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Importance of training volume through the use of step trackers apps promoted from the subject of physical education to change body composition, physical fitness and physical activity in adolescents and the influence of gender☆,☆☆

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ABSTRACT

The aim of the present study was to determine the changes in physical activity level (PA), kinanthropometric and derived variables, and physical fitness in adolescents, as a result of an out-of-school intervention with mobile step tracker apps promoted from the field of physical education, according to the volume of training completed and gender. A randomized controlled trial was carried out with 400 adolescents (210 males and 190 females) aged 12 to 16 years old (mean age: 13.96 ± 1.21 years-old). Adolescents were divided into experimental group (EG) (n = 240) and control group (CG) (n = 160). Two measurements were carried out, separated by a 10-week intervention, and PA, kinanthropometric variables and physical condition were measured. During the intervention, EG must use Strava (n = 74); Pokémon Go (n = 59); Pacer (n = 60); and MapMyWalk (n = 47) a minimum of 3 times per week, covering an incremental distance from 7,000 steps per day (week 1) to 12,500 steps per day (week 10). After that, EG were divided in quartile according to the volume of training completed. The results obtained showed a significant increase between pre-and post in PA (p = 0.009–0.044) and curl-up (p < 0.001–0.040) in EG regardless the quartile of compliance, and a reduction in fat variables (p < 0.001) and an increase in CMJ in 75–100 % compliance group (p = 0.005). The introduction of the covariate gender did not introduce changes in the intra-group evolution. On inter-group differences, differences were only found for the post-test values between 0–25 % Vs 25–50 % and between 50–75 % Vs 75–100 % with the group that completed a longer distance being the one that showed the lowest values in the post-test in both cases. When including the covariate gender, no significant differences were found for either the pre-test or the post-test on either variable. To conclude, a higher training volume with mobile apps seems to be relevant in the increase PA and strength and decrease of fat mass. The gender factor is not influential in the intra-group changes, but it is influential in the inter-group differences.

1. Introduction

Adolescence is one of the most decisive stages during an individual's development towards adulthood [1], with the acquisition of healthy habits being one of the main objectives pursued during this stage [2]. This is because the habits acquired during adolescence have a high probability of being maintained during adulthood [1], and they are especially relevant for reducing the probability of contracting chronic diseases such as hypertension, diabetes, or different types of cancer [3].

Among the most important healthy habits during adolescence, the practice of physical activity has gained special relevance, as it promotes the acquisition of other healthy habits such as a good diet [4], and is also related to numerous changes in body composition and fitness variables of the adolescent population [5]. Recent research in adolescents aged twelve to sixteen years old has shown that physical inactivity leads to an increase in body fat percentage, fat mass, and fat mass index, as well as poorer cardiorespiratory performance, hamstring and lower back flexibility, sit-ups, and upper limb resistance [6], with all of these factors

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associated to a poorer health status [7].

For these reasons, the benefits of physical activity on body composition and fitness in adolescents have been extensively studied [5]. For it to be truly effective and generate substantial changes, a certain volume of practice must be reached, with a minimum of three days a week at moderate and/or high intensity, established for aerobic interventions [8]. Previous research has shown that the practice of aerobic sports can result in improvements in body composition and fitness in adolescents, such as a reduction in body fat mass and body fat percentage, or an increase in maximum oxygen consumption (VO2max) [8,9], making this an important factor in the prevention of obesity and chronic diseases during adolescence. Although the recommendations for physical activity for adolescents indicate that it is necessary to practice three days a week [10], schools in Spain only provide two hours of physical education per week (one hour per day, two days a week), in which adolescents do not reach the minimum recommended level of physical activity [11], and most adolescents are also inactive in their free time [12]. Thus, solutions are needed from the educational and socio-health fields to reverse the situation.

Compliance with the minimum volume of physical activity was greatly impaired after the COVID-19 pandemic [13], with a large increase in the drop-out rate of physical activity. About 80 % of the adolescent population was considered inactive, as they performed less than sixty minutes of physical activity daily, and more than 35 % were sedentary [14], because they sat for three or more hours per day outside of school, with the negative effects on fitness and body composition that this entailed in this population [15]. One of the main triggers for this situation was the drastic change in the lifestyle and leisure time habits of the adolescent population during the pandemic, with a decrease in the time spent being active [16] and an increase in the time spent sitting or lying down [17]. More specifically, it was found that adolescents were less likely to comply with physical activity recommendations during the COVID-19 pandemic compared to beginning of the COVID-19 pandemic, giving up their sports and any type of recreational sports activity [18]. A decrease in walking time and average daily steps was also observed, as well as an increase in time spent sitting [17]. This could be due to a change in the paradigm of leisure time occupation among adolescents, where the time previously devoted to physical activity is now spent in inactive and sedentary leisure activities such as watching television, using new technologies, or playing video games [19,20]. This situation also led to changes in other healthy lifestyle habits, such as the intake of fast food and soft drinks, with adolescents who dedicated more than eight hours to sedentary behaviours being the most affected [21].

Clearly the pandemic has negatively affected the practice of physical activity as a leisure activity in the adolescent population and, as with previous global natural disasters [22], the negative consequences in physical activity have been sustained in the months and years that have followed [23,24]. Physical activity has remained at lower levels than pre-pandemic in adolescents while screen time and sedentary time has increased [23,24]. Beyond the short-term effects of the pandemic, it highlights the entry in a vicious cycle in which decreased physical activity and increased sedentary behaviours in leisure time may become even worse because adolescents feeling less and less competent and being in poorer physical condition, which are determining factors for the practice of physical activity [25,26]. So it is very likely that adolescents will become increasingly inactive and sedentary, preferring to occupy their leisure time with activities that do not involve physical activity, which will lead them to have an unhealthy lifestyle, highly correlated with chronic disease [27,28].

Although the world is recovering from the COVID-19 pandemic, the pandemic of physical inactivity and sedentary behaviours is emerging stronger every day [22], and measures are needed to combat the situation. In this regard, the increased use of technologies and, in particular, the mobile phone can play a very relevant role [29]. This is due to the fact that, since the COVID-19 pandemic [26], recent research has shown that mobile devices can offer a useful alternative for increasing aerobic physical activity in the adolescent population [30,31]. These studies have shown that the use of these devices can generate improvements in the level of physical activity, body composition, and fitness of adolescents, but one of the main drawbacks is that they have not been able to generate sufficient adherence to obtain conclusive and sustained results over time [31]. Furthermore, these studies have not considered the effect of the volume of training completed during the mobile app interventions, on changes in body composition and fitness, despite its importance in the effectiveness of other aerobic exercise intervention programs [8], which may be another reason why the results are inconclusive.

In addition, it would be particularly interesting to know if there are gender differences in the changes obtained with the use of mobile applications according to training volume for two main reasons. Firstly, because the physical activity of adolescent females has been shown to be lower than that of males, both in terms of frequency and duration of practice [32,33]. However, when physical activity is promoted from the educational field, no differences are found in the follow up of the intervention by males and females, which leads to similar benefits in both genders [34]. Secondly, because although the use of mobile devices among adolescent males and females is different in terms of the reasons for their use, since it has been found that males use them more for gaming and gambling, and females for social networks and online communication [35,36], none of the studies that have promoted mobile applications to promote physical activity in leisure time has analysed the differences between genders, so the response according to gender is unknown [37].

Given the drastic reduction in physical activity in the adolescent population in recent years [13,14], the scarce and inconclusive previous literature on the use of mobile applications to promote physical activity in the adolescent population [38], the reduced number of hours of physical education classes at school per week, as well as the absence of research that has considered the volume of training, and the differences between male and female adolescents in programs developed using mobile applications to promote changes in body composition and physical fitness in this population, the objectives of the present research were a) to determine the changes in physical activity level, kinanthropometric and derived variables, and physical fitness variables of adolescents, produced by an out-of-school intervention with mobile step tracker apps, promoted from the field of physical education, according to the volume of training completed; and b) to assess whether differences in the study variables are affected by the gender of the adolescents.

Based on previous scientific literature, the research hypotheses posed are that a) adolescents who achieved a higher volume of training using the mobile applications will show superior improvements in physical activity level, kinanthropometric and derived variables, as well as in physical fitness, as compared to the control group (CG) and experimental group (EG) who achieved lower volumes (H1); and b) previous scientific literature does not allow us to establish a clear hypothesis as to whether males or females will obtain more benefits depending on the volume of training completed with the apps, but it could be that the benefits would be similar at the same level of training completed (H2).

2. Material and methods

2.1. Design

The present study is a randomised controlled trial, composed of two groups (EG and CG), where two measurements (pre-test and post-test) separated by 10 weeks were performed. During this period, EG participants used a step tracker app (Strava, Pokémon Go, Pacer or MapMyWalk) a minimum of 3 times per week, covering an incremental distance from 7000 steps per day (week 1) to 12,500 steps per day (week 10). After that, EG were divided according to the volume of training completed in quartiles. Meanwhile, CG participants continued with their usual physical activity routine. For both groups, the outcomes variables analysed were physical activity level, kinanthropometric variables and physical condition.

The design of the present study was carried out in accordance with the World Medical Association and the Helsinki Declaration guidelines. The institutional ethics committee of the Universidad Católica de Murcia approved the research design (code: CE022102). A longitudinal study was conducted following the Consolidated Standards of Reporting Trials (CONSORT) guidelines [39]. Prior to the start of the study, the research protocol was registered in ClinicalTrials.gov (code: NCT04860128).

The sampling was non-probabilistic by convenience, selecting two centres of compulsory secondary education in different geographical areas of the Region of Murcia (Spain). An initial meeting was held with the interested adolescents and their parents, where the objectives and procedures of the research were explained. The adolescents who were interested in participating completed the informed consent form with their signature and that of their parents.

2.2. Participants

The sample size was calculated using Rstudio v.3.15.0 statistical software (Rstudio Inc., USA), based on the standard deviation (SD) of previous studies that used mobile apps to increase physical activity in adolescents aged twelve to sixteen years old in out-of-school hours (SD=0.60) [30]. For an estimated error (d) of 0.06 and a 95 % confidence interval, the minimum sample needed for conducting the research was 385 adolescents. The minimum sample size of each intervention group was calculated based on the SD of previous research (SD = 0.70) [40], with it being 30 ($d = 0.25$).

A total of 873 adolescents formed part of the selected educational centers, of whom 400 finally participated in the study (210 males and 190 females) aged between twelve and sixteen years old (mean age: 13.96 ± 1.21 years-old). According to the Physical Activity Questionnaire for Adolescents (PAQ-A) [41], the average score obtained in the pretest for the level of physical activity was 2.67 ± 0.68, indicating that the adolescents did not achieve a daily physical activity level equivalent to a minimum of 60 min of moderate-vigorous physical activity per day [42].

The inclusion criteria were a) enrolment in compulsory secondary education; b) not presenting any incapacitating illness or surgical operations that prevented participation; c) participating in pre- and post-tests, and completing all questionnaires, measurements, and physical fitness tests; and d) aged between twelve and sixteen years old. The exclusion criteria were a) not having a cell phone; b) missing more than 80 % of the physical education sessions scheduled during the course; c) starting any type of physical activity that was not performed before the start of the study, understand this as starting to practice a specific sport or going to the gym, not increasing of walking or running, since this is the aim of the research; d) abandoning any type of physical activity that was being carried out prior to the start of the study; e) transferring schools during the intervention period.

2.3. Randomization and blinding

The principal investigator carried out the randomization process using a computer-generated random number table in the presence of other uninvolved investigators. All students in the same class in each school centre were randomly assigned to participate as intervention or control classes. For intervention classes, a second randomization procedure was used to assign them to the application to be used (Strava; Pokémon Go; Pacer; and MapMyWalk).

Baseline measures were conducted after randomization. All researchers involved in the measurement process were blinded to the group to which each participant belonged, as well as to the individual's ratings in the previous measurement for the post-test evaluation. For their part, the researchers in charge of monitoring the intervention for each pupil were blinded by the results of the evaluations obtained for these students.

2.4. Instruments

To measure the level of physical activity, kinanthropometric and derived variables, and physical fitness of the adolescents, the protocol from previous research was followed [5,30].

2.4.1. Physical activity level

The physical activity level was measured using the Spanish version of the PAQ-A [41]. It has an intraclass correlation coefficient of 0.71 for the final score of the questionnaire, and an internal consistency of 0.74. This questionnaire is a 7-day recall and self-administered instrument composed of nine items, the first eight of which are completed with a Likert scale of 1 to 5 points, and the last one is answered dichotomously (yes or no). The arithmetic mean of the scores from the first eight items provides a final physical activity score [42]. A higher score in this indicates a greater practice of physical activity.

2.4.2. Kinanthropometric and derived variables measurement

Kinanthropometric variables were measured following the protocol established by the International Society for the Advancement of Kinanthropometry (ISAK) [43]. Three anthropometrists (levels 2 to 4) were in charge of measuring three basic measurements (body mass, height, and sitting height), 3 skinfolds (triceps, thigh, and calf), and five girths (relaxed arm, waist, hips, thigh, and calf).

The equipment needed for the measurements was a TANITA BC 418-MA Segmental scale (TANITA, Tokyo, Japan); a SECA stadiometer 213 (SECA, Hamburg, Germany); a Harpenden skinfold caliper (Burgess Hill, UK); and an inextensible tape, Lufkin W606PM (Lufkin, Missouri City, TX, USA).

All measurements corresponding to each adolescent were performed by the same anthropometrist in pre-and post-test to reduce inter-evaluator error. Each measurement was repeated a minimum of two times, with a third measurement being necessary when the differences between the first two was greater than 5 % in the skinfolds, and 1 % in the rest of the measurements [43].

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

Using the kinanthropometric measurements, the following derived variables were calculated: BMI (body mass/height^2), sum of 3 skinfolds (triceps, thigh, and calf), corrected girths [(corrected arm girth = arm relaxed girth - π*triceps skinfold); (corrected thigh girth = thigh girth - π*thigh skinfold); and corrected calf girth = calf girth - π*calf skinfold)], waist-to-hip ratio (waist girth/hips girth) [44], muscle mass [45], and fat mass (%) [46].

2.4.3. Physical fitness measurement

According to the methodology from previous research [30], the following physical fitness test were performed: 20-m shuttle run test to measure cardiorespiratory capacity and prediction of VO2max [47]; handgrip strength test for the measurement of upper limb strength using a Takei Tkk5401 digital handheld dynamometer (Takei Scientific Instruments, Tokyo Japan), by applying as much force as possible with the elbow fully extended [48]; countermovement jump (CMJ) to assess lower limb explosive strength, through the use of a force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) with which jump height was measured [49]; the 20-m sprint to measure running speed using single-beamed photocells (Polifemo Light, Microgate, Italy) placed at hip height [50]; and the curl-up test to measure abdominal strength and endurance by performing the highest number of trunk flexions in which the upper back area was no longer in contact with the floor, with hands crossed over the chest and feet flat on the floor [51].

Four researchers with previous experience in the measurement of fitness tests were in charge of familiarizing and overseeing the performance of the adolescents, with the same researcher always being in charge of the same tests in order to reduce inter-evaluator error.

2.5. Procedure

The pre- and post-test measurements followed the protocol from previous studies [30]. First, the adolescents completed the PAQ-A questionnaire. Subsequently, kinanthropometric measurements were taken, and after these were completed, the handgrip strength, CMJ, 20-m sprint, and curl-up tests were explained to the students, after which they had the opportunity to become familiarized with them. Once the familiarization process was completed, a progressive warm-up of running with joint mobility was performed, and two repetitions of each test were carried out, leaving two minutes of rest between each repetition of the same test, and five minutes between different tests, considering the best result obtained. Handgrip strength, the CMJ, and 20 m sprint tests took place randomly for each adolescent. After finishing these physical tests, a single repetition of the 20-m shuttle run test was performed.

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 [52]. This same criterion has already been used in previous research where the physical fitness of adolescents has been assessed [30, 53].

To minimize the interference of contaminating variables, the measurements were performed during the physical education class time, always between 8.30 a.m. and 2.30 p.m. in the morning, using the covered sports pavilions for the physical tests, and the locker rooms for the kinanthropometric measurements. The time of measurement of each of the class groups was the same in the pre- and post-test measurements, thus avoiding that the changes suffered by some of the kinanthropometric variables throughout the day could influence the results [54,55]. It should be noted that the same spaces were always used to reduce the influence of contaminating variables as much as possible. The temperature in the locker room was always kept stable.

2.6. Step tracker apps intervention

The initial sample consisted of 421 adolescents who were divided into a EG and CG. Each EG used a similar step tracker app (Strava®, Pokémon Go®, Pacer®, and MapMyWalk®), chosen for including a large number of techniques for behavioral change [56]. Initially 260 adolescents belonged to the intervention group (Strava: $n = 75$; Pokémon Go: $n = 62$; Pacer: $n = 63$; MapMyWalk: $n = 60$), and 161 to the CG.

The adolescents in the EG were provided an explanation on the functioning of each of the step tracker apps and were given a bonus in the physical education subject to use them outside school hours during a 10-week intervention period.

Considering that the sample of the present study did not reach the equivalent of sixty minutes of moderate-vigorous physical activity per day in the pre-test measurements, a progressive intervention was proposed to ensure that the adolescents reached the recommended minimum distance at the end of the study. Previous research has shown that adolescents should perform moderate to vigorous physical activity at least three days a week for sixty minutes[10]. These recommendations are equivalent to completing between 11,000 and 14,000 steps per day [57], so the adolescents were instructed to use the mobile app three times a week, starting with 7000 steps each day in the first week, and ending with 12,500 steps each day in the tenth week of the intervention (Table 1). To make it easier for the adolescents to quantify the distance, the steps were converted to kilometers, following the indications from previous studies in which one kilometer corresponded to approximately 1565 steps in this population[58], as the apps quantify the distance in kilometers.

Table 1
Training volume progression using step tracker mobile apps.

Week	Volume per session (steps)	Volume per session (km)	Volume per week (steps)	Volume per week (km)
1	7152	4.57	21,456	13.71
2	7747	4.95	23,240	14.85
3	8341	5.33	25,024	15.99
4	8936	5.71	26,808	17.13
5	9547	6.10	28,639	18.30
6	10,141	6.48	30,424	19.44
7	10,736	6.86	32,208	20.58
8	11,331	7.24	33,992	21.72
9	11,925	7.62	35,776	22.86
10	12,520	8.00	37,560	24.00

Regarding the EG, not all adolescents completed the total distance requested by the end of the intervention. It should be noted that adolescents who did not meet the criteria for participation in the intervention (did not complete the indicated weekly distance) were not excluded from their respective groups. They were given the post-test measurements and continued to be part of the *n* of the research.

2.7. Control group

The CG did not use any mobile apps during the 10-week intervention period and continued to attend physical education classes and physical activity habits normally.

2.8. Data analysis

The normality of the data was assessed using the Kolmogorov-Smirnov test, as well as kurtosis, skewness, and variance analysis. As the data followed a normal distribution, the statistical analysis was performed using parametric tests. The mean and standard deviation (M ± SD) were used as descriptive values for the sample. A two-way repeated measures ANOVA was used to analyse the intra-group and inter-group differences in each of the groups analysed (CG, 0–25 %, 25–50 %, 50–75 % and 75–100 % groups) between the pre-test and post-test. An ANCOVA was performed to establish the influence of the gender variable on the results obtained. The Bonferroni post-hoc test was used to determine if: a) the differences were significant between groups or measurements, and b) between which groups/measurements. Partial eta squared (η^2) was used to calculate the effect size, as indicated by small: ES ≥ 0.10; moderate: ES ≥ 0.30; large: ES ≥ 1.2; or very large: ES ≥ 2.0, with an error of $p < 0.05$ [59]. Statistical significance was established for a value of $p < 0.05$. The statistical analyses were performed with the SPSS v.25.0 statistical package (SPSS Inc., IL).

3. Results

Applying the exclusion criteria 21 participants were excluded, so the final sample consisted of 400 adolescents, 160 belonging to the CG and 240 to the EG (Strava: $n = 74$; Pokémon Go: $n = 59$; Pacer: $n = 60$; MapMyWalk: $n = 47$). The adolescents in the EG were divided according to the volume of training completed: 0–25 % ($n = 129$), 25–50 % ($n = 39$), 50–75 % ($n = 33$), and 75–100 % ($n = 39$), in accordance with previous research that used quartiles to divide the sample [60].

The use of the different apps was not taken into consideration for the analysis of the results, as the number of adolescents who completed each volume of training was similar between the apps: 0–25 % (Strava: $n = 44$; Pokémon Go: $n = 27$; Pacer: $n = 32$; MapMyWalk: $n = 26$); 25–50 %

(Strava: $n = 11$; Pokémon Go: $n = 11$; Pacer: $n = 9$; MapMyWalk: $n = 8$); 50–75 % (Strava: $n = 9$; Pokémon Go: $n = 9$; Pacer: $n = 8$; MapMyWalk: $n = 7$); 75–100 % (Strava: $n = 10$; Pokémon Go: $n = 12$; Pacer: $n = 11$; MapMyWalk: $n = 6$).

Table 2 shows the differences in physical activity level, kinanthropometric and derived variables, as well as in physical fitness between adolescents with different training volumes completed. The differences were significant between pre and post measurements in all the variables analysed ($p < 0.001$–0.011), except for sitting height ($p = 0.876$) and waist girth ($p = 0.575$). It is important to highlight that the inclusion of the covariate "gender" was only significant in the variables height ($p < 0.001$), muscle mass ($p = 0.011$), fat mass ($p = 0.039$), V02 max ($p < 0.001$) and handgrip (right: $p = 0.036$; left: $p = 0.039$).

The variables in which significant differences were found in the study groups between pre- and post-tests are shown in Fig. 1. The physical activity level increased in all EG, regardless the quartile of compliance ($p = 0.009$–0.044), but not in the CG ($p = 0.960$). When the covariate gender was introduced, it was found that the change remained significant for the 0–25 % (diff=−0.12 ± 0.04; $p = 0.010$; CI 95 %=−0.225; −0.031) and 75–100 % (diff=−0.19 ± 0.09; $p = 0.030$; CI 95 %=−0.375; −0.020) groups.

Regarding the kinanthropometric and derived variables, the results showed a significant increase in body mass and height in all groups ($p <$ 0.001–0.030), except for the 50–75 % compliance group ($p =$ 0.053–0.090). When the covariate gender was introduced, it was found that the change in body mass (diff=−1.01 ± 0.15 to −0.71 ± 0.33; $p =$ 0.032 to 0.000; CI 95 %=−1.51; −0.060) and height (diff=−0.91 ± 0.14 to −0.55 ± 0.13; $p = 0.028$ to 0.000; CI 95 %=−1.207; −0.069) continued to be significant for all groups.

BMI increased significantly only in the CG without covariables ($p <$ 0.001) but also after included BMI as covariable (diff=−0.26 ± 0.05; $p = 0.000$; CI 95 %=−0.381; −0.151).

The sum of 3 skinfolds ($p = 0.005$) and fat mass ($p < 0.001$) decreased significantly in the 75–100 % compliance group at the intervention distance. After the inclusion of the gender variable the decrease for both variables remained significant in the 75–100 % group (diff=4.09 ± 1.45; $p = 0.005$; CI 95 %=−6.957; −1.226; and diff=1.98 ± 0.55; $p = 0.000$; CI 95 %=−3.052; −0.904; respectively).

Muscle mass ($p < 0.001$–0.026) increased significantly in all groups both without the inclusion of the covariate, and by including gender as a covariate (diff=−0.48 ± 0.22 to −0.83 ± 0.21; $p = 0.027$ to $p < 0.001$; CI 95 %=−1.258; −0.054).

Regarding corrected girths, significant increases were found in all groups ($p < 0.001$–0.035), except for the 50–75 % compliance group, in corrected thigh girth ($p = 0.146$) and corrected calf girth ($p = 0.368$), as well the 25–50 % compliance group, in corrected calf girth ($p = 0.217$). With the inclusion of the covariate gender, a significant increase in corrected arm girth was still found in all groups (diff=−0.33 ± 0.15 to −0.59 ± 0.17; $p = 0.036$ to 0.000; CI 95 %=−0.931; −0.021). The same happened with the corrected thigh girth, where after the inclusion of the covariate gender again the evolution of all groups was significant except for the 50–75 % group (diff=−0.48 ± 0.39 to −0.98 ± 0.36; $p = 0.023$ to 0.000; CI 95 %=−1.261; −0.114). For the corrected calf girth after inclusion of the gender covariate, a significant increase was also found for the CG, 0–25 % and 75–100 %, as had been the case in the general model (diff=−0.38 ± 0.16 to −0.98 ± 0.30; $p = 0.020$ to 0.000; CI 95 %=−1.574; −0.060).

Furthermore, with respect to hip girth, a significant increase was found in the CG ($p < 0.001$) and in the 0–25 % compliance group ($p <$ 0.001). These changes were maintained when the gender covariate was introduced (diff=−1.22 ± 0.19 to −1.27 ± 0.18; $p = 0.000$; CI 95 %=−1.617; −0.834).

Regarding the physical fitness variables (Fig. 1), there was a significant increase in VO2max in all groups ($p < 0.001$–0.013), which was maintained when the gender variable was introduced, except for the 50–75 % group (diff=−1.70 ± 0.47 to −0.53 ± 0.24; $p = 0.033$ to 0.000; CI 95 %=−2.649; −0.043).

The handgrip value increased significantly in CG (left hand: $p = 0.018$; right hand: 0.016) and 0–25 % groups ($p \leq 0.001$) for both hands, and the 75–100 % group for right hand ($p = 0.004$). The results were maintained with the inclusion of the covariate gender both for the right hand, with significant evolution in the CG, 0–25 % group and 75–100 % group (diff=−0.78 ± 0.36 to −2.12 ± 0.72; $p = 0.032$ to 0.000; CI 95 %=−3.548; −0.069); and left hand for CG and 0–25 % group (diff=−0.62 ± 0.28 to −1.01 ± 0.31; $p = 0.029$ to 0.001; CI 95 %=−1.622; −0.063).

The CMJ test only showed a significant increase in the 75–100 % compliance group ($p = 0.005$). The change is maintained with the inclusion of the covariate gender (diff=−3.61 ± 1.27; $p = 0.005$; CI 95 %= 1.110; 6.120).

The curl-up test improved in all EG regardless the quartile of compliance (0–25 %: $p = 0.002$; 25–50 %: $p < 0.001$; 50–75 %: $p = 0.040$; 75–100 %: $p = 0.002$), but not for the CG ($p = 0.073$). The increase was maintained in all EG, regardless the quartile of compliance, with the inclusion of the gender covariate, except for the 50–75 % group (diff=−6.01 ± 1.72 to −2.85 ± 0.94; $p = 0.003$ to 0.001; CI 95 %=−8.784; −1.008).

Regarding the 20-m sprint, the improvement was significant in the CG ($p = 0.002$), the 0–25 % compliance group ($p = 0.032$) and the 50–75 % compliance group ($p = 0.022$). The changes were maintained with the inclusion of the covariate gender (diff=−0.17 ± 0.08 to −0.36 ± 0.16; $p = 0.035$ to 0.002; CI 95 %=0.012; 0.696).

Table 3 shows the differences in the pre- and post-values between the different study groups in the physical activity level, kinanthropometric and derived variables, and in the physical fitness variables. The results showed significant differences in the sum of 3 skinfolds and fat mass in the post-test, but not in the pre-test, between the 0–25 % vs. 50–75 % groups (sum of 3 skinfolds pre: $p = 0.057$; post: $p = 0.041$; fat mass pre: $p = 0.056$; post: $p = 0.038$) and between the 50–75 % vs. 75–100 % groups (sum of 3 skinfolds pre: $p = 0.289$; post: $p = 0.031$; fat mass pre: $p = 0.309$; post: $p = 0.029$), with the group that completed a longer distance being the one that showed the lowest values in the post-test in both cases. When including the covariate gender, no significant differences were found for either the pre-test or the post-test on either variable (sum of 3 skinfolds pre: $p = 0.239$–1.000; post: $p = 0.149$–1.000; fat mass pre: $p = 0.104$–1.000; post: $p = 0.076$–1.000).

No significant differences were found in the physical activity level nor in the physical fitness variables when comparing pre- and post-test values between the groups, both considering and disregarding the gender covariate ($p = 0.131$–1.000).

4. Discussion

The first objective of the present research was to determine the changes in physical activity level, kinanthropometric and derived variables, and physical fitness variables in adolescents produced by an out-of-school intervention with mobile step tracker apps, promoted from the field of education, according to the volume of training completed. With respect to the kinanthropometric variables, it should be noted that the fat mass and the sum of 3 skinfolds of the adolescents decreased significantly between the pre- and post-test measurements in the group with the highest training volume completed (75–100 %). But what is really novel about the present study in the kinanthropometric and derived variables, is that the values in fat mass and the sum of 3 skinfolds after the intervention was significantly lowest in the groups that completed a higher volume of training as compared to those that completed a lower volume, with no differences in the pre-test. These results are similar to those obtained in intervention programs in which moderate-intensity continuous training protocols were used with adolescents, which showed decreases in body fat mass and body fat percentage, as compared to CG [8,9]. However, the programs used in previous studies were aimed at overweight and obese adolescents [8,9],

Table 2
Pre-post differences in kinanthropometric and derived variables, and in physical fitness variable according to the training volume completed and the gender covariate.

		Descriptors (*M* ± SD)					Training volume			Training Volume * Gender		
		Control (*n* = 160)	0–25 % (*n* = 129)	25–50 % (*n* = 39)	50–75 % (*n* = 33)	75–100 % (*n* = 39)	F	p	Effect size (η2)	F	p	Effect size (η2)
Physical activity level	pre	2.69 ± 0.68	2.69 ± 0.68	2.68 ± 0.68	2.50 ± 0.63	2.59 ± 0.65	15.495	<0.001	0.038	1.324	0.250	0.003
	post	2.70 ± 0.73	2.82 ± 0.66	2.86 ± 0.61	2.67 ± 0.49	2.80 ± 0.53						
Body mass (kg)	pre	51.99 ± 11.20	54.71 ± 9.87	54.98 ± 11.77	58.85 ± 18.10	57.31 ± 14.45	53.679	<0.001	0.122	2.703	0.101	0.007
	post	53.04 ± 11.02	55.58 ± 9.79	55.86 ± 11.37	59.49 ± 18.19	58.17 ± 14.48						
Height (cm)	pre	160.29 ± 8.54	162.67 ± 9.16	163.96 ± 8.90	161.80 ± 8.55	165.84 ± 9.59	41.206	<0.001	0.096	13.885	<0.001	0.035
	post	160.90 ± 8.46	163.57 ± 8.97	164.54 ± 8.97	162.28 ± 8.59	166.55 ± 9.65						
BMI (kg/m^2)	pre	20.18 ± 3.81	20.65 ± 2.90	20.38 ± 3.63	22.38 ± 5.03	20.68 ± 3.59	9.934	0.002	0.025	0.012	0.912	0.001
	post	20.44 ± 3.58	20.74 ± 2.83	20.58 ± 3.44	22.36 ± 5.07	20.85 ± 3.66						
Sitting height (cm)	pre	82.78 ± 11.69	84.21 ± 11.73	82.98 ± 20.32	84.81 ± 4.71	86.37 ± 4.44	0.024	0.876	0.001	0.680	0.410	0.002
	post	82.49 ± 14.37	84.48 ± 11.73	86.18 ± 4.98	85.21 ± 4.84	83.60 ± 20.38						
Sum of 3 skinfolds (cm)	pre	46.20 ± 26.72	48.97 ± 23.67	49.97 ± 27.51	62.90 ± 28.64	49.50 ± 23.34	10.926	0.001	0.028	0.153	0.696	0.001
	post	45.11 ± 24.55	48.41 ± 22.79	47.24 ± 22.83	62.13 ± 26.35	45.50 ± 20.38						
Corrected arm girth (cm)	pre	20.58 ± 2.71	20.94 ± 2.73	20.99 ± 2.79	20.89 ± 3.14	21.28 ± 2.62	21.839	<0.001	0.108	0.032	0.857	0.001
	post	20.98 ± 2.65	21.32 ± 2.53	21.32 ± 2.77	21.49 ± 3.24	21.62 ± 2.58						
Corrected thigh girth (cm)	pre	38.52 ± 4.24	39.70 ± 5.30	39.17 ± 4.87	39.74 ± 5.92	39.86 ± 4.31	29.554	<0.001	0.071	2.755	0.098	0.007
	post	39.37 ± 4.00	40.26 ± 4.27	40.05 ± 4.96	40.32 ± 5.86	40.83 ± 4.30						
Corrected calf girth (cm)	pre	28.52 ± 2.66	28.98 ± 2.72	29.50 ± 5.78	28.67 ± 2.99	29.22 ± 3.05	9.820	0.002	0.025	0.132	0.716	0.001
	post	29.05 ± 2.59	29.36 ± 2.69	29.12 ± 2.81	28.96 ± 3.38	30.21 ± 2.89						
Waist girth (cm)	pre	67.13 ± 8.06	67.99 ± 6.80	67.99 ± 7.39	71.23 ± 11.46	69.75 ± 9.01	0.314	0.575	0.001	0.051	0.822	0.001
	post	67.44 ± 7.95	68.32 ± 6.49	67.27 ± 6.76	71.31 ± 11.92	69.36 ± 8.49						
Hip girth (cm)	pre	85.98 ± 8.45	88.49 ± 7.29	89.20 ± 9.34	93.01 ± 11.95	90.35 ± 8.27	38.882	<0.001	0.092	1.186	0.277	0.003
	post	87.23 ± 8.17	89.73 ± 6.96	89.71 ± 8.55	93.70 ± 11.95	91.06 ± 7.83						
Waist/hip ratio	pre	0.78 ± 0.05	0.77 ± 0.05	0.76 ± 0.04	0.76 ± 0.06	0.77 ± 0.04	46.528	<0.001	0.108	0.046	0.830	0.001
	post	0.77 ± 0.05	0.76 ± 0.05	0.75 ± 0.04	0.76 ± 0.06	0.76 ± 0.04						
Muscle mass (kg)	pre	17.68 ± 4.32	18.38 ± 5.05	18.22 ± 5.18	17.82 ± 5.75	19.04 ± 5.07	56.719	<0.001	0.129	6.541	0.011	0.017
	post	18.35 ± 4.27	18.88 ± 4.74	18.70 ± 5.03	18.45 ± 6.06	19.88 ± 5.39						
Fat mass (%)	pre	20.31 ± 10.78	21.72 ± 9.17	21.87 ± 10.57	27.39 ± 11.25	22.13 ± 9.70	12.453	<0.001	0.031	4.297	0.039	0.011
	post	20.00 ± 10.42	21.57 ± 9.16	20.92 ± 9.30	27.08 ± 10.18	20.15 ± 8.35						
VO2max. (ml/kg/min)	pre	38.54 ± 5.01	38.29 ± 5.07	37.99 ± 4.92	36.54 ± 4.33	38.68 ± 4.55	29.401	<0.001	0.079	13.991	<0.001	0.039
	post	39.18 ± 5.30	39.20 ± 5.45	39.61 ± 6.15	37.27 ± 5.25	40.04 ± 5.65						
Handgrip right arm (kg)	pre	23.81 ± 7.07	24.68 ± 7.65	25.80 ± 8.08	23.70 ± 6.79	25.52 ± 8.30	23.114	<0.001	0.055	4.446	0.036	0.011
	post	24.69 ± 8.27	26.10 ± 7.95	27.06 ± 9.22	24.77 ± 8.46	27.65 ± 8.83						
Handgrip left arm (kg)	pre	22.67 ± 6.62	23.12 ± 7.14	23.89 ± 7.40	22.67 ± 7.28	24.02 ± 7.09	10.422	0.001	0.026	3.730	0.039	0.008
	post	23.35 ± 7.70	24.12 ± 7.26	24.58 ± 8.02	23.07 ± 8.63	24.82 ± 7.31						
CMJ (cm)	pre	21.79 ± 7.29	22.42 ± 7.48	23.34 ± 8.75	20.04 ± 5.93	21.88 ± 7.46	6.475	0.011	0.016	2.405	0.122	0.006
	post	22.41 ± 8.95	23.15 ± 8.14	23.67 ± 10.14	20.99 ± 7.33	25.51 ± 7.55						
20-m-sprint (s)	pre	3.90 ± 0.84	3.84 ± 0.71	3.72 ± 1.00	4.18 ± 0.46	3.71 ± 0.95	8.471	0.004	0.021	0.542	0.462	0.001
	post	3.67 ± 1.10	3.67 ± 0.95	3.51 ± 1.13	3.80 ± 1.05	3.85 ± 0.41						

(*continued on next page*)

Table 2 (*continued*)

		Descriptors ($M \pm$ SD)					Training volume			Training Volume * Gender		
		Control (n = 160)	0–25 % (n = 129)	25–50 % (n = 39)	50–75 % (n = 33)	75–100 % (n = 39)	F	p	Effect size (η2)	F	p	Effect size (η2)
Curl-up (repetition)	pre	20.15 ± 11.73	21.75 ± 10.26	19.10 ± 13.79	17.09 ± 9.85	20.84 ± 12.10	35.266	<0.001	0.083	1.147	0.285	0.003
	post	21.70 ± 11.88	24.64 ± 11.88	25.26 ± 9.47	21.00 ± 9.25	26.21 ± 8.18						

BMI: body mass index; VO2max: maximum oxygen consumption; CMJ: countermovement jump.

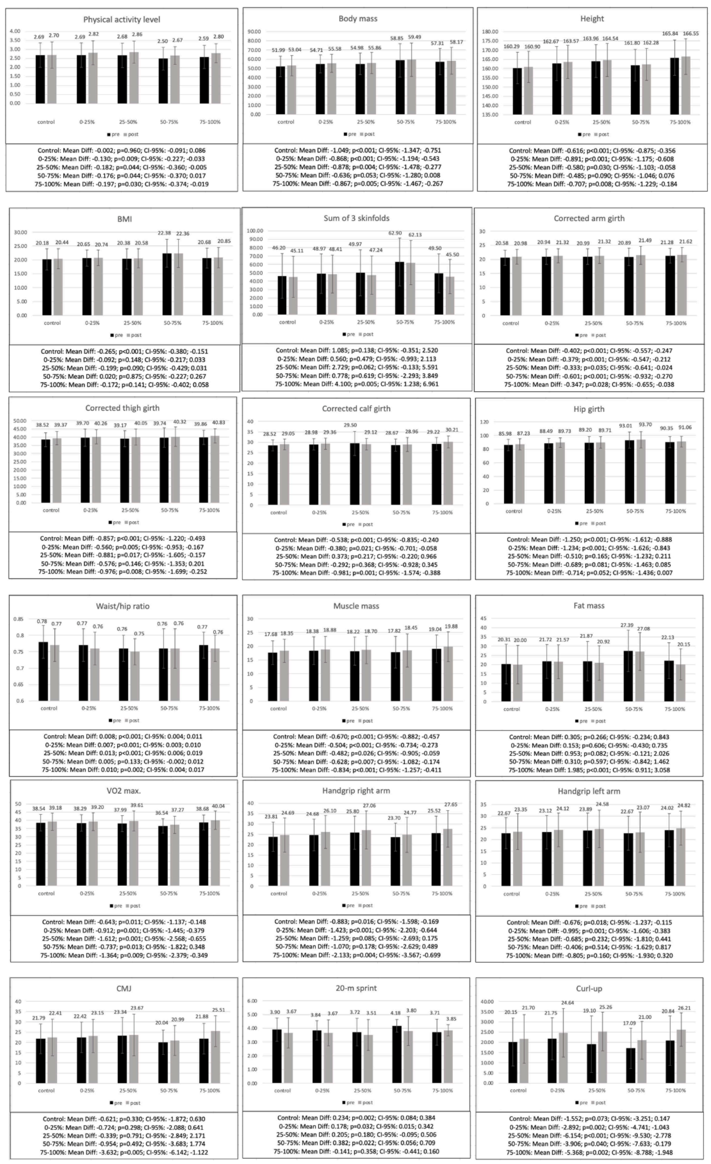

Fig. 1. Bonferroni post-hoc of the pre-post differences in kinanthropometric and derived variables, and in physical fitness variable according to the training volume completed.

whereas the results obtained in the present study did not refer exclusively to this population, which could indicate that a high volume of training using step tracker mobile apps would be useful for reducing variables related to fat mass in the adolescent population, regardless of their weight status. Although future research is needed to corroborate these results, step tracker mobile apps could become a useful element to prevent overweightness and obesity in the adolescent population by means of an attractive device that is already widely used by adolescents [61].

When comparing the differences in pre and post values in fat mass and sum of 3 skinfolds, no significant differences were found between any EG and CG, but significant differences were found between some of the EG depends of the quartile of compliance. Some possible explanations for these results could be that the optimal duration of the intervention to produce changes in fat variables is a minimum of 12 weeks [62,63], so the 10-week duration of the present investigation may have

Table 3
Differences in the pre- and post-test values when comparing the research groups in the kinanthropometric and derived variables and in the fitness variables.

		Mean differences; p-value									
		Control vs. 0–25 %	Control vs. 25–50 %	Control vs. 50–75 %	Control vs. 75–100 %	0–25 % vs. 25–50 %	0–25 % vs. 50–75 %	0–25 % vs. 75–100 %	25–50 % vs. 50–75 %	25–50 % vs. 75–100 %	50–75 % vs. 75–100 %
Physical Activity Level	Pre	0.002; p = 1.000	0.016; p = 1.000	0.199; p = 1.000	0.101; p = 1.000	0.014; p = 1.000	0.197; p = 1.000	0.099; p = 1.000	0.182; p = 1.000	0.085; p = 1.000	−0.098; p = 1.000
	Post	−0.126; p = 1.000	−0.164; p = 1.000	0.025; p = 1.000	−0.093; p = 1.000	−0.038; p = 1.000	0.150; p = 1.000	0.032; p = 1.000	0.189; p = 1.000	0.071; p = 1.000	−0.118; p = 1.000
Body mass (kg)	Pre	−2.720; p = 0.567	−2.992; p = 1.000	−6.865; p = 0.029	−5.317; p = 2.160	−0.272; p = 1.000	−4.145; p = 0.756	−2.597; p = 1.000	−3.873; p = 1.000	−2.325; p = 1.000	1.548; p = 1.000
	Post	−2.540; p = 0.723	−2.821; p = 1.000	−6.452; p = 0.046	−5.135; p = 0.168	−0.281; p = 1.000	−3.912; p = 0.903	−2.595; p = 1.000	−3.631; p = 1.000	−2.314; p = 1.000	1.317; p = 1.000
Height (cm)	Pre	−2.389; p = 0.249	−3.677; p = 0.229	−1.511; p = 1.000	−5.557; p = 0.006	−1.288; p = 1.000	0.878; p = 1.000	−3.169; p = 0.541	2.166; p = 1.000	−1.880; p = 1.000	−4.046; p = 0.564
	Post	−2.665; p = 0.117	−3.642; p = 0.230	−1.380; p = 1.000	−5.648; p = 0.004	−0.977; p = 1.000	1.284; p = 1.000	−2.984; p = 0.673	2.262; p = 1.000	−2.007; p = 1.000	−4.268; p = 0.424
BMI (kg/m^2)	Pre	−0.476; p = 1.000	−0.207; p = 1.000	−2.207; p = 0.016	−0.506; p = 1.000	0.269; p = 1.000	−1.731; p = 0.146	−0.030; p = 1.000	−2.000; p = 0.207	−0.299; p = 1.000	1.702; p = 0.489
	Post	−0.303; p = 1.000	−0.140; p = 1.000	−1.922; p = 0.044	−0.413; p = 1.000	0.162; p = 1.000	−1.620; p = 0.182	−0.110; p = 1.000	−1.782; p = 0.331	−0.272; p = 1.000	1.510; p = 0.708
Sitting height (cm)	Pre	−1.423; p = 1.000	−0.195; p = 1.000	−2.024; p = 1.000	−3.587; p = 0.944	1.228; p = 1.000	−0.602; p = 1.000	−2.164; p = 1.000	−1.830; p = 1.000	−3.392; p = 1.000	−1.563; p = 1.000
	Post	−1.991; p = 1.000	−3.686; p = 1.000	−2.715; p = 1.000	−1.109; p = 1.000	−1.695; p = 1.000	−0.724; p = 1.000	0.882; p = 1.000	0.971; p = 1.000	2.577; p = 1.000	1.606; p = 1.000
Sum of 3 skinfolds (cm)	Pre	−2.771; p = 1.000	−3.775; p = 1.000	−16.706; p = 0.008	−3.305; p = 1.000	−1.005; p = 1.000	−13.935; p = 0.057	−0.534; p = 1.000	−12.931; p = 0.350	0.471; p = 1.000	13.401; p = 0.289
	Post	−3.295; p = 1.000	−2.131; p = 1.000	−17.013; p = 0.002	−0.290; p = 1.000	1.164; p = 1.000	**−13.718; p = 0.041**	3.005; p = 1.000	−14.882; p = 0.084	1.841; p = 1.000	**16.723; p = 0.031**
Corrected arm girth (cm)	Pre	−0.365; p = 1.000	−0.410; p = 1.000	−0.317; p = 1.000	−0.699; p = 1.000	−0.045; p = 1.000	0.049; p = 1.000	−0.334; p = 1.000	0.093; p = 1.000	−0.289; p = 1.000	−0.383; p = 1.000
	Post	−0.342; p = 1.000	−0.340; p = 1.000	−0.516; p = 1.000	−0.644; p = 1.000	0.002; p = 1.000	−0.173; p = 1.000	−0.301; p = 1.000	−0.175; p = 1.000	−0.303; p = 1.000	−0.128; p = 1.000
Corrected thigh girth (cm)	Pre	−1.183; p = 0.420	−0.648; p = 1.000	−1.226; p = 1.000	−1.338; p = 1.000	0.535; p = 1.000	−0.043; p = 1.000	−0.155; p = 1.000	−0.578; p = 1.000	−0.690; p = 1.000	−0.112; p = 1.000
	Post	−0.886; p = 0.936	−0.672; p = 1.000	−0.946; p = 1.000	−1.457; p = 0.688	0.214; p = 1.000	−0.059; p = 1.000	−0.570; p = 1.000	−0.273; p = 1.000	−0.784; p = 1.000	−0.511; p = 1.000
Corrected calf girth (cm)	Pre	−0.461; p = 1.000	−0.982; p = 0.892	−0.156; p = 1.000	−0.709; p = 1.000	−0.521; p = 1.000	0.305; p = 1.000	−0.248; p = 1.000	−0.826; p = 1.000	−0.553; p = 1.000	−0.553; p = 1.000
	Post	−0.303; p = 1.000	−0.071; p = 1.000	0.090; p = 1.000	−1.153; p = 0.213	0.232; p = 1.000	0.393; p = 1.000	−0.850; p = 0.944	0.161; p = 1.000	−1.082; p = 0.868	−1.243; p = 0.579
Waist girth (cm)	Pre	−0.858; p = 1.000	−0.862; p = 0.254	−4.099; p = 0.084	−2.620; p = 0.738	−0.004; p = 1.000	−3.241; p = 0.398	−1.762; p = 1.000	−3.237; p = 0.920	−1.758; p = 1.000	1.479; p = 1.000
	Post	−0.877; p = 1.000	0.171; p = 1.000	−3.874; p = 0.108	−1.921; p = 1.000	1.048; p = 1.000	−2.996; p = 0.516	−1.044; p = 1.000	−4.044; p = 0.314	−2.092; p = 1.000	1.953; p = 1.000
Hip girth (cm)	Pre	−2.518; p = 0.141	−3.221; p = 0.378	−7.034; p < 0.001	−4.371; p = 0.051	−0.702; p = 1.000	−4.515; p = 0.069	−1.852; p = 1.000	−3.813; p = 0.606	−1.150; p = 1.000	2.663; p = 1.000
	Post	−2.502; p = 0.112	−2.481; p = 0.959	−6.473; p < 0.001	−3.835; p = 0.102	0.022; p = 1.000	−3.970; p = 0.134	−1.332; p = 1.000	−3.992; p = 0.412	−1.354; p = 1.000	2.638; p = 1.000
Waist/hip ratio	Pre	0.012; p = 0.451	0.018; p = 0.525	0.016; p = 0.980	0.010; p = 1.000	0.006; p = 1.000	0.004; p = 1.000	−0.002; p = 1.000	−0.002; p = 1.000	−0.007; p = 1.000	−0.006; p = 1.000
	Post	0.011; p = 0.626	0.023; p = 0.137	0.014; p = 1.000	0.013; p = 1.000	0.011; p = 1.000	0.002; p = 1.000	0.002; p = 1.000	−0.009; p = 1.000	−0.010; p = 1.000	−0.001; p = 1.000
Muscle mass (kg)	Pre	−0.697; p = 1.000	−0.533; p = 1.000	−0.141; p = 1.000	−1.359; p = 1.000	0.164; p = 1.000	0.555; p = 1.000	−0.662; p = 1.000	0.392; p = 1.000	−0.826; p = 1.000	−1.218; p = 1.000
	Post	−0.531; p = 1.000	−0.346; p = 1.000	−0.100; p = 1.000	−1.523; p = 0.806	0.185; p = 1.000	0.431; p = 1.000	−0.992; p = 1.000	0.246; p = 1.000	−1.177; p = 1.000	−1.424; p = 1.000
Fat mass (%)	Pre	−1.414; p = 1.000	−1.562; p = 1.000	−7.079; p = 0.003	−1.826; p = 1.000	−0.148; p = 1.000	−5.765; p = 0.056	−0.412; p = 1.000	−5.517; p = 0.234	−0.264; p = 1.000	5.253; p = 0.309
	Post	−1.566; p = 1.000	−0.914; p = 1.000	−7.074; p = 0.002	−0.146; p = 1.000	0.652; p = 1.000	**−5.508; p = 0.038**	1.419; p = 1.000	−6.159; p = 0.079	0.768; p = 1.000	**6.927; p = 0.029**
VO2max (ml/kg/min)	Pre	0.247; p = 1.000	0.543; P = 0.560	1.999; p = 0.517	−0.143; p = 1.000	0.296; p = 1.000	1.752; p = 0.924	−0.390; p = 1.000	1.456; p = 1.000	−0.686; p = 1.000	−2.142; p = 0.940
	Post	−0.023; p = 1.000	−0.426; p = 1.000	1.904; p = 0.946	−0.865; p = 1.000	−0.404; p = 1.000	1.927; p = 0.953	−0.842; p = 1.000	2.331; p = 0.918	−0.439; p = 1.000	−2.769; p = 0.513
Handgrip right arm (kg)	Pre	−0.870; p = 1.000	−1.992; p = 1.000	0.105; p = 1.000	−1.710; p = 1.000	−1.122; p = 1.000	0.975; p = 1.000	−0.840; p = 1.000	2.097; p = 1.000	0.282; p = 1.000	−1.815; p = 1.000
	Post	−1.410; p = 1.000	−2.368; p = 1.000	−0.082; p = 1.000	−2.960; p = 0.479	−0.957; p = 1.000	1.329; p = 1.000	−1.550; p = 1.000	2.286; p = 1.000	−0.592; p = 1.000	−2.879; p = 1.000
Handgrip left arm (kg)	Pre	−0.450; p = 1.000	−1.218; p = 1.000	0.007; p = 1.000	−1.341; p = 1.000	−0.769; p = 1.000	0.457; p = 1.000	−0.892; p = 1.000	1.226; p = 1.000	−0.123; p = 1.000	−1.349; p = 1.000
	Post	−0.769; p = 1.000	−1.227; p = 1.000	0.277; p = 1.000	−1.471; p = 1.000	−0.459; p = 1.000	1.045; p = 1.000	−0.702; p = 1.000	1.504; p = 1.000	−0.244; p = 1.000	−1.748; p = 1.000
CMJ (cm)	Pre	−0.636; p = 1.000	−1.547; p = 1.000	1.752; p = 1.000	−0.090; p = 1.000	−0.911; p = 1.000	2.388; p = 0.991	0.546; p = 1.000	3.299; p = 0.609	1.457; p = 1.000	−1.842; p = 1.000

(*continued on next page*)

Table 3 (*continued*)

		Mean differences; p-value									
	Post	−0.738; p = 1.000	−1.265; p = 1.000	1.419; p = 1.000	−3.101; p = 0.437	−0.527; p = 1.000	2.157; p = 1.000	−2.363; p = 1.000	2.683; p = 1.000	−1.836; p = 1.000	−4.519; p = 0.262
20-m-sprint (s)	Pre	0.056; p = 1.000	0.183; p = 1.000	−0.279; p = 0.703	0.187; p = 1.000	0.127; p = 1.000	−0.335; p = 0.325	0.131; p = 1.000	−0.462; p = 0.154	0.004; p = 1.000	0.467; p = 0.145
	Post	0.001; p = 1.000	0.155; p = 1.000	−0.131; p = 1.000	−0.187; p = 1.000	0.154; p = 1.000	−0.132; p = 1.000	−0.188; p = 1.000	−0.285; p = 1.000	−0.342; p = 1.000	−0.057; p = 1.000
Curl-up (repetition)	Pre	−1.597; p = 1.000	1.047; p = 1.000	3.056; p = 1.000	−0.693; p = 1.000	2.644; p = 1.000	4.652; p = 0.391	0.904; p = 1.000	2.009; p = 1.000	−1.740; p = 1.000	−3.748; p = 1.000
	Post	−2.937; p = 0.277	−3.555; p = 0.763	0.701; p = 1.000	−4.509; p = 0.263	−0.618; p = 1.000	3.638; p = 0.993	−1.572; p = 1.000	4.256; p = 1.000	−0.954; p = 1.000	−5.211; p = 0.524

BMI: body mass index; VO2max: maximum oxygen consumption; CMJ: countermovement jump. NOTE: Significant results are marked in bold.

influenced the fact that the evolution in the different EG depends on the quartile of compliance were not consistent. This leads to the consideration that other variables within the intervention may be more relevant than the distance covered. Thus, the time spent in each session could be more relevant, since the interventions that have shown changes advocate a minimum of 60 min [62,63], and it could be in the present research that the adolescents who covered more distance did not necessarily do so in a longer time, so that future research should include the time of each session as an aspect to be considered. In addition, it should be considered that the distance covered groups presented disparity in the sample size, which could be affecting the statistical analyses. For this reason, future research should follow the line of the present study and, once the usefulness of mobile apps to increase the level of physical activity has been confirmed, a greater importance should be given to specific variables such as the volume or intensity of the training performed with mobile applications, as this will provide more relevant data in this field of study and will define step tracker mobile apps as a real alternative for promoting physical activity and preventing childhood obesity.

In addition, muscle mass increased significantly between the pre- and post-test measurements in all groups, with differences also found in corrected girths in all groups. These results are similar to those from previous research, in which it was observed that adolescents who participated in regular physical activity at least three hours per week increased their muscle mass [64]. However, the differences that were also found between pre- and post-tests in the CG, as well as the absence of differences in the values of the pre-test and post-test between the different research groups, suggest that the modification produced in muscle mass was not so much due to the intervention, as to the effect of maturation on the adolescents [65]. Thus, previous research has shown that adolescents are in the midst of a maturational process in which growth hormones and sex steroid hormones reach peaks of concentration that significantly influence muscle mass [65,66]. Similarly, the differences found in body mass and height in all study groups between pre- and post-test measurements could be influenced by this maturational process, as previous research has shown that the most significant increases in these variables occur between 13.58 and 14.58 years of age [67]. Furthermore, there were no significant differences in the values of muscle mass, corrected girths, body mass and height between groups, neither when considering the covariate gender in the pretest or post-test, so that all the participants were similarly affected regardless of the group or gender they belonged to. In addition, it should be noted that testosterone generation in males and females is very low until age at peak velocity (APHV) [68], so that changes in strength could be due to sensorimotor adaptations, rather than differential structural changes, as testosterone levels are still continuously increasing [69]. Therefore, future research is needed to find out whether there are changes between different training volume groups in muscle mass gains with this type of aerobic activity, once the APHV has been overcome.

With respect to physical fitness, there was an improvement between the pre- and post-test values in all groups in VO2 max, regardless gender. In the handgrip, curl-up and 20-m sprint tests, the improvement was also significant in practically all the groups analysed, also regardless gender. One possible explanation for these results could be related to the increase in muscle mass in all the study groups and independently gender, and they could be due to the fact that the maturational process influences the strength production and cardiorespiratory capacity of adolescents [70], which would explain the increase in performance in these fitness tests in all groups [70]. However, an interesting result from the present study was that in the CMJ test, improvements were only observed in the group with the highest training volume completed (75–100 %). This result could be due to the fact that these adolescents were providing greater stimuli to their lower limb musculature, as this group had the greatest increase in the correct calf and thigh girths, with these being determining factors for the production of strength and the achievement of performance in the CMJ test [71].

However, although all groups showed improvements between the pre- and post-test in the fitness tests, it should be noted that no significant differences were found between the groups in the pre- and post-test measurements in these variables. This could be due, firstly, to the fact that the intensity of the aerobic physical activity performed with the mobile apps is not sufficient to produce changes in VO2max, as shown in previous research in which high-intensity programs produced improvements in VO2max, while moderate-intensity programs did not affect this variable [8,9]. Secondly, the absence of differences in the fitness tests related to strength could be explained by the fact that none of the mobile apps chosen included strength exercises, with minimal stimulus being necessary to produce significant changes in performance [72]. To date, there is no known research that has used strength mobile apps in the adolescent population, so future studies are needed to provide conclusive results in this respect.

Another important finding was that the level of physical activity significantly increased in all EG regardless the quartile of compliance, but not in the CG. These results are similar to those from previous studies that used mobile apps to increase the level of physical activity in the adolescent population [30]. The novelty of the present study was that the change produced between the pre- and post-test in each of the EG with different quartiles of compliance was not significantly different from that produced in the rest of the groups with different volumes completed or in comparison with the CG. A possible explanation for these results is that physical activity was measured using the PAQ-A questionnaire, which, although previously validated and reliable, provides a subjective measurement of physical activity [41,42]. In addition, it reports general physical activity, but does not differentiate between the different intensities of the physical activity performed [41,73], so it is possible that the adolescents were not able to correctly state the increase in physical activity achieved with the mobile apps in their questionnaire responses. Therefore, it may be that the adolescents are walking more, but are not able to differentiate how much more, and whether this amount is too much or too little distance to change the answers of the PAQ-A questionnaire. Consequently, it would be necessary for future research to analyse the differences in the level of physical activity practiced between groups with different volumes of training completed with the mobile apps but using an objective measure of this variable such as accelerometry.

According to the results obtained in the present investigation, the first research hypothesis (H1) that adolescents with a higher volume of training performed using the mobile applications will show superior improvements in the level of physical activity, kinanthropometric and derived variables, as well as in fitness, as compared to the CG and the EG that completed a lower volume, must be partially rejected, as significant differences were only found between the groups in the changes in fat mass and sum of 3 skinfolds. Nevertheless, these results are encouraging and could indicate that step tracker mobile apps are useful tools for preventing childhood obesity, if a minimum training volume is reached.

The second objective of the present research was to assess whether differences in the study variables are affected by the gender of the adolescents. The results showed that gender only significantly influence height, muscle mass, fat mass, cardiorespiratory fitness, and handgrip strength. As for the variables that showed significant differences, it is important to highlight that during adolescence there are significant changes in muscle and adipose tissue, with significant differences between males and females [74,75]. Sexual dimorphism caused by the difference in hormone production after puberty [76] leads to an increase in muscle mass in males, while in females the accumulation of adipose tissue prevails [70,77,78]. In addition, with respect to height, the age at peak height velocity (APHV), understood as the time of puberty when the fastest growth occurs [79], is different in males and females, being between 13.8–14.4 years of age in males, and between 11.4–12.2 years old in females [80,81]. This stage is characterized by increases in height of 9.0–10.3 cm per year [82], which could explain why the males of the sample being in the APHV, the height shows significant differences with respect to the females. Physical fitness also shows significant differences according to sex, with males performing better in physical fitness tests [83], mainly due to biological differences between them [70,77,78], but also because they tend to be more active than females [83].

Despite these initial gender differences because of biological factors, it was found that gender did not modify the intra-group differences shown for EG depends on quartile of compliance and CG. This could be since the follow-up of the intervention by the males and females may not differ so that the progression achieved was similar regardless of gender. Previous studies have already found that when physical activity interventions promoted in educational centres settings are considered, their follow-up does not differ according to gender [34]. Given that women are generally less active than men [84], educational centres-based interventions could be a good way to increase the practice of physical activity, especially in this group, and thus improve their health [30,85].

A notable result of the present investigation was that, when the covariate gender was introduced, the inter-group differences in terms of the degree of compliance with the intervention for the variables sum of 3 skinfolds and fat mass disappeared. During adolescence there are significant differences in the amount and distribution of adipose tissue between males and females [74,75], and since the sample is homogeneous in terms of males and females, the natural accumulation of adipose tissue in females could be attenuating the effects of the intervention to the point of making the comparison between groups statistically non-significant. For all these reasons, gender could be a variable to be considered in future research using mobile applications with adolescents, but it is necessary that the sample size allows the adolescents to be divided according to the quartile of compliance with the distance covered and their gender to look into this issue in more detail.

The previous scientific literature did not allow us to establish a second consistent research hypothesis regarding the volume of training with mobile apps and gender, so it was determined that the benefits would be similar at the same level of training completed (H2). Based on the results obtained, this research hypothesis could be accepted for intra-group differences but not for inter-group differences, where the inclusion of the gender variable meant that the change observed between groups in terms of the degree of compliance with the intervention was no longer significant.

The present research is not free of limitations. The sample was selected by convenience, considering the centres with the highest number of adolescents in compulsory secondary education. The sample size of the groups that completed a higher volume of training was small as compared to the CG and the groups that completed a lower volume, which could affect the statistical analyses. In addition, the fact that the distance compliance groups were small in terms of sample size prevented comparative analyses between males and females. The PAQ-A questionnaire provides a subjective measurement of physical activity, which could influence the self-assessment of physical activity performed by adolescents, and future research needs to use an objective measurement such as accelerometry. The maturational process in which adolescents are immersed could have influenced both the kinanthropometric and derived variables, and physical fitness results, so this should be considered in future research with mobile apps in this population. Although the initiation of a new sports activity once the intervention began was considered as an exclusion criterion, adolescents who regularly practiced strength activities or attended the gym, could have improved their strength and body composition during the intervention. Therefore, this aspect should be monitored more rigorously in future research.

5. Conclusions

The results of the present investigation allowed us to conclude that there were significant differences in the level of physical activity, anthropometric variables and physical fitness variables between adolescents with different training volumes completed. Thus, it was found that all EG, regardless the quartile of compliance, increased their level of physical activity practice. Also, the sum of 3 skinfolds and fat mass decreased significantly in the group with 75–100 % compliance, while muscle mass increased in all groups. As for physical fitness, VO2 max increased significantly in all groups, while CMJ and curl up increased in some of the EG depends on the quartile of compliance. It should be noted that the covariate gender did not show significant intra-group effects on the level of physical activity practiced, nor on most of the anthropometric and physical fitness variables, so it is concluded that the use of apps in adolescent males and females may be equally beneficial, with the differences found being explained by differences in the maturational process depending on gender. It should also be noted that the comparison for the pre-test and post-test values of the fat variables when comparing EG and CG were not significant, but the post-test values were significantly different for fat-related variables between the different intervention compliance groups, with these differences disappearing when the covariate gender was introduced, so the possibility that the distance covered is not the most relevant parameter for changes in body composition is discussed, and it may be necessary to consider the duration of each session, the total duration of the intervention or gender influence in future research.

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Declaration of Competing Interest

None.

Data availability

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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