being the lack of adherence to the intervention after the first weeks. For this reason, the main objectives of the research were to determine the changes produced by a compulsory ten-week period of after-school intervention with mobile step-tracking applications on adolescents' health; and the final objective to compare the benefits obtained by each of the mobile applications. To meet the objectives, a longitudinal study with non-probability convenience sampling was proposed. The sample consisted of 400 adolescents from two public compulsory secondary schools in the Region of Murcia, Spain, whose body composition, level of physical activity, adherence to the Mediterranean diet, and physical fitness were measured. The SPSS statistical software was used for statistical analysis. The results showed that adolescents in the experimental group showed a higher level of physical activity and better body composition and physical fitness variables after the intervention compared to the control group, with differences between the different applications used. In conclusion, this research shows the usefulness of mobile applications if they are used in a compulsory way after school hours. The relevance of these results for policymakers lies in the fact that they provide statistical data on the usefulness of mobile applications as an educational resource, being an option to make up for the lack of sufficient physical education teaching hours to meet global physical activity recommendations.

Keywords Adolescent development · Behavior change · Health · Mobile application · High school students

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Human Kinetics
ORIGINAL RESEARCH

Influence of Pokémon Go Playing Style on Physical Activity and Its Effect on Kinanthropometry Variables and Body Composition in Adolescents

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Background: Pokémon Go is a mobile app that offers both continuous and intermittent (gamified) gameplay, but no previous research in adolescents is known to have addressed changes in physical activity and body composition according to playing style. For this reason, the aims of the present investigation were (1) to establish the differences in the level of physical activity, and its influence on the kinanthropometric and body composition, of the adolescent population, considering their Pokémon Go playing style; and (2) to analyze whether the practice of previous physical activity has an influence on the effects of the use of Pokémon Go on the level of physical activity and changes in kinanthropometric and body composition variables. ***Methods:*** A total of 94 adolescents (50 males and 44 females; mean age: 13.66 [1.17] years-old; mean body mass index: 20.82 [4.03] kg/m^2) whose physical activity level and body composition were measured, participated in the investigation. Two groups of adolescents completed a 10-week intervention using Pokémon Go continuously (n = 30) or intermittently (n = 31), while the control group (n = 33) did not use any after-school app. A one-way analysis of variance (ANOVA), a multivariate analysis of variance, and 2 repeated-measures ANOVA were performed to analyze the data. ***Results:*** Inactive adolescents in the continuous use group increased their physical activity between the pretest and posttest ($P = .038$), but this did not occur in the active group. Regarding body composition variables, the increase in body mass ($P < .001$) and body mass index ($P = .006$) in the control group was significantly higher than in the continuous use group of adolescents who were inactive, but not in the active group, while the decrease in fat mass ($P < .001$–$.036$) and sum of 3 skinfolds ($P < .001$–$.003$) was significantly higher in both Pokémon Go use groups as compared to the control group, regardless of the previous physical activity level. ***Conclusions:*** The continuous style of play seems to be more effective in increasing physical activity in adolescents, but the changes in body composition and kinanthropometric variables occur similarly with continuous and intermittent gameplay. Therefore, the playful use of Pokémon Go can be used in educational and health fields to produce changes in body composition in this population.

Keywords: continuous, intermittent, videogames, youth, fat mass

The decrease in physical activity in the adolescent population in recent years[1] has had a negative impact on their body composition, as observed by the increase in the variables related to fat mass.[2] In light of this situation, different types of interventions have been proposed in order to increase the practice of physical activity, and positively influence the body composition of adolescents, trying to reduce fat mass and increase muscle mass.[3,4] Among the most innovative interventions in this population, those using electronic devices[5,6] are particularly relevant, as these devices are fully integrated into the lives of adolescents,[7] with high usage times from early stages of life.[8] These interventions are characterized by the wide range of devices that can be used, including mobile applications,[9] wearables,[9] or internet websites,[10] which have shown beneficial effects on the practice of physical activity and changes in body composition of adolescents.[11–13] In this sense, interventions with electronic devices have been shown to be useful, albeit modestly, in increasing physical activity and decreasing fat mass and body mass index (BMI).

More specifically, in recent years, mobile applications have gained special relevance due to the continuous development of smartphones for monitoring human movement,[14] as well as the integration of these devices in the daily life of adolescents,[15] which allows for greater adherence to interventions.[16] Moreover, their effectiveness in increasing physical activity and producing changes in the body composition of adolescents has made them highly useful devices for the fields of education and health.[11–13]

Among the most relevant mobile applications for the adolescent population, Pokémon Go is underlined, as it is a virtual reality game in which players must move in the real world to capture Pokémons.[17] This application was a pioneer in the field of augmented reality and is characterized by offering 4 areas of user experience: educational, entertainment, esthetic, and evasion, and generating an environment in which users interact face-to-face in real life.[18] On the other hand, Pokémon Go shows hedonic, emotional, and social benefits that facilitate users' permanence in the game.[19] These aspects have allowed its use in areas such as education,[20] tourism,[21] or physical activity and health,[12,22] thereby showing that this mobile application has a great potential to provide benefits. In this regard, previous research has shown that the use of Pokémon Go increased the physical activity of the players, by increasing the daily number of steps and the time spent in moderate intensity physical activity,[12,22] ultimately resulting in a reduction of the fat mass in adolescents.[23,24]

However, it is worth noting that Pokémon Go provides 2 gameplay options, continuous or intermittent, which have shown differences in their effectiveness in increasing the level of physical activity, with the continuous form being the most effective in this regard.[25] This could be because in the continuous form of play, players do not allocate time on the gamified part of the application (catching Pokémons or facing other players), while in

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Esa hoja en blanco es la **contraportada**, por lo que no lleva encabezado (hay un cambio de sección).