TESIS DOCTORAL

UCAM
UNIVERSIDAD CATÓLICA DE MURCIA

ESCUELA INTERNACIONAL DE DOCTORADO

Programa de Doctorado en Ciencias del Deporte

Efectos del entrenamiento de fuerza en maquinaria biosaludable sobre la salud en personas adultas y mayores

Autor:

D. Alejandro Espeso García

Directores:

Dr. D. Pablo Jorge Marcos Pardo

Dra. Dña. Noelia González Gálvez

Dra. Dña. Raquel Vaquero Cristóbal

Murcia, julio de 2024

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RESUMEN

El envejecimiento es un proceso natural que conlleva cambios a nivel celular, en tejidos y órganos, que reduce la capacidad de adaptación y respuesta del organismo, aumentando la prevalencia de enfermedades crónicas y provocando un deterioro de la capacidad funcional y la calidad de vida. El sedentarismo y la inactividad física agravan aún más esta situación, acelerando este declive.

La realización de actividad física regular mediante materiales como las bandas elásticas de resistencia o la maquinaria biosaludable se presenta como una estrategia para contrarrestar los efectos del envejecimiento. Estos materiales ofrecen alternativas sencillas y económicas a los gimnasios tradicionales, permitiendo trabajar los principales grupos musculares y mejorar la fuerza, la capacidad cardiovascular y la flexibilidad, mientras se promueve la interacción social y se eliminan barreras de accesibilidad.

Los objetivos de la presente tesis doctoral fueron: 1) proporcionar recomendaciones para el ejercicio efectivo y seguro con bandas elásticas de resistencia; 2) analizar los efectos del entrenamiento con maquinaria biosaludable en población adulta y mayor según la literatura existente; 3) diseñar un protocolo para un estudio controlado aleatorizado que analice los efectos del entrenamiento de fuerza con maquinaria biosaludable sobre la salud; y 4) analizar los efectos de un programa de entrenamiento de fuerza con maquinaria biosaludable sobre la composición corporal, la condición física y la salud en adultos y mayores, analizando la influencia de la edad en los resultados.

Para dar respuesta al primer objetivo, se presenta una revisión bibliográfica sobre el uso de bandas elásticas de resistencia en el contexto de la pandemia de COVID-19, consultando bases de datos académicas con palabras clave relacionadas con la resistencia elástica y ejercicio en personas mayores.

Respecto al segundo objetivo, se presenta una revisión bibliográfica sobre los beneficios y limitaciones del entrenamiento con maquinaria biosaludable. Se realizó una búsqueda en las bases de datos EBSCO, SPORTDiscus, Medline, PsycINFO, WOS y Scopus con palabras clave relacionadas con la maquinaria biosaludable, el entrenamiento de fuerza y la salud.

Para dar respuesta al tercer y cuarto objetivo, se presenta un estudio de protocolo y un ensayo controlado aleatorizado en maquinaria biosaludable. El protocolo describe un ensayo controlado aleatorizado, con un grupo (TG) que realiza un programa de entrenamiento de fuerza con maquinaria biosaludable durante 8 semanas y un grupo control (CG) que realiza sus actividades diarias habituales. El cuarto artículo presenta el ensayo controlado aleatorizado propuesto en el artículo de protocolo, examinando el efecto del entrenamiento de fuerza en circuito con maquinaria biosaludable sobre parámetros de salud en adultos y mayores, así como la influencia de la edad en los resultados obtenidos. Un total de 149 voluntarios fueron asignados aleatoriamente al TG y CG. Se evaluó la composición corporal mediante DXA, la fuerza isométrica máxima (MVIC) en extensión de rodilla, flexión de codo y prensión manual, junto con la prueba de caminar 4 m, la prueba Timed Up and Go (TUG) y el Cuestionario de Salud SF-36.

El primer estudio reveló que el entrenamiento con bandas elásticas de resistencia puede ser efectivo para mantener y mejorar la salud física y psicológica en adultos. Se observaron mejoras en la fuerza muscular, la funcionalidad, la calidad de vida y el bienestar psicológico en las personas que realizan ejercicio con este tipo de materiales.

El segundo estudio indicó que el entrenamiento con maquinaria biosaludable puede mejorar la salud cardiovascular, la fuerza muscular y la calidad de vida. Sin embargo, sus efectos pueden ser limitados al usar el propio peso corporal como carga de entrenamiento. Además, las limitaciones metodológicas de los estudios, como la falta de grupos control o muestras pequeñas, resaltan la necesidad de más investigaciones.

En relación al ensayo controlado aleatorizado detallado en el artículo de protocolo, se observaron diferencias en la composición corporal, condición física y percepción de la salud de ambos grupos. El TG mostró una disminución en la masa grasa ($p < .001$) y el índice de masa grasa ($p < .001$), y un aumento en el índice de masa magra ($p = .045$), mientras que el CG presentó una disminución en la masa magra ($p = .024$) y el índice de masa magra ($p = .008$). En cuanto a la condición física, el TG tuvo mejoras en la MVIC en ambas piernas ($p < .001$) y brazos ($p < .001$), así como en la prueba TUG ($p < .001$) y la prueba de caminar 4 metros ($p = .006$). En contraste, el CG mostró disminuciones en la MVIC de la pierna izquierda ($p = .019$) y brazos ($p < .001$), así como en la prueba TUG ($p < .001$). Según los resultados del

Cuestionario SF-36, el TG tuvo mejores puntuaciones en las dimensiones de funcionamiento físico ($p < .001$) y rol físico ($p = .006$) en comparación con el CG.

En base a los resultados de los cuatro estudios se concluye, que para mejorar la salud mediante el entrenamiento de fuerza con bandas elásticas de resistencia, se recomienda entrenar 2-3 días a la semana, enfocándose en movimientos que imiten las actividades cotidianas y trabajen los principales grupos musculares; que los programas de ejercicio con maquinaria biosaludable tienen el potencial de mejorar la salud de adultos y mayores, aunque es necesaria más investigación; y, que el entrenamiento de fuerza con maquinaria biosaludable, realizado de manera pautada y controlada durante 8 semanas, puede ser una estrategia eficaz para prevenir enfermedades y mejorar la composición corporal, la condición física y la calidad de vida, sugiriendo que la edad puede influir en la respuesta antes este tipo de entrenamiento.

PALABRAS CLAVE

Envejecimiento activo, Envejecimiento, Coronavirus, Entrenamiento con resistencia elástica, Ejercicio, Capacidad funcional, Envejecimiento saludable, Personas mayores, Gimnasio al aire libre, Equipamiento de fitness al aire libre, Actividad física, Ejercicio físico, Desempeño físico funcional, Entrenamiento de fuerza, Sarcopenia.

ABSTRACT

Aging is a natural process that involves changes at the cellular, tissue, and organ levels, which reduces the body's capacity to adapt and respond, increasing the prevalence of chronic diseases and leading to a deterioration in functional capacity and quality of life. Sedentary lifestyle and physical inactivity further aggravate this situation, accelerating this decline.

Regular physical activity using materials such as elastic resistance bands or outdoor fitness equipment is presented as a strategy to counteract the effects of aging. These materials offer simple and inexpensive alternatives to traditional gyms, allowing work on major muscle groups and improving strength, cardiovascular capacity and flexibility, while promoting social interaction and eliminating accessibility barriers.

The objectives of this doctoral dissertation were: 1) to provide recommendations for effective and safe exercise with elastic resistance bands; 2) to analyze the effects of training with outdoor fitness equipment in adult and older adults according to the existing literature; 3) to design a protocol for a randomized controlled trial to analyze the effects of strength training with outdoor fitness equipment on health status; and 4) to analyze the effects of a strength training program with outdoor fitness equipment on body composition, physical fitness and health in adults and older adults, examining the influence of age on the results.

To respond the first objective, a literature review on the use of elastic resistance bands in the context of the COVID-19 pandemic is presented, searching academic databases with keywords related to elastic resistance and exercise in the older adults.

Regarding the second objective, a literature review on the benefits and limitations of training with outdoor fitness equipment is presented. A search was carried out in the EBSCO, SPORTDiscus, Medline, PsycINFO, WOS and Scopus databases with keywords related to outdoor fitness equipment, strength training and health.

To respond to third and fourth objectives, a protocol study and a randomized controlled trial on outdoor fitness equipment are presented. The protocol describes a randomized controlled trial, with one group (TG) performing a strength training

program with outdoor fitness equipment for 8 weeks and a control group (CG) performing their usual daily activities. The fourth article presents the randomized controlled trial proposed in the protocol article, examining the effect of circuit strength training with outdoor fitness equipment on health outcomes in adults and older adults, and the influence of age on the results obtained. A total of 149 volunteers were randomly assigned to TG and CG. Body composition was assessed by DXA, maximal isometric strength (MVIC) in knee extension, elbow flexion and hand grip, together with the 4 m walking test, the Timed Up and Go (TUG) and the SF-36 Health Questionnaire.

The first study revealed that resistance elastic band training can be effective for improving and maintaining physical and psychological health in adults. Improvements in muscle strength, functionality, quality of life and psychological well-being were observed in people exercising with this type of material.

The second study reported that training with outdoor fitness equipment can improve cardiovascular health, muscle strength and quality of life. However, its effects may be limited due to the use of body weight as training load. Furthermore, the methodological limitations of the studies, such as the lack of control groups or small sample sizes, emphasize the need for additional research.

Regarding the randomized controlled trial described in the protocol article, differences were observed in the body composition, physical condition, and health perception of both groups. The TG showed a decrease in fat mass ($p < .001$) and fat mass index ($p < .001$), and an increase in lean mass index ($p = .045$), whereas the CG presented a decrease in lean mass ($p = .024$) and lean mass index ($p = .008$). In terms of physical fitness, TG had improvements in MVIC in both legs ($p < .001$) and arms ($p < .001$), as well as in the TUG test ($p < .001$) and the 4-meter walk test ($p = .006$). In contrast, CG showed decreases in left leg ($p = .019$) and arms ($p < .001$) MVIC, as well as in the TUG test ($p < .001$). According to the results of the SF-36 Questionnaire, the TG had better scores on the physical functioning ($p < .001$) and physical role ($p = .006$) dimensions compared to the CG.

From the results of the four studies, it is concluded that to improve health through strength training with elastic resistance bands, it is recommended to exercise 2-3 days a week, focusing on movements that emulate daily activities and work the main muscle groups; that exercise programs with outdoor fitness equipment have the potential to improve the health of adults and older adults,

although more research is needed; and, that strength training with outdoor fitness equipment, performed in a regular and controlled manner for 8 weeks, can be an effective strategy to prevent diseases and improve body composition, physical fitness and quality of life, suggesting that age may influence the response to this exercise program.

KEYWORDS

Active ageing, Aging, Coronavirus, Elastic resistance training, Exercise, Functional capacity, Healthy aging, Older people, Outdoor gym, Outdoor fitness equipment, Physical activity, Physical exercise, Physical functional performance, Resistance training, Sarcopenia.

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The solution to a problem changes the nature of the problem (John Peers).

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SIGLAS Y ABREVIATURAS

η2, Partial eta squared

ANCOVA, Analysis of Covariance

ANOVA, Analysis of Variance

BMI, Body Mass Index

Borg CR-10, Borg´s Category Ratio scale

Bpm, Beats per Minute

CG, Control Group

CI, Confidence Interval

CONSORT, Consolidated Standards of Reporting Trials

COP, Center of Pressure

COVID-19, Coronavirus Disease 2019

CRF, Cardiorespiratory Fitness

DBP, Diastolic Blood Pressure

Dif., Differences

DXA, Dual-Energy X-Ray Absorptiometry

ECG, Electrocardiogram

ES, Effect Size

EWGSOP, European Working Group on Sarcopenia in Older People

HG, Handgrip Strength Test

HR, Heart Rate

IAEA, International Atomic Energy Agency

ISAK, International Society for the Advancement in Kinanthropometry

MHealth, Mobile Health

MVIC, Maximum Voluntary Isometric Contraction

OFE, Outdoor Fitness Equipment

PH, Physical Health

PR, Pulse Rate

PREDIMED Score, Validated 14-item Questionnaire of Mediterranean Diet Adherence

Reps, Repetitions

RISE, Resistance Intensity Scale for Exercise

RPE, Rating of Perceived Exertion

SBP, Systolic Blood Pressure

SD, Standard deviation

SF-36, 36-item Short-Form Health Survey

SPIRIT, Standard Protocol Items: Recommendations for Interventional Trials

SPPB, Short Physical Performance Battery

SWL, Satisfaction with Life Scale

TG, Training Group

TUG, Timed Up and Go

WHO, World Health Organization

WHO-FRAX, World Health Organization Fracture Risk Assessment Tool

X, Mean

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ÍNDICE DE FIGURAS

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I – INTRODUCCIÓN

I - INTRODUCCIÓN

El envejecimiento es un proceso universal caracterizado por una serie de cambios en el organismo, donde células, tejidos y órganos experimentan transformaciones a medida que se envejece (WHO, 2015a). Estos cambios pueden dar lugar a una disminución de la capacidad de adaptación y respuesta del organismo (Ferrucci et al., 2020; He et al., 2023; López-Otín et al., 2013), un incremento en la prevalencia de enfermedades crónicas (Kennedy et al., 2014; Lee et al., 2012), un deterioro de la capacidad funcional (Perrig-Chiello et al., 2006; Volpi et al., 2004) o una disminución de la calidad de vida (Beard & Bloom, 2015; Casas-Herrero et al., 2022), lo que plantea retos para las sociedades y las personas (Beard & Bloom, 2015; Casas-Herrero et al., 2022; Melzer et al., 2020; WHO, 2022).

Aunque el envejecimiento se asocia frecuentemente con la edad cronológica, los cambios observados no son lineales, existiendo gran variabilidad entre individuos (Levine et al., 2018; Melzer et al., 2020). Esta heterogeneidad se atribuye principalmente a la interacción de factores genéticos, ambientales, conductuales y sociales (Steves et al., 2012; Tam et al., 2020). En consecuencia, mientras algunas personas mantienen un buen nivel de salud y estado físico con edades avanzadas, otras pueden desarrollar ciertas patologías o experimentar limitaciones en su funcionalidad (Ferrucci et al., 2018; Kennedy et al., 2014; WHO, 2015a).

La realización de ejercicio de forma regular es crucial para mejorar la salud y combatir los efectos adversos del envejecimiento (Marcos-Pardo et al., 2020). Tradicionalmente, este tipo de entrenamientos se ha dirigido hacia la mejora cardiovascular (Bouariz et al., 2017). Sin embargo, en los últimos años el entrenamiento de fuerza ha cobrado protagonismo por su capacidad para mantener la masa muscular, que se ha mostrado como uno de los pilares fundamentales para mejorar la calidad de vida y retrasar los efectos del envejecimiento (Cadore et al., 2013; Nascimento et al., 2019). Los programas dirigidos a personas adultas y mayores ofrecen distintos tipos de entrenamientos que incluyen fuerza, resistencia, equilibrio, multicomponente o multimodal (Liu et al., 2017; Shen et al., 2023; Weng et al., 2022). Sin embargo, existen numerosas barreras que limitan el acceso a estas actividades, como factores económicos, culturales o de movilidad (Martins et al., 2021). Frente a estas restricciones, muchas

personas optan por participar en actividades al aire libre o realizar ejercicios en casa, utilizando su propio peso corporal o con materiales sencillos (Colado et al., 2010; Labat & Hey, 2017; Marcos-Pardo et al., 2021; Page & Ellenbecker, 2020).

Entre los materiales tradicionales más utilizados para la realización de ejercicio en casa se encuentran las bandas elásticas de resistencia, que destacan por su versatilidad, bajo coste y portabilidad (Ooi et al., 2021). Estas permiten a los usuarios realizar una amplia gama de ejercicios, abarcando los principales grupos musculares y demostrando ser efectivas para aumentar la fuerza muscular y la capacidad funcional en adultos mayores (Bårdstu et al., 2020). Otro de los materiales que ha aumentado su popularidad en los últimos años han sido los parques biosaludables, que surgen como una alternativa sencilla y gratuita para la realización de actividad física (Grigoletto et al., 2021). Estos espacios combinan zonas verdes con equipos de fitness al aire libre (OFE), diseñados específicamente para su uso exterior y adaptados de las máquinas de gimnasio tradicionales, permitiendo el entrenamiento de fuerza, cardiovascular o de flexibilidad (Chow et al., 2021; Marcos-Pardo et al., 2023), y facilitando que cualquier persona pueda realizar ejercicio, independientemente de su experiencia previa (Chow et al., 2017).

Considerando los desafíos y la evidencia existente, integrar el uso de novedosos y accesibles materiales como las bandas de resistencia elástica y los parques biosaludables instalados en espacios outdoor en las estrategias de salud pública podría ser clave para combatir el sedentarismo y promover un envejecimiento activo y saludable en la población adulta y mayor. No obstante, la evidencia actual sobre los efectos de estos equipos en la salud de adultos y mayores es limitada, lo que destaca la necesidad de realizar más investigaciones que confirmen sus beneficios.

La presente investigación se centra en el estudio de los efectos del entrenamiento con bandas elásticas de resistencia y con maquinaria biosaludable como una estrategia innovadora y de fácil accesibilidad para ayudar a mejorar la salud de personas adultas y mayores. Este enfoque responde a una doble necesidad: combatir el aumento de la inactividad física y la prevalencia de enfermedades crónicas asociadas a la inactividad física y al envejecimiento, así como superar las barreras de accesibilidad presentadas por otros programas de entrenamiento, ofreciendo una alternativa adecuada, sencilla y gratuita para esta población.

II – JUSTIFICACIÓN

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A medida que la esperanza de vida de la población aumenta, se vuelve fundamental comprender los mecanismos que regulan el proceso de envejecimiento y desarrollar estrategias para mitigar sus efectos negativos. Desde una perspectiva fisiológica, el envejecimiento implica numerosos cambios en el organismo que, dependiendo de su naturaleza, pueden estar asociados a un proceso normal o a un declive acelerado (Ferrucci et al., 2020; Tam et al., 2020). En este sentido, un factor común es la acumulación de daño en el ADN a lo largo de la vida (Ferrucci et al., 2018; Levine et al., 2018; López-Otín et al., 2013; Melzer et al., 2020). Este factor tiene un impacto directo sobre la integridad fisiológica, contribuyendo a un deterioro en la funcionalidad celular y de los sistemas, como la alteración de la función cardiovascular (Costantino et al., 2016; Zhang et al., 2018); la reducción de la fuerza y la masa muscular (Cruz-Jentoft et al., 2014; Melouane et al., 2019); cambios en la composición corporal como el aumento de la grasa abdominal y visceral, la disminución de la grasa subcutánea y la disminución de la densidad mineral ósea (Franzago et al., 2022; Mancuso & Bouchard, 2019; Ponti et al., 2020; Tam et al., 2020); así como alteraciones en el metabolismo y un aumento de prevalencia de enfermedades crónicas (Amorim et al., 2022; Wu et al., 2023).

Dentro de este contexto, se ha identificado el mantenimiento de la masa muscular y la prevención de la sarcopenia como un factor crítico en el desarrollo del envejecimiento (Nascimento et al., 2019). Se define sarcopenia como un trastorno progresivo y generalizado del músculo esquelético caracterizado principalmente por una baja fuerza muscular, la pérdida de masa muscular y asociado a una mayor probabilidad de caídas, fracturas, discapacidad física y mortalidad (Cruz-Jentoft et al., 2019; Frontera & Ochala, 2015; Gao et al., 2021). Aunque tradicionalmente se ha encontrado asociada al envejecimiento, la evidencia señala que existen múltiples factores que pueden influir en este proceso, desarrollándose incluso en etapas previas (Cruz-Jentoft et al., 2019; Sayer et al., 2008).

La sarcopenia afecta entre el 5-13% de las personas adultas, cifra que se incrementa hasta el 50% en personas mayores de 80 años, con una reducción de un 8% de la masa muscular por cada década a partir de los 40 años (von Haehling et

al., 2010). La pérdida de la masa y la fuerza muscular no solo contribuye a estos efectos adversos, sino que también puede limitar la capacidad de las personas para realizar sus actividades de la vida cotidiana, afectando a su funcionalidad, autonomía y calidad de vida (Larsson et al., 2019).

En los últimos años el sedentarismo ha emergido como un desafío de salud pública a nivel mundial (Raffin et al., 2023; Wullems et al., 2016), este se define como el tiempo que una persona pasa sentada o tumbada con un gasto energético bajo (≤ 1.5 METs) mientras realiza actividades de la vida cotidiana como estar despierto, comer, trabajar, estudiar, coger el transporte o estar en casa, y se identifica como un factor de riesgo para el desarrollo de enfermedades crónicas no transmisibles en personas de todas las edades (Bauman et al., 2012; Bull et al., 2020; Chastin et al., 2021; WHO, 2022). Su prevalencia es especialmente elevada en población adulta y mayor, donde las tasas de inactividad física aumentan debido a factores como la pérdida de capacidad funcional, el acceso limitado a instalaciones o la falta de conciencia sobre los beneficios de mantener un estilo de vida activo (Martins et al., 2021; WHO, 2020a). Además, un estilo de vida sedentario puede acelerar la pérdida de la fuerza muscular e incrementar el riesgo de enfermedades cardiovasculares, afectando negativamente a la calidad de vida (Beaudart et al., 2016; Reid & Fielding, 2012; Schneider et al., 2021). En este sentido, la realización de ejercicio físico puede ayudar a mejorar la salud metabólica al limitar la pérdida de masa muscular, atenuar la pérdida de densidad mineral ósea (DMO) y reducir la incidencia de enfermedades crónicas, además de contribuir a mejorar la sensibilidad a la insulina, la actividad mitocondrial y la función física (Izquierdo et al., 2021; Valenzuela et al., 2019).

Según Guthold et al. (2018) la inactividad física, caracterizada por no alcanzar los niveles de actividad física recomendados (WHO, 2020a), afecta al 27.5% de la población mundial adulta. Se estima que entre 2020-2030 se producirán casi 500 millones de nuevos casos de enfermedades crónicas asociadas a la inactividad física, generando un costo sanitario superior a 300 mil millones de dólares (Santos et al., 2023). Ante este escenario, la adopción de un estilo de vida activo puede contrarrestar los efectos del sedentarismo y de la inactividad física, reduciendo los comportamientos sedentarios y mejorando la salud de la población. Además, otros estudios indican una relación directa no lineal entre el tiempo dedicado a comportamientos sedentarios y un aumento de la mortalidad por todas las causas,

incluso después de ajustar por nivel de actividad física (Leask et al., 2015; Saunders et al., 2020; Wu et al., 2022). De esta manera, las personas que pasan más de 8 horas sentadas al día tienen un mayor riesgo de mortalidad, a menos que su nivel de actividad física sea muy elevado (Ekelund, Brown, et al., 2019; Mo et al., 2023). La probabilidad de efectos negativos aumenta de forma gradual a partir de las 7.5-9 horas de sedentarismo diario, alcanzando un riesgo entre 1.48-2.92 veces mayor cuando el tiempo de comportamiento sedentario supera las 10-12 horas en un día (Ekelund, Tarp, et al., 2019).

De acuerdo con la Encuesta de Hábitos Deportivos en España, aproximadamente seis de cada diez personas mayores de 15 años practicaron deporte en el último año, lo que representa un incremento respecto a años anteriores (Ministerio de Cultura y Deporte, 2022). Sin embargo, Montero-Torreiro et al. (2024) señalan que el nivel de actividad física ha disminuido drásticamente, especialmente en personas mayores. Este comportamiento se vio aún más agravado por la pandemia de COVID-19, que impactó significativamente en los hábitos deportivos de adultos y mayores, reduciendo temporalmente los niveles de actividad física durante el confinamiento y en los meses posteriores (Runacres et al., 2021). Aunque en la actualidad se observa como los niveles de actividad física están aumentando en todas las edades, todavía no se alcanzan los previos a la pandemia (Ministerio de Cultura y Deporte, 2022).

Frente a esta situación, se hace necesario adoptar medidas que fomenten la actividad física regular en población adulta y mayor. La Organización Mundial de la Salud y el "European Working Group on Sarcopenia in Older People 2" (EWGSOP2) subrayan la importancia de realizar ejercicios que mejoren tanto la fuerza como la capacidad cardiovascular (Cruz-Jentoft et al., 2019; WHO, 2022). Se recomienda que las personas adultas y mayores participen en al menos 150 minutos de actividad física moderada o 75 minutos de actividad vigorosa semanalmente, complementados con ejercicios de fortalecimiento muscular dos o más días a la semana (WHO, 2020a). La realización de estas actividades es esencial para preservar la funcionalidad y prevenir la sarcopenia (Abud et al., 2022), contribuyendo a los objetivos del Plan de Acción Mundial sobre Actividad Física 2018-2030 para reducir la inactividad física y fomentar un envejecimiento saludable (WHO, 2018). En este contexto, resulta esencial entender cómo el ejercicio mejora la capacidad cardiovascular, aumenta la fuerza muscular y optimiza la

composición corporal, factores clave para maximizar sus beneficios en esta población (Eckstrom et al., 2020).

La capacidad cardiovascular, que permite al corazón y a los sistemas circulatorio y respiratorio suministrar oxígeno y eliminar residuos metabólicos durante ejercicios prolongados, es esencial para una vida activa y saludable (Li et al., 2020). Las intervenciones de ejercicio aeróbico pueden prevenir la ateroesclerosis relacionada con el envejecimiento y revertirla en individuos con bajos niveles de actividad física, mejorando la función endotelial, reduciendo el estrés oxidativo y preservando la biodisponibilidad del óxido nítrico, lo que mejora la capacidad del cuerpo para manejar las demandas de oxígeno durante el ejercicio y las actividades diarias (Nowak et al., 2018; Ricci & Cunha, 2020; Seals et al., 2019). Además, estas mejoras pueden contribuir a una menor incidencia de enfermedades cardiovasculares y aumentar la capacidad de la persona para realizar esfuerzos físicos, traduciéndose en una mejora en su autonomía y calidad de vida (Izquierdo et al., 2021b; Rossman et al., 2018).

La fuerza muscular resulta esencial para conservar la autonomía y realizar actividades cotidianas, sobre todo en adultos mayores (Marcos-Pardo et al., 2020). El entrenamiento de fuerza tiene la capacidad de aumentar la masa y la fuerza muscular, mejorar la coordinación neuromuscular y aumentar el reclutamiento de unidades motoras, lo que resulta esencial para realizar una contracción muscular óptima (Larsson et al., 2019). Además, el aumento de la masa muscular puede producir beneficios significativos en la masa ósea, el equilibrio hormonal y el metabolismo (Kirk et al., 2020). Estas adaptaciones son fundamentales para prevenir caídas y mejorar el control postural, así como para mantener la capacidad funcional y prevenir la dependencia funcional, especialmente en la edad avanzada (Marcos-Pardo et al., 2019; Shen et al., 2023). Por lo tanto, el incremento de la masa muscular puede mejorar la capacidad funcional, al mismo tiempo que influye sobre la composición corporal, reduciendo el riesgo de enfermedades crónicas relacionadas con el envejecimiento como la osteoporosis o la diabetes (Al-Sofiani et al., 2019).

La composición corporal es un factor clave que influye significativamente en los niveles fisiológicos y metabólicos esenciales para mantener un adecuado estado de salud (Merchant et al., 2021). Se ha señalado que un aumento de la masa grasa puede acelerar la disfunción mitocondrial y el estrés oxidativo, deteriorando la

integridad del ADN mitocondrial y nuclear, comprometiendo la función celular y elevando el riesgo de patologías asociadas a la edad (Tam et al., 2020). Intervenciones como una dieta equilibrada y ejercicio regular pueden optimizar la composición corporal, fomentando un correcto funcionamiento metabólico, mejorando la regulación hormonal y disminuyendo el riesgo de enfermedades crónicas (Colleluori & Villareal, 2021). Además, el ejercicio regular ayuda a incrementar la masa y la fuerza muscular, reducir la grasa corporal y mantener la densidad mineral ósea, lo que contribuye a mejorar la salud y calidad de vida en esta población (Marcos-Pardo et al., 2020; Westcott, 2012).

De todo lo anterior se extrae la importancia de adoptar un estilo de vida activo y resalta la necesidad de explorar métodos de entrenamiento que promuevan un envejecimiento saludable. En este sentido, el incremento de la esperanza de vida y la disminución de la mortalidad plantean un desafío para las sociedades, enfrentándose al reto de mejorar no solo la salud, sino también el bienestar general de las personas (Mitchell & Walker, 2020). A esto se añade que la pandemia de COVID-19 destacó la importancia de realizar de actividad física regular para mejorar la salud física y mental. Durante este periodo la actividad física ayudó a mantener la condición física y desempeñó un papel fundamental en la reducción del estrés, la ansiedad y la depresión, mejorando la calidad de vida de la población (Wang et al., 2023). Sin embargo, las restricciones de movilidad y las políticas de confinamiento, unido al acceso reducido a espacios públicos adecuados, limitaron las posibilidades para realizar ejercicio de una forma efectiva (Sonza et al., 2021). Estos desafíos fueron particularmente significativos en poblaciones vulnerables, como las personas mayores, quienes vieron reducidas sus opciones para realizar ejercicios de una forma segura, reduciendo sus niveles de actividad física (Kirwan et al., 2020; Ministerio de Cultura y Deporte, 2022). Esta situación impulsó la necesidad de buscar soluciones alternativas que se adaptaran a las condiciones y necesidades de la población, como la realización de ejercicio en casa o al aire libre, con el propio peso corporal o el uso de equipamientos sencillos como las bandas elásticas de resistencia o la maquinaria biosaludable (Ghram et al., 2021; Randall, 2023).

El uso de las bandas elásticas de resistencia se ha popularizado en los últimos años, al ser un equipamiento que permite realizar múltiples ejercicios, trabajando los principales grupos musculares, sin necesidad de disponer de grandes espacios

o inversiones (Bårdstu et al., 2020; Ooi et al., 2021). Estudios han comparado el entrenamiento con bandas elásticas y el entrenamiento de fuerza tradicional con pesos libres, encontrando que las bandas elásticas activan los músculos agonistas a niveles similares, lo que sugiere que estas pueden ser tan efectivas como el equipamiento tradicional con maquinaria de fitness para mejorar la activación neuromuscular (Colado & Triplett, 2008; Melchiorri & Rainoldi, 2011).

A pesar de su eficacia, el entrenamiento con bandas elásticas puede presentar ciertas limitaciones, especialmente para personas sin experiencia previa o que necesitan de supervisión técnica. Dado que se trata de un movimiento no guiado y con una resistencia variable, se requiere de supervisión o una técnica adecuada para evitar lesiones y maximizar los beneficios (Andersen et al., 2011; Sibley et al., 2020; Simoneau et al., 2001). Además, la resistencia proporcionada por las bandas podría resultar insuficiente para progresar en la carga de entrenamiento cuando los usuarios alcanzan ciertos niveles de condición física, limitando su utilidad a largo plazo. Sin embargo, estas limitaciones pueden ser fácilmente mitigadas mediante la correcta supervisión y el uso de bandas elásticas de diferentes resistencias (Hostler et al., 2001; Page & Ellenbecker, 2002). De esta manera, las bandas elásticas son especialmente útiles para personas que buscan una forma accesible y sencilla de realizar ejercicio, ya que su uso no requiere de un espacio dedicado o una inversión considerable y se trata de un material portable que permite que la persona pueda incluso viajar y adaptar su lugar de entrenamiento.

Otro de los recursos que han aumentado su popularidad para el entrenamiento de la fuerza muscular en la población adulta y mayor en los últimos años han sido los parques biosaludables, que emergen como una alternativa innovadora que ofrece una solución sencilla, accesible y segura para la práctica de ejercicio físico en espacios al aire libre (Grigoletto et al., 2021). La elección de la maquinaria biosaludable como intervención innovadora se justifica por su capacidad para superar las limitaciones de los materiales tradicionales como la maquinaría de fitness indoor, los pesos libres, las bandas de resistencia o la maquinaria para el entrenamiento cardiovascular, que pueden ser pesados, costosos o requerir un espacio considerable, además de que ofrece la posibilidad de entrenar en espacios al aire libre. Destacar de que las personas adultas y mayores, desde la etapa post-Covid han venido demandando espacios de entrenamiento outdoor.

Los OFE presentan ciertas ventajas en comparación con otros métodos, como su mayor accesibilidad o la capacidad de promover las relaciones sociales, gracias a su instalación en espacios públicos al aire libre (Avers, 2020). Además, los OFE son particularmente sencillos de utilizar, al ser maquinaria guiada y estar equipada con instrucciones de uso (Chow & Wu, 2019). La localización, la facilidad de uso y de acceso a los OFE favorecen la interacción y mejoran la experiencia del usuario, creando un entorno menos intimidante y eliminando barreras de accesibilidad (Grigoletto et al., 2021). El ejercicio regular en OFE puede contribuir a la mejora de la capacidad cardiovascular, fundamental para la prevención de enfermedades cardíacas (Arufe et al., 2013; Chow & Ho, 2018); aumentar la fuerza muscular, mejorando la funcionalidad y reduciendo el riesgo de caídas en personas mayores (Kim et al., 2018; Sales et al., 2017); o mejorar la composición corporal, reduciendo el riesgo de enfermedades metabólicas (Jansson et al., 2019; Marcos-Pardo et al., 2024), fomentando la autonomía e independencia funcional, y permitiendo que las personas se ejerciten a su propio ritmo sin la necesidad de equipos complejos o supervisión.

Sin embargo, su diseño y características hace que se presenten ciertos obstáculos que podrían afectar a su efectividad. La principal limitación de estas máquinas es que utilizan el propio peso corporal del usuario como resistencia, lo cual puede presentar un problema en términos de adaptabilidad y de progresión en la carga de entrenamiento (Chow & Ho, 2018). Para personas con sobrepeso o con un bajo nivel de condición física, esto podría traducirse en una carga excesiva, dificultando una ejecución técnica adecuada, segura y aumentando el riesgo de lesiones. Por otro lado, para individuos con bajo peso, estas máquinas podrían no alcanzar la carga mínima necesaria para que los ejercicios sean efectivos, limitando los posibles beneficios en su condición física y a nivel de salud.

A pesar de la utilidad de estos equipos, existe un número limitado de estudios que hayan analizado su potencial (Marcos-Pardo et al., 2024). Una revisión narrativa reciente sugiere que los OFE podrían tener el potencial de mejorar la salud de los usuarios. Sin embargo, existe una gran carencia de estudios experimentales rigurosos que demuestren sus efectos a medio y largo plazo (Marcos-Pardo et al., 2023). En esta línea, investigaciones previas presentan limitaciones metodológicas como la ausencia de grupos control, muestras pequeñas o el uso de un número reducido de máquinas, predominando las

destinadas a ejercicios cardiovasculares sobre las de entrenamiento de la fuerza muscular (Chow et al., 2021; Kim et al., 2018). Además, estos estudios suelen tener un volumen de entrenamiento reducido o no evalúan variables directamente relacionadas con la salud y el bienestar general de las personas (Marcos-Pardo et al., 2024). Por todo esto, se hace evidente la necesidad de realizar investigaciones más rigurosas que aborden estas limitaciones, explorando nuevas perspectivas teóricas y aplicaciones prácticas.

III – OBJETIVOS

III - OBJETIVOS

3.1. OBJETIVOS GENERALES

1. Evaluar la efectividad y seguridad del entrenamiento con bandas elásticas de resistencia y maquinaria biosaludable sobre la salud de personas adultas y mayores en base a la literatura existente.
2. Analizar el efecto del entrenamiento de fuerza en circuito realizado con maquinaria biosaludable sobre parámetros de salud en personas adultas y mayores.

3.2. OBJETIVOS ESPECÍFICOS

1. Proporcionar recomendaciones para la realización de ejercicios en casa con bandas elásticas de resistencia de manera segura y efectiva en población adulta y mayor.
2. Analizar los efectos sobre la salud del entrenamiento con maquinaria biosaludable en población adulta y mayor, analizando las limitaciones de esta maquinaria y sugiriendo modificaciones para un entrenamiento seguro y efectivo.
3. Diseñar un protocolo para un estudio controlado aleatorizado que analice los efectos del entrenamiento de fuerza-resistencia en circuito con maquinaria biosaludable sobre la condición física, la composición corporal, la funcionalidad, la percepción de salud y calidad de vida en adultos y mayores.
4. Analizar los efectos de un programa de entrenamiento de fuerza-resistencia en circuito realizado con maquinaria biosaludable sobre la salud en adultos y mayores, incluyendo la composición corporal, la condición física y la salud física, así como analizar el efecto de la edad en los resultados encontrados.

3.3. GENERAL OBJECTIVES

1. To evaluate the effectiveness and safety of training with elastic resistance bands and outdoor fitness equipment on the health outcomes of adults and older adults, based on existing literature.
2. To analyze the effect of circuit-based strength training using outdoor fitness equipment on health parameters in adults and older adults.

3.4. SPECIFIC OBJECTIVES

1. To provide recommendations on how older adults can safely and effectively perform elastic resistance training at home.
2. To understand how outdoor fitness equipment can enhance the health of older adults and to analyze the limitations of these machines, suggesting modifications for safer and more effective training.
3. To design the study protocol of a randomised controlled trial to investigate the effects of a circuit resistance training intervention with OFE on relevant physical and psychosocial performance in healthy community-dwelling middle and older adults.
4. To assess the impact of a resistance training program conducted in OFE on health-related variables, including the body composition, physical fitness, and physical health of middle-aged and older adults, as well as analyzing the effect of age on the results found.

IV – HIPÓTESIS

IV -HIPÓTESIS

4.1. HIPÓTESIS GENERALES

1. La literatura existente señalará que el entrenamiento con bandas elásticas de resistencia y maquinaria biosaludable es efectivo y seguro para la mejora de la salud en personas adultas y mayores.
2. El entrenamiento de fuerza en circuito realizado con maquinaria biosaludable mejorará parámetros de salud física y psicológica, la condición física, la composición corporal y previene los efectos adversos del envejecimiento en personas adultas y mayores, en comparación con personas que solo realizan sus actividades diarias.

4.2. HIPÓTESIS ESPECÍFICAS

1. La literatura científica existente sobre el uso de bandas elásticas de resistencia señalará que el entrenamiento de fuerza con este tipo de material es una estrategia efectiva y segura para mantener y mejorar la salud en la población adulta y mayor.
2. Atendiendo a investigaciones previas, el entrenamiento con maquinaria biosaludable tendrá efectos positivos sobre la salud de población adulta y mayor, aunque es posible que se identifiquen ciertas limitaciones respecto a su uso.
3. Se diseñará un protocolo de estudio para un ensayo controlado aleatorizado que valore el efecto del entrenamiento de fuerza en maquinaria biosaludable sobre la salud en personas adultas y mayores. Este protocolo dará pautas específicas sobre la metodología y la planificación del entrenamiento durante la intervención.
4. El entrenamiento de fuerza en circuito realizado con maquinaria biosaludable mejorará la composición corporal, incrementando la masa magra y reduciendo la masa grasa, así como la condición física, aumentando la fuerza muscular y la capacidad funcional de adultos y mayores, teniendo un impacto positivo sobre la salud física y la calidad de

vida. Sin embargo, se espera que el aumento de la edad de los participantes influya negativamente en los efectos obtenidos, evidenciando diferencias en el nivel de mejora según la edad de la población.

4.3. GENERAL HYPOTHESIS

1. The literature will indicate that elastic resistance band training and outdoor fitness equipment training are effective at improving health in adults and older people.
2. Circuit strength training with outdoor fitness equipment will improve physical and psychological health outcomes, physical fitness, body composition and will prevent the adverse effects of ageing in adults and older people, compared to people who only perform their daily activities.

4.4. SPECIFIC HYPOTHESIS

1. The scientific literature on the use of elastic resistance bands will indicate that strength training with this type of material is an effective and safe strategy for health maintenance in adult and older adult.
2. Based on previous research, training with outdoor fitness equipment will have positive effects on the health of the adult and older adults, although some limitations to its use may be identified.
3. A study protocol will be provided for a randomized controlled trial to assess the effect of strength training on outdoor fitness equipment on health in adults and older adults. This protocol will provide specific guidelines on the methodology and training program during the intervention.
4. Circuit strength training on outdoor fitness equipment will improve body composition, increasing lean mass and reducing fat mass, as well as physical fitness, increasing strength and functional capacity in adults and older adults, having a positive impact on physical health and quality of life. However, increasing age of the participants is expected to negatively influence the effects obtained, showing differences in the level of improvement according to the age of the population.

V – MÉTODO Y RESULTADOS

V - MÉTODO Y RESULTADOS

El método y los resultados de la presente tesis doctoral se componen de cuatro artículos científicos publicados en revistas sujetas a revisión por pares. A continuación, se describen las referencias de dichos artículos:

Artículo 1

Marcos-Pardo, P. J., Espeso-García, A., López-Vivancos, A., Abelleira Lamela, T., & Keogh, J. W. L. (2020). COVID-19 and social isolation: A case for why home-based resistance training is needed to maintain musculoskeletal and psychosocial health for older adults. *Journal of Aging and Physical Activity, 29*(2), 353–359. https://doi.org/10.1123/japa.2020-0131

JCR Impact Factor: 1.961; Quartile: Q3; Category: Sport Sciences (65/88).

SJR Impact Factor: 0.684; Quartile: Q2; Category: Physical Therapy, Sports Therapy and Rehabilitation (66/255).

Artículo 2

Marcos-Pardo, P. J., Espeso-García, A., Abelleira-Lamela, T., & Machado, D. R. L. (2023). Optimizing outdoor fitness equipment training for older adults: Benefits and future directions for healthy aging. *Experimental Gerontology, 181*, 112279. https://doi.org/10.1016/j.exger.2023.112279

JCR Impact Factor: 3.3; Quartile: Q2; Category: Geriatrics & Gerontology (27/54).

SJR Impact Factor: 1.051; Quartile: Q2; Category: Aging (17/38).

Artículo 3:

Marcos-Pardo, P.J., Espeso-García, A., Vaquero-Cristóbal, R., Abelleira-Lamela, T., Esparza-Ros, F., & González-Gálvez, N. (2023). Physical and psychological effects of outdoor fitness equipment training on middle-aged and older adults: study protocol of a randomised controlled trial. *BMJ Open Sport & Exercise Medicine*, *9*(4), e001829. https://doi.org/10.1136/bmjsem-2023-001829

Journal Citation Indicator: 3.9; Quartile: Q1; Category: Sport Sciences (13/127).

SJR Impact Factor: 1.253; Quartile: Q1; Category: Physical Therapy, Sports and Rehabilitation (17/241).

Artículo 4:

Marcos-Pardo, P.J., Espeso-García, A., Vaquero-Cristóbal, R., Abelleira-Lamela, T., & González-Gálvez, N. (2024). The Effect of Resistance Training with Outdoor Fitness Equipment on Body Composition, Physical Fitness, and Physical Health of Middle-aged and Older Adults: A Randomized Controlled Trial. *HealthCare, 12*(7), 726. https://doi.org/10.3390/healthcare12070726

JCR Impact Factor: 2.4; Quartile: Q2; Category: Health Policy & Services (49/118).

SJR Impact Factor: 0.606; Quartile: Q2; Category: Health Policy (135/305).

VA - ESTUDIO 1: COVID -19 AND SOCIAL ISOLATION: A CASE FOR WHY HOME-BASED RESISTANCE TRAINING IS NEEDED TO MAINTAIN MUSCULOSKELETAL AND PSYCHOSOCIAL HEALTH FOR OLDER ADULTS

Va - ESTUDIO 1 - COVID-19 and Social Isolation: A Case for Why Home-Based Resistance Training is Needed to Maintain Musculoskeletal and Psychosocial Health for Older Adults

5.1. ABSTRACT

The coronavirus disease outbreak in China has become the world's leading health headline and is causing major panic and public concerns. Public health guidelines in many countries are suggesting that people stay at home to avoid human-to-human transmission of the virus, which may lead to reduced physical activity and greater feelings of isolation. Such effects may be particularly problematic in older adults due to their reduced physical capacities and their potential for increased mental health issues, such as anxiety and depression. A potential way to minimize many of these side effects of stay-at-home guidelines may be progressive home-based resistance training. A simple way to provide progressive overload in home-based resistance training may involve elastic resistance, which has been demonstrated to provide similar benefits to traditional resistance training equipment typically found in gymnasiums. Recommendations on how older adults can safely and effectively perform elastic resistance training at home are provided.

5.2. INTRODUCTION

The coronavirus disease (COVID-19) outbreak in China has become the world's leading health headline and is causing major panic and public concerns. On January 30, 2020, the World Health Organization declared that the new coronavirus outbreak is a public health emergency of international concern (WHO, 2020b). The virus has already had a direct impact on millions of people around the world, posing a health threat of unknown magnitude at the global level. As of March 26, 2020, the pandemic, one of the biggest health crises in recent years whose consequences are still unpredictable, has spread to more than 170 countries, resulting in ~470,000 cases and more than 20,000 deaths. In Spain, the number of positive cases of COVID-19 exceeds 56,000, ranking it as the second highest in Europe, with only Italy having a greater number of confirmed cases. Spain is also currently ranked second in the world in terms of the number of confirmed deaths

from coronavirus. Specifically, Spain has already recorded 4,145 deaths, whereas China has had 3,293 confirmed deaths so far. Italy, with at least 7,500, has already doubled the number (Ministerio de Sanidad del Gobierno de España, 2020). Currently, there is no vaccine for the prevention or treatment of the disease caused by the virus; its origins and the ultimate scope of this pandemic are unknown. The causes or mechanisms of transmission, the incubation period, risk assessments, and effective treatment or intervention options for the virus are also currently poorly understood.

Health authorities in countries such as China, Italy, the United States, Australia, and Spain, among others, have advised the public to reduce travel, stay home, and maintain social distancing when in public as a basic means of limiting people's exposure to the virus. Unfortunately, travel restrictions and directives against participation in outdoor activities, including sport, physical activity, and regular exercise, will inevitably disrupt the daily activities of tens of millions of people.

5.3. ISSUES FOR OLDER ADULTS

While containing the virus as quickly as possible is the urgent public health priority, there have been few public health guidelines as to what people, especially older adults, can or should do in terms of maintaining their daily exercise or physical activity routines. This is a concern as a large percentage of adults and older people do not meet the global recommendations for physical activity, especially resistance training, needed to reduce morbidity and maintain functional capacity (Sun et al., 2013; Winett et al., 2008). Arguably, staying home, while a safe measure, may have unintended negative consequences since such efforts to avoid human to human transmission of the virus may lead to reduced physical activity (Chen et al., 2020). Long hours in the home may lead to increased sedentary behavior and inactivity or little physical activity and long periods of sitting and lying down, all of which increase the risk of developing or exacerbating chronic diseases (Owen et al., 2010). Staying at home can also be socially isolating, particularly for older adults who may already have a reduced network of friends compared with younger adults and children (Freedman & Nicolle, 2020; Santini et al., 2020). This isolation for older adults may exacerbate issues related to their mental health, with increased

levels of anxiety and depression the likely result (Freedman & Nicolle, 2020; Santini et al., 2020).

As many older adults are already highly concerned about contracting COVID-19 and the serious adverse events or even death that may result from contracting the virus, such self-isolation has the potential to cause a host of psychosocial and physical problems. Aging is a complex process characterized by structural and physiological changes in various systems of the human body that can compromise anthropometric (e.g., muscle mass, regional adiposity) and neurovascular (muscle strength and motor control) variables and reduce the physical independence of older adults (Chodzko-Zajko et al., 2009).

Aging is associated with a progressive decrease of muscle mass and a reduced capacity of the muscles to produce strength and power that, ultimately, results in a decline in the ability to perform a range of functional tasks, including standing up from a chair or walking, particularly upstairs or while carrying additional handheld loads (Aagaard et al., 2010; Guizelini et al., 2018). The ability of the lower extremity muscles to generate force and muscular power is a fundamental component for maintaining balance (Li et al., 2018), with the assessment of the force–velocity ratio advocated to determine the maximum capacities of older adults to produce force, speed, and power (Marcos-Pardo et al., 2019). These age-related losses of muscle mass, strength, and physical performance are now referred to as the geriatric syndrome, sarcopenia (Cruz-Jentoft et al., 2019). These sarcopenia-related changes may increase the risk of falls and fractures, which could contribute to the loss of independence and deterioration in the physical function and quality of life of older adults (Gadelha et al., 2018; Trombetti et al., 2016; Zhang et al., 2018).

This relative disability and increase in falls and fall-related fractures may require additional health care services and costs, with the available health care services and funding already stretched due to the COVID-19 pandemic. In particular, public health programs need to ensure that older adults can maintain their levels of muscular strength to minimize these major health care cost implications. Specifically, Pinedo-Villanueva et al. (2019) reported that each older adult with muscle weakness (defined as having handgrip strength < 26 kg for men or < 16 kg for women) cost the U.K. healthcare system an additional U.S. $3,372 at current exchange rates per year (Pinedo-Villanueva et al., 2019).

5.4. EXERCISE BENEFITS FOR OLDER ADULTS

One way to counteract the potential psychosocial and physical deterioration as well as increased health care costs that may be associated with the reduced level of physical activity that may occur with social distancing and stay-at-home policies currently being advocated by many governments is exercise (Henwood et al., 2019; Raafs et al., 2020); although, in the current climate, it is recommended that such exercise be home based. Exercise at home using various safe, simple, and easily implementable exercises is well suited to avoid the airborne coronavirus and maintain fitness levels. Such forms of exercise may include, but are not limited to, strengthening (resistance training) exercises, activities for balance and control, cardiovascular activity, stretching exercises, or a combination of these (Chen et al., 2020).

Resistance training is widely recommended to slow down the negative effects of aging in sarcopenia-related decline because it is considered the most effective method for improving muscle mass, strength, and power, which are key to counteracting disability in older adults (Cadore et al., 2014; Chodzko-Zajko, 2014; Marcos-Pardo, Orquin-Castrillón, et al., 2019). In addition, individuals undertaking resistance training demonstrate an increased motivation and adherence to training (Kekäläinen et al., 2018; Marcos-Pardo et al., 2018). Due to the confined state of adults and older people, safe and effective strategies for resistance training at home are needed.

Home resistance training with minimal supervision is a safe, effective, and low-cost exercise option for increasing muscle strength and functional capacity in healthy older adults as well as older subjects with a variety of health conditions who can overcome some of the common barriers to exercise (Henwood et al., 2019). It is an attractive, viable, and, from a public health perspective, feasible alternative to supervised resistance training in gymnasiums (Kis et al., 2019), which are now largely unavailable due to the risk of spreading the virus to vulnerable older adults. Training with small overload materials, such as bottles or dumbbells available at home, as well as elastic resistance training are effective resistance training materials and easy to use for this age group (Andersen et al., 2011; Jensen et al., 2014). Elastic resistance exercises are often used during unsupervised home training wherein the exercise professional or instructional web-based video provides the patient with

initial instruction on how to perform the exercise. These instructions may focus on exercise prescription variables including loading, range of motion, number of repetitions, sets, pauses between exercises, and proper starting position (Faber et al., 2015).

The use of elastic resistance training during confinement has multiple advantages for training at home; the elastic bands are easy to use, can be adjusted to different loads, and are less expensive and do not take up as much space as dumbbells or specialized resistance training machines. Multiple studies have compared elastic band training with traditional free weights-based resistance training (e.g., dumbbells) in terms of the muscle activation levels (Andersen et al., 2010; Colado et al., 2010; Melchiorri & Rainoldi, 2011). These studies generally demonstrated that exercise training with elastic resistance activates the agonists at a similar level to that achieved with dumbbells or weight machines, suggesting that bands can be as effective in improving strength and reducing muscle loss as more traditional resistance training tools. Such a viewpoint is supported by a number of training studies demonstrating similarity in training related adaptations to elastic and traditional resistance training in middle-aged to older healthy adults (Lima et al., 2018; Mikesky et al., 1994; Yasuda et al., 2016).

5.5. PSYCHOSOCIAL BENEFITS OF RESISTANCE EXERCISE FOR OLDER ADULTS

The National Strength and Conditioning Association has recently released a position statement (Fragala et al., 2019) outlining the physical and psychosocial benefits of resistance training for older adults. A major psychosocial benefit is improved quality of life, which can be defined as the subjective view of an individual about their general well-being and ability to participate in enjoyable life events (Dionigi, 2007; Kekäläinen, Kokko, Sipilä, et al., 2018; Pedersen et al., 2017). These improvements in older adults' quality of life with resistance training may reflect a range of other psychosocial benefits, including improved self-esteem/confidence (O'Connor et al., 2010), sense of coherence (Kekäläinen, Kokko, Sipilä, et al., 2018), and sleep quality (O'Connor et al., 2010) as well as a reduction in depression and/or anxiety (O'Connor et al., 2010; Tsutsumi et al., 1997). It has even been reported that the improvements in depression that may be observed with resistance training are similar in magnitude to standard pharmacotherapy

interventions for older adults with depression (Singh et al., 2005). Furthermore, there is even evidence that some forms of resistance training improve older adults' cognitive function, with enhancements in executive function accompanied by functional changes in the frontal lobe (Herold et al., 2019). Such improvements in cognitive function may even have the potential to offset some of the behavioral issues associated with advanced age dementia (Chen et al., 2017).

Therefore, exercise during quarantine can help to combat many of the negative physical and mental consequences of the social isolation policies adopted in many countries due to the COVID-19 pandemic (Jiménez-Pavón et al., 2020). The participation of older people in resistance training programs can serve as a prophylactic to delay or prevent the appearance of biological aging. The physical and psychological benefits have been demonstrated with a minimum dose of 2 days a week and 60 min of training (Fisher et al., 2017).

5.6. HOME ELASTIC RESISTANCE TRAINING RECOMMENDATIONS

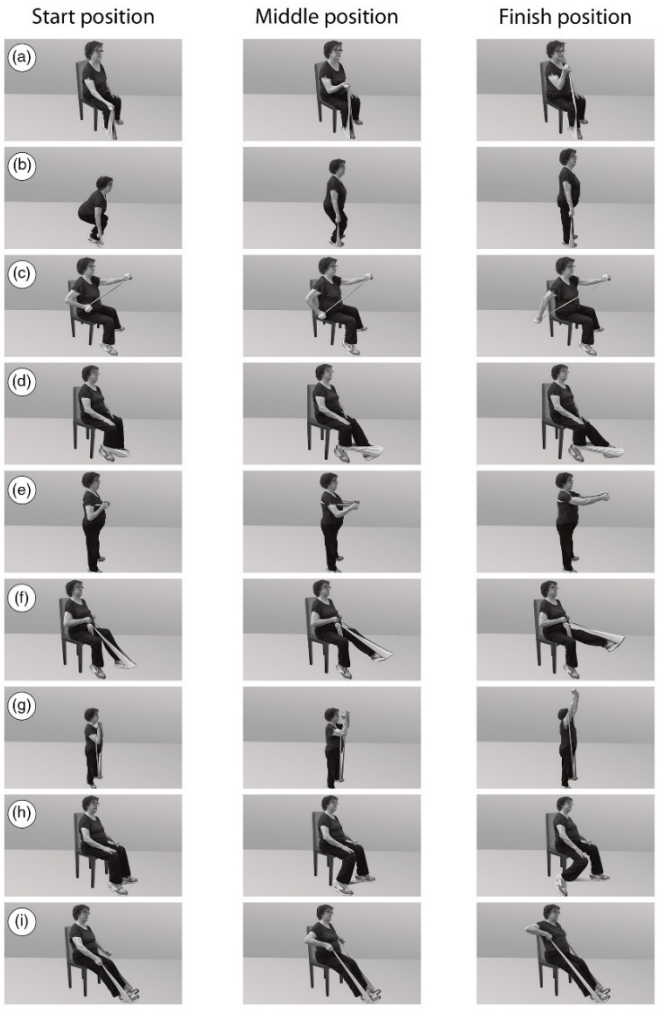
Consistent with exercise guidelines for older adults (Fragala et al., 2019), it would be recommended that older people perform elastic resistance training 2–3 days a week, with such sessions, perhaps, starting off with a duration of 15 or 20 min, but progressing up to 45–60 min. In the first few training sessions, the older adult should become familiar with the different movements, learn how the use of elastics or other forms of resistance (e.g., additional household objects) increases the difficulty of the exercise, and become comfortable with the potential delayed-onset muscle soreness that may occur for a few days postexercise.

The muscle groups and movements to be trained should focus on movements that replicate many common activities of daily living and involve the major trunk and limb muscle groups. These exercises should seek to improve lower body muscle mass, strength, and power as well as balance so that the older adult can minimize their fall risk and maintain their independence in performing common activities such as the sit-to-stand movement and walking, particularly up or down stairs or carrying additional loads, such as groceries. Older adults also need to maintain or improve upper body strength so that they can continue to hold loads in their hands, lift objects from lower to higher positions, such as onto shelves, and so that they are able to get off the floor if they experience a fall. Each elastic

resistance training session should consist of a warm-up at the beginning and general stretching at the end. In particular, we would recommend that the following movements be performed with adequate resistance: (a) elbow curl, (b) squat, (c) elbow extension, (d) knee extension, (e) chest press, (f) leg press, (g) shoulder overhead press, (h) knee curl, and (i) shoulder seated row. An example of the execution of the elastic resistance training can be seen in Figure 1.

Figure 1

Home elastic resistance training exercises

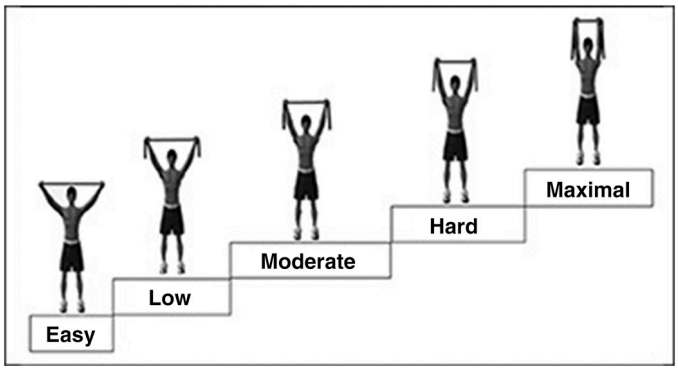


Note. (a) Elbow curl, (b) squat, (c) elbow extension, (d) knee extension, (e) chest press, (f) leg press, (g) shoulder overhead press, (h) knee curl, and (i) shoulder seated row.

The resistance of the elastics training varies from brand to brand and differs by color. Each color offers a different level of resistance to the practitioner. It is very important that, for the safety and effectiveness of the training, the practitioner is familiar with the load (strength of the band), the range of motion including the starting and finishing positions, the number of repetitions per set, and the optimal speed of execution. To control the intensity of exercise with elastic bands, it is advisable to use the Resistance Intensity Scale for Exercise (RISE) in older people (Colado et al., 2020). The RISE scale (see Figure 2) is a valid method for assessing the perceived exertion during resistance exercises performed with elastic bands, which better discriminates in older adults between medium and low intensities than the Exercise Scale of Perceived Exertion (Colado et al., 2012, 2018).

Figure 2

RISE in older people



Note. This pictorial demonstrates how the intensity of the exercise can be increased from easy to maximal by placing the hands closer together on the exercise band. In order to standardize this progressive increase in intensity, it is recommended to mark set distances on the bands. When the required number of repetitions and sets are performed with a given intensity, progression of the exercise can be achieved by placing the hands on the next closer marked distance. RISE = Resistance Intensity Scale for Exercise (Colado et al., 2020).

One way to perform the resistance training program that may also provide some cardiovascular health benefit, which is also important because of the potential for reduced opportunities for cardiovascular exercise, such as walking, during self-isolation, is to perform the resistance training exercises in a circuit training format

(Fritz et al., 2018; Souza et al., 2019). The following recommendations for how the elastic resistance training exercises may be performed, progressed, and incorporated into a circuit format for older adults are based on the literature (Colado et al., 2020; de Oliveira et al., 2020; Fritz et al., 2018; Krause et al., 2019; Osuka et al., 2019; Rieping et al., 2019; Silva et al., 2018; Souza et al., 2019). An older adult with little resistance training experience may initially perform one to two series of the circuit with a load that allows 12–15 repetitions per set at a low to moderate level effort on the RISE. As each repetition should be performed under control with a 2-s concentric (lifting the weight) and 2-s eccentric (lowering the weight) phase, each set of an exercise may last up to 60 s. The older adult can increase the intensity of the exercises as assessed by the RISE, increasing toward a perception of hard level effort between the second and fourth week. After 4 weeks of training, it is advisable to progressively increase the number of training series, ultimately looking to perform three or four series of the exercise circuit. As the weeks go by, and the older adult adapts to the load, he or she should, optionally, increase the repetitions or increase the load, in this case changing to another elastic of greater resistance. Older adults with some resistance training experience can start with a moderate intensity level with a higher resistance elastic and perform 10–12 repetitions per series with a hard level of effort perception by performing three or four sets of training, progressing up to 3–4 days a week.

Where possible, we recommend older adults seek some supervision from an exercise specialist with experience in working with older adults. Nowadays, a host of telehealth/video conferences can be incorporated whereby these exercise specialists can help older adults to safely and effectively perform these home-based progressive resistance training sessions.

5.7. CONCLUSIONS

Following these recommendations can help during the confinement period to reduce the loss of muscle mass and strength, control and/or reduce body weight, avoid the accumulation of fatty tissue, and combat the occurrence of or reduce existing chronic diseases in adults and older people. Home resistance training using elastic materials is a beneficial and necessary option for the maintenance of musculoskeletal and psychosocial health.

VB - ESTUDIO 2: OPTIMIZING OUTDOOR FITNESS EQUIPMENT TRAINING FOR OLDER ADULTS: BENEFITS AND FUTURE DIRECTIONS FOR HEALTHY AGING

Vb - ESTUDIO 2: Optimizing Outdoor Fitness Equipment Training for Older Adults: Benefits and Future Directions for Healthy Aging

5.8. ABSTRACT

Regular physical activity is vital for the health and disease prevention of older adults. Outdoor fitness equipment has gained popularity for natural exercise spaces among middle-aged and older individuals.

This narrative review demonstrates that these programs have the potential to improve cardiovascular health, muscle strength, flexibility, balance, and reduce falls, while also enhancing quality of life, alleviating depression, and anxiety, and boosting self-esteem. However, our understanding is hindered by limited rigorous experimental studies.

Future directions include implementing standardized measurements, conducting long-term studies, and addressing equipment limitations to enable better adjustment of training intensity and promote correct postures on machines.

New, more rigorous research is needed to comprehensively understand the psychophysiological and social effects on health. Additionally, suggested modifications could render the machines more effective and safer. The primary objective is to enhance this type of machinery to encourage its use in outdoor spaces, thus aiding adults and older individuals in achieving overall health and enjoying a healthy aging process.

5.9. INTRODUCTION

For more than 20 years, we have had scientific evidence of the role of physical activity in the primary prevention of cardiovascular disease, diabetes, and some types of cancer (Brown et al., 2007). According to the World Health Organization (WHO), physical activity can reduce the risk of developing chronic diseases such as heart disease, stroke, diabetes, and some cancers by as much as 30–40% in older adults (WHO, 2015a). Regular physical activity is essential for maintaining good health and preventing chronic diseases among older adults, different studies have been demonstrated to decrease morbidity and mortality by reducing the risk of heart disease, diabetes, high blood pressure, colon cancer, depression/anxiety, and

weight gain while promoting and maintaining healthy bones, muscles, and joints (Anderson & Durstine, 2019; Paluch et al., 2022; Thacker et al., 2005; Warburton et al., 2006). Physical activity is advised to attain cardiometabolic advantages and to safeguard or enhance bone health, particularly for older adults with an elevated risk of fractures (Wherry et al., 2022). Consistent process of aging and could potentially serve as both a preventative measure and treatment option for numerous musculoskeletal disorders (Ciolac & Rodrigues-da-Silva, 2016). The decline in skeletal muscle mass, decrease in motor unit discharge rate, and diminished function are mainly linked with the process of aging. This can be classified as either sarcopenia, which refers to the age-related loss of skeletal muscle mass and function, or dynapenia, which is characterized by the age-associated reduction in muscle strength that is not caused by neurological or muscular diseases (Maestroni et al., 2020). Mobility and physical activity of the upper and lower extremities decrease with age (Tatangelo et al., 2022), leading to sarcopenia and loss of muscle strength, so strength training is very important. As a result of the growing number of sedentary jobs and increased reliance on motorized transportation, leisure-time physical activity has become a crucial factor in achieving recommended levels of physical activity worldwide. Participation in leisure-time physical activity can occur in various community settings, such as nearby parks, which are often available to the public at little or no cost (Edwards & Tsouros, 2006).

Public spaces are optimal for promoting physical activity as they comprise green spaces and structures (e.g., playgrounds and outdoor fitness equipment) that are purpose-built to foster physical activity (Bedimo-Rung et al., 2005; García de Jalón et al., 2021; McKenzie et al., 2006). Physical activity in the outdoors spaces can provide benefits for pulmonary, cardiovascular, cognitive, and systemic health (Giles & Koehle, 2014). Few studies have examined the benefits of outdoor fitness equipment training for older adults (Grigoletto et al., 2021; Jansson, Lubans, Smith, et al., 2019). Thus, this narrative review aimed to contextualize the psychophysiological and social advantages of such training. Then, our primary objective was to understand how outdoor fitness equipment can enhance the health of older people. The secondary objective was to analyze the limitations of the machines and suggest modifications for safer and more effective training.

5.10. METHODS

5.10.1. Eligibility Criteria

The selection of scientific studies was based on the following inclusion criteria: a) experimental or quasi-experimental designs, systematic reviews, study protocols or observational studies; b) intervention based on the systematic performance of outdoor fitness equipment. We applied the exclusion criteria established in previous reviews (Bustamante-Sanchez et al., 2022; Clemente-Suárez, Navarro-Jiménez, Moreno-Luna, et al., 2021; Clemente-Suárez, Navarro-Jiménez, Ruisoto, et al., 2021): a. Analysis conducted outside of the designated time frame; b. Topics covered that were not within the scope of the review; c. Utilized unpublished materials such as conference proceedings, abstracts, and PhD dissertations.

5.10.2. Search Methods and Strategies for Research Identification

In order to achieve our research goal, we carried out a comprehensive evaluation and analysis by scrutinizing primary sources like scholarly research and secondary sources including databases, web pages, and bibliographic indexes, using the same procedures as those applied in previous critical narrative reviews. (Bustamante-Sánchez et al., 2022; Clemente-Suárez, Navarro-Jiménez, Jiménez, et al., 2021; Clemente-Suárez, Navarro-Jiménez, Moreno-Luna, et al., 2021; Clemente-Suárez, Navarro-Jiménez, Ruisoto, et al., 2021). Peer-reviewed articles published in the English language were acquired via online data base searches of the following data bases: EBSCO, SPORT discus, Medline, PsycINFO, Web of Science and Scopus searching for MeSH-compliant keywords such as: (outdoor fitness equipment OR outdoor gyms OR bio-healthy parks OR outdoor exercise equipment OR outdoor green spaces OR senior exercise park OR outdoor exercise park OR outdoor gyms OR outdoor fitness equipment in parks OR fitness equipment in public parks OR outdoor playground equipment OR outdoor gym resistance training OR fitness parks). The search encompassed time frames from 2000 to June 2023. Research endeavors that documented the effectiveness of utilizing outdoor fitness equipment use for physical activity, fitness, or health related results, as well as portrayals of outdoor gyms and their users, met the criteria for inclusion.

5.10.3. Study Selection and Data Extraction

We included studies that met rigorous scientific methodological standards and were relevant to the subsections addressed in this review. Data analysis was carried out by the review's four authors. The principal investigator assessed the eligibility of the studies according to their title and abstract in a first review, with an assistant in a second review to jointly verify these criteria and the results obtained. In this second review, the full text of the articles was reviewed. Research that did not meet the inclusion and exclusion criteria was excluded.

5.11. WHY DID OUTDOOR FITNESS EQUIPMENT SPACES EMERGE?

The idea of creating outdoor fitness equipment spaces began to gain popularity in the 1990s and 2000s, as more research was conducted on the health benefits of physical activity and the importance of access to green spaces (Takano et al., 2002). In 2009, Europe introduced this new type of exercise space which was designed specifically to improve muscular strength, flexibility, coordination, and balance in a fun and engaging way. It was built with the intention of encouraging physical activity among older adults by providing an accessible and enjoyable environment for exercise (Sales et al., 2015).

Outdoor fitness equipment spaces have emerged as a response to the growing interest in promoting physical activity and healthy lifestyles. Green spaces, such as parks or public gardens, are safe, accessible, and attractive environments that generally allow people to be physically active (Gladwell et al., 2013; Mytton et al., 2012; Vich et al., 2021). In particular, the concept of "green exercise" emerged, which refers to physical activity undertaken in natural environments, such as parks or forests (Barton & Pretty, 2010; Pretty et al., 2005, 2007). Outdoor fitness equipment spaces typically feature a range of exercise equipment that is designed to be used in an outdoor setting, such as resistance machines, ellipticals, and other cardio machines.

Outdoor fitness equipment is usually installed in municipal and public parks and places, residential complexes, resorts, schools, and beaches and should even be installed in health centers, at the doors of hospitals, women's social centers, old people's homes, and geriatric residences. Outdoor spaces and parks are ideal places to promote physical activity, they are freely accessible, and most of the users

observed in the studies in this review performed with moderate to vigorous intensity (Joseph & Maddock, 2016).

Creating an age-friendly environment is a crucial approach towards promoting healthy aging. The WHO Global Network for Age-friendly Cities and Communities Network is a clear example of this. As a response to global population aging and rapid urbanization, this Network focuses on action at the local level that fosters the full participation of older people in community life and promotes healthy and active aging. Despite this, this recent study affirms the scarcity of studies that measure the impact of training with outdoor fitness equipment and the use of an outdoor multi-sports court on physical activity with different age groups and evidences the need to improve these spaces and this equipment (Veitch et al., 2021).

To achieve this, it is necessary to encourage people of all ages to engage in outdoor community activities. This can be done by designing public or urban spaces that are friendly to older adults, making them more accessible and accommodating for people of all ages to participate in physical activities (Levinger et al., 2018; Pleson et al., 2014). Research has shown that older adults perceive outdoor fitness equipment in parks to contribute to their overall health promotion, providing not only physical but also social and psychological benefits (Chow, 2013). Furthermore, in addition to physical activity, it's important to recognize other essential benefits of park use, including psychological, social, economic, and environmental aspects (Bedimo- Rung et al., 2005).

This "outdoor fitness equipment" (Abelleira-Lamela et al., 2021; Chow et al., 2017; Chow & Ho, 2018; Chow & Wu, 2019; Chow et al., 2021; Liu et al., 2020) is also known as "bio-healthy parks" (Arufe et al., 2013), "outdoor exercise equipment" (Leavy et al., 2022; Sami et al., 2020), "outdoor green spaces" (Czembrowski et al., 2019; Pleson et al., 2014; Takano et al., 2002), "senior exercise park" (Levinger et al., 2018; Ng et al., 2023), "outdoor exercise park" (Ng et al., 2021), "outdoor fitness equipment in parks" (Chow, 2013; Liu et al., 2020), "outdoor gyms" (Cranney et al., 2019; Lee et al., 2018; Stride et al., 2017), "fitness equipment in public parks" (Copeland et al., 2017), "outdoor playground equipment" (Grozdanovic et al., 2014), "outdoor gym resistance training" (Plotnikoff et al., 2023) or simply "fitness parks" (Copeland et al., 2017).

Outdoor fitness equipment, such as exercise equipment is becoming increasingly popular as a way for older adults to be physically active in natural settings. These programs have the potential to provide older adults with a fun, free and accessible way to improve their health. However, there is still a lack of research on the effects of outdoor fitness equipment programs on psychophysiological and social health in older adults (Ng et al., 2021). A strategic objective of public health policies should be to prevent the diseases that cause the most deaths, identifying the main diseases that shorten the lives of older people, their geographical variability, and the associated factors. Promoting healthy aging would save inappropriate polymedication and its risks, as well as considerable drug costs to the healthcare system (Mangin et al., 2018; Rambhade et al., 2012). Thus, a recent study, highlights the use of a smartphone application with standardized workouts adapted to 12 outdoor gyms and an introductory session, where participants are informed of the importance of performing at least 2 workouts per week in outdoor fitness parks to obtain health benefits (Plotnikoff et al., 2023).

Outdoor fitness equipment spaces are a public solution to promote the wellness and health of adults, middle-aged and older adults, and other age groups through exercise. In addition, they are a way for institutions to meet their objectives, raise awareness of the importance of care for health and maintenance of physical fitness, improve quality of life, provide meeting places and fun for all, and help preserve municipal green areas, all free of charge.

5.12. PHYSIOLOGICAL HEALTH BENEFITS OF TRAINING WITH OUTDOOR FITNESS EQUIPMENT

Training with outdoor fitness equipment has become increasingly popular, particularly among older adults. There is growing interest in understanding the physiological health benefits of this training, including improvements in cardiovascular health, muscle strength, flexibility, and balance. In this subtopic, we will explore some of the various physiological health benefits associated with outdoor fitness equipment training.

- Improved muscle mass and strength: Studies have shown that outdoor fitness equipment training can lead to improvements in muscle mass and strength in older adults (Chow et al., 2017; Chow et

al., 2021; Grigoletto et al., 2021; Jansson, Lubans, Duncan, et al., 2019; Jansson, Lubans, Smith, et al., 2019; Kim et al., 2018; Sales et al., 2015; Sales et al., 2018).

- Improved balance, coordination, and physical function: Regular participation in outdoor fitness equipment training can help older adults improve balance and coordination, which can reduce the risk of falls (Chow et al., 2017; Jansson, Lubans, Smith, et al., 2019; Sales et al., 2015, 2016, 2018).
- Improved cardiovascular health: Studies have found that participating in outdoor fitness equipment training can lead to improved cardiovascular health (Chow & Ho, 2018; Chow et al., 2021; Grigoletto et al., 2021; Jansson, Lubans, Smith, et al., 2019; Kim et al., 2018; Sales et al., 2015).
- Improved flexibility: Studies have found that participating in outdoor fitness equipment training can lead to improved flexibility (Chow et al., 2017, 2021; Sales et al., 2018).

In Addition, in this recent study, resistance training intervention with outdoor fitness equipment resulted in improved self-assessment and training self-efficacy. Although conducted primarily during a global pandemic, this study shows the population health potential of using mhealth technology and utilizing outdoor fitness training spaces for the general population (Plotnikoff et al., 2023).

It is important to note that the effects of resistance training with outdoor fitness equipment may be influenced by a variety of factors, such as the specific type of equipment used, the intensity and frequency of the program, and the characteristics of the older adults participating. More research is needed to fully understand the benefits and challenges of these types of programs, particularly their long-term effects.

5.13. PSYCHOLOGICAL AND SOCIAL HEALTH BENEFITS OF TRAINING WITH OUTDOOR FITNESS EQUIPMENT

Despite the scarcity of studies on the subject, there is also evidence of psychological and social health benefits associated with outdoor fitness equipment training. The social aspect of exercising in a community setting can lead to increased socialization and a sense of belonging (Davis et al., 2021; Komatsu et al., 2017; Suragarn et al., 2021). In this subtopic, we will explore the psychological and social health benefits of training with outdoor fitness equipment.

- Reduced symptoms of depression and anxiety: Older adults who participate in outdoor fitness equipment training have reported reduced symptoms of depression and anxiety (Sales et al., 2018).
- Reduced fear of falling and improved self-perception: A study has also shown that participation in outdoor fitness equipment training can lead to reducing fear of falling and improved self-perception (Sales et al., 2015).
- Increased social participation: Studies have shown that participation in outdoor fitness equipment training can improve social relations (Chow et al., 2017; Furber et al., 2014; Sales et al., 2015, 2018; Stride et al., 2017).
- Increased mood and self-esteem and self-efficacy: A study has also shown that participation in outdoor fitness equipment training can lead to increased self-esteem and self-efficacy among older adults (Thompson et al., 2011).
- Improved positive impacts on well-being: A study has also shown that participation in outdoor fitness equipment training can lead to an increased sense of well-being (Bowler et al., 2010; Sales et al., 2015).
- Improved quality of life: Other studies have shown that participation in outdoor fitness equipment training can lead to improved quality of life perception (Sales et al., 2015).

Table 1 shows the characteristics of the different studies.

Table 1

Characteristics of the different studies

Studies	Type	Variables	Frequency	Exercise prescription	Duration	Instrument/test
Bowler et al. (2010)	Systematic review	-	-	-	-	-
Chow et al. (2021)	Intervention study	Cardiorespiratory	5 days/ week	Operation tempo 60 bpm	40 min.	- 2 min. Step test
		Muscle strength	2 days/ week	Week 1–6, 8 reps 3 sets/ Week 7–12, 12 reps 3 sets	10 min.	- Hand grip test - 30 s chair stand
		Flexibility	2 days/ week	Per stretching time for 30 s/	10 min.	- Back scratch
		Balance	2 days/ week	Week 1–4, 2 ft for 10 min Week 5–8, 2 ft for 10 min, 1 ft for 2 min Week 6–12, 2 ft for 6 min, 1 ft for 4 min	10 min.	- Single leg stand - 8 ft up and go
Chow et al. (2017)	Observational study	-	-	-	-	- Observing Play and Recreation in Communities (SOPARC questionnaire) - Peak Hour Observation Using Video Camera
Furber et al. (2014)	Intervention study	-	-	-	-	- Face-to-face questionnaire
Grigoletto et al. (2021)	Systematic review	-	-	-	-	-
Jansson, Lubans, Duncan, et al. (2019)	Systematic review	-	-	-	-	-
Jansson, Lubans, Smith, et al. (2019)	Observational study	-	-	-	-	- Observing Play and Recreation in Communities (SOPARC questionnaire)

Sales et al. (2015)	Study protocol	Muscle strength Balance Coordination Flexibility	2 days/ week	Level 1 to 9 Level 1 to 13 Level 1 to 3 Level 1 to 11 The intensity of each level is explained in the document. Week number 1 to 18/ set time 60 s to 90s/ rest time 60 s to change over and rest to 30 s change over and rest	60–90 min.	- Functional Reach Test - Static Balance Standing - Step test - Timed Up and Go test - Hand grip strength test - 2 min. Walk test - Lower limb strength - Strength of the knee extensor muscles - Spatio-Temporal Gait Parameters - Short Form (12) Health Survey Version 2 (SF-12v2™) - The Incidental and Planned Activity Questionnaire (IPAQ) - The falls efficacy scale (Short FES–I) questionnaire - Falls and physical activity calendar
Sales et al. (2016)	Intervention study	Muscle strength Balance Coordination Flexibility	2 days/ week	5 to 10 min of warm-up exercises 45 to 75 min on the equipment stations 5 to10 min of cool-down exercises The exercise classes were circuit based with the warm-up and cool-down exercises being performed in a group and the core part of the session being carried out in training pairs. The intensity of each level is explained in the document.	60–90 min.	- The Balance Outcome Measure for Elder Rehabilitation (BOOMER) - Single leg stance test standing on the dominant leg with eyes open was used to measure static balance - Hand grip strength test - 2 min. Walk test - 30-s sit-to-stand test - Knee extensor muscles test - Gait speed test - Short Form (12) Health Survey Version 2 (SF-12v2) - Falls and physical activity calendar

Sales et al. (2018)	Intervention study	Muscle strength Balance Coordination Flexibility	2 days/ week	5 to 10 min of warm-up exercises 45 to 75 min on the equipment stations 5 to10 min of cool-down exercises The exercise classes were circuit based with the warm-up and cool-down exercises being performed in a group and the core part of the session being carried out in training pairs. The intensity of each level is explained in the document.	60–90 min.	- Face-to-face interview about confidence and well-being, depression symptom, social interaction, supervision, frequency, duration, progression of exercises, level of difficulty of exercises, changes to their life in general, and general level of satisfaction
Stride et al. (2017)	Observational study	Cardiorespiratory Strength Balance Flexibility	-	12 separate equipment pieces on a soft rubber surface providing aerobic, strength, balance, and flexibility exercise. Park users were free to use the outdoor fitness machines.	-	Interview questions included: place of usual exercise; frequency and purpose of park use; frequency and purpose of outdoor gym use; preferred equipment pieces; enablers and barriers to outdoor gym use; physical activity (using the validated 3Q-PA) and demographics
Vancampfort et al. (2011)	Systematic review	-	-	-	-	-

5.14. DISCUSSION AND FUTURE DIRECTIONS

Recent studies indicate that current outdoor fitness equipment is mostly used by the older population (Chow et al., 2017; Veitch et al., 2021). Another recent systematic review indicates that there is inconclusive evidence of the benefits of longitudinal outdoor versus indoor exercise, due to a high risk of bias in most articles and a need for more rigorous trials and more complete reporting (Noseworthy et al., 2023). This review with meta-analysis shows that older adults value the health and social interaction benefits of using outdoor exercise parks, but the findings should be interpreted with caution due to small sample sizes and a limited number of studies (Ng et al., 2021). In addition, quality of life and life satisfaction are very important aspects in the older people, one of the important determinants for to improve the quality of life is the adoption of sports practice, as well as the creation of a conducive social environment and the promotion of conviviality, which have a significant influence on the adoption of a healthy lifestyle, particularly in terms of commitment to physical activity and sports (Parra-Rizo et al., 2022). Therefore, training in outdoor fitness equipment can promote engagement in the practice and socialization, which can lead to the creation of a healthy lifestyle. Also, it is essential to consider several variables that affect the perception of self-satisfaction with health in the older population, such as well-developed functional, physical and psychological capacities, along with the regular practice of physical activity (Agustí et al., 2023), and properly designed training programs with outdoor fitness equipment can favor the improvement of functional, physical and psychological capacity.

A rigorous randomized controlled trial study indicates that there were no significant changes between the experimental group that trained with outdoor fitness equipment and the control group and that the possible reasons for the limited training effects could be the lack of resistance components and the diversity of the design of this equipment (Liu et al., 2020), this study, in contrast to the studies included in Table 1 that show physical, psychological or social health benefits of training with outdoor fitness equipment, supports the need for more rigorous studies with a better protocol to control the intensity of training and where a progression in the intensity of training loads is planned. These findings suggest the

need for further research and improvements in outdoor fitness equipment design to optimize training outcomes. One approach could be to conduct studies comparing the effectiveness of different types of outdoor fitness equipment and their impact on training outcomes. Additionally, feedback from older adults who regularly use outdoor fitness equipment could be collected to identify specific design features that are most beneficial and areas for improvement. This approach can help ensure that the new designs are more effective, user friendly, and enjoyable for older adults, leading to greater adherence and long-term benefits. Another study presents tangible proof suggesting that the way numerous individuals utilize outdoor fitness equipment may pose potential hazards to safety, potentially resulting in accidents and injuries that could lead to liability concerns for manufacturers or relevant authorities (Chow & Wu, 2019).

Also, in order to optimize the utilization of outdoor fitness areas by older adults, we propose the installation of a diverse range of apparatuses that cater to cardiovascular fitness, muscular strength, balance, and flexibility. These installations should be positioned in convenient and visually pleasing spots, in proximity to other centers for physical pursuits and conveniences. A strategic promotional approach, encompassing informative workout sessions and guidance, could effectively encourage secure and enduring engagement with the outdoor gym facilities (Scott et al., 2014).

Middle-aged and older adults have spinal misalignments when using outdoor fitness equipment to train in the standing position, so these machines should be able to be adapted to allow for safe and effective training (Abelleira-Lamela et al., 2021). This study concludes that the biomechanical characteristics of adults and older adults must be considered in the design of outdoor fitness equipment programs, specifically to minimize the risk of falls and injuries, as well as to maximize the benefits of exercise. Another study measuring the ergonomic properties of outdoor leg press, chest press and pull chair fitness machines indicates that they could play an important role in the occurrence of musculoskeletal injuries among users of these machines and highlights the need to follow ergonomic standards in the design and production of these types of outdoor fitness equipment (Sanchooli et al., 2021).

In addition, current outdoor fitness equipment only provides resistance through the individual's own body weight, which may not be sufficient for some and may be injurious to others. The lack of ability to increase the resistance provided by the machines may limit the potential for older adults to increase their training loads and generate improvements in muscle mass and strength.

Also, outdoor fitness equipment should have clear, easy to understand instructions and labels. Older adults may have difficulty understanding complex instructions and labels on outdoor training machines, which can lead to improper use and increased risk of injury. Manufacturers should provide clear user manuals (or demonstration videos) on the correct use of their equipment and warning labels on risky behaviors. Manufacturers can design and develop equipment that meets certain principles of safety, ergonomics, and ease of maintenance. Park authorities can organize sessions to provide useful guidelines to the public in the community and implement effective promotional strategies. Manufacturers can place a label on equipment with a quick response (QR) code linking to a video demonstrating how to properly use each piece of equipment. Park managers can post warning signs to prevent children from using the equipment and regularly monitor and manage equipment areas. Companies should offer a training app that provides information for their equipment's safe and effective use. In addition, training courses should be held for physical exercise and health professionals for the correct use of the machinery and for them to learn how to plan training programs adapted to the characteristics of the user.

Older adults have a higher risk of falling and therefore need greater stability and safety on the outdoor fitness equipment. That is why they should have non-slip surfaces and handrails for greater stability and safety for them. In summary, outdoor fitness equipment for use by older people should have adjustable resistance levels, clear and easy-to understand instructions and labels, non-slip surfaces and handrails for added stability and safety.

Outdoor fitness equipment presents some challenges and limitations that should be considered in the development of new, safer, and more effective machines. Table 2 shows a series of recommendations for improvement outdoor fitness equipment.

Table 2

Recommendations for improvement new outdoor fitness equipment

Aspects	Recommendations
Ergonomics	Equipment should be designed to be adjustable to different body sizes and to allow for spinal alignment that preserves physiological curves during execution. It is advisable to include comfortable handles that reduce stress on hands and wrists.
Biomechanics	The lever system should provide a resistance that can be regulated according to the strength and capacity of the user, allowing movement patterns and muscle activation, reducing the risk of injury, and increasing the effectiveness of the exercise. Current machines are not adaptable for older adults to improve their psychophysiological and social health.
Effectiveness	Equipment should be designed with multiple resistance levels and allow for progression. It is advisable to use machines that train polyarticular exercises and that involve large muscle groups involved in the activities of daily living and the functionality of the person.
Standardization	The diversity of brands, designs and functions hinders the correct use of outdoor fitness equipment, which underlines the importance of standardization and uniformity of outdoor fitness equipment to ensure homogeneous usability and user experience. In addition, this equipment should be supported by previous studies, and its manufacturers can offer this information to users via website, Qr codes etc.
Safety	To ensure the safety and effectiveness of outdoor fitness equipment, testing, validation, and maintenance service is very important. This includes testing and validating equipment to meet safety and quality standards, incorporating safety features such as non-slip surfaces, cushioned areas, and clear instructions for use. Safety features can improve the overall user experience and make the equipment more attractive so that more users become engaged and adhere to training with it.
Accessibility	To promote inclusion and accessibility, outdoor fitness equipment can be adapted for people with disabilities, including those with mobility impairments. This includes the ability to perform seated or supported exercises and equipment with low initial resistance and that allows for progression. However, current outdoor

	fitness equipment in public parks is not accessible to people with mobility impairments, such as those who use wheelchairs or walkers. Therefore, it is critical that parks consider accessibility when installing outdoor fitness equipment to ensure that everyone has the opportunity to enjoy the benefits of physical activity.
Maintenance	The safety and longevity of outdoor fitness equipment in public parks depends on regular maintenance and cleaning. This ensures that the equipment is safe for use and can provide effective workouts for users. In addition, it is crucial to include instructions for proper use and furthermore, for users to promptly report any broken or malfunctioning equipment.
Education	To maximize the effectiveness of this equipment, it is crucial to educate and inform the public about its benefits and how they can train safely and effectively. Therefore, educational programs are important to inform the public about the benefits of training on outdoor fitness equipment. Companies that manufacture this equipment can install information boards with instructions for safe and effective use. Alternatively, QR codes can be placed on equipment that direct users to mobile apps or a website that provide workout information and allow for feedback, including notification of malfunctions or other problems. This can help improve the user experience and encourage safe and effective use of outdoor fitness equipment.

Therefore, to design feasible interventions and improve physical activity levels in parks, effective collaboration among various professionals is essential. This includes public health experts, of parks and recreational facility planners and managers, sociologists, psychologists, economists, urban planners, architects, landscapers, trainers, researchers, and public safety officers (Bedimo-Rung et al., 2005). In addition, health training should always be under the prescription of a medical professional and a sports physical educator.

5.15. CONCLUSIONS

To our knowledge, this is the first narrative review that updates the psychophysiological and social effects of training with outdoor fitness equipment. At present, there are limited experimental studies, probably due to the limitations of current outdoor fitness equipment. Outdoor fitness equipment programs have the potential for improve psychophysiological and social health in older adults, but

further research is required to understand the benefits and challenges of their use. More rigorous and randomized clinical trial studies are needed to investigate the optimal frequency, intensity, and duration of training with this equipment for older adults. Barriers to outdoor fitness equipment programs use among older adults, lack of standardized measurement of outcomes and limited studies on long-term effects are challenges that must be overcome to fully understand the benefits and challenges of their use. Current outdoor fitness equipment requires several modifications such as those suggested in this study to maximize the effectiveness and safety of training on it.

The present study has certain limitations. As already indicated, there are few rigorous studies with outdoor fitness equipment. In addition, the machines may differ between manufacturers and not activate the same musculature, as well as affect the person differently. A systematic review with meta-analysis was not possible due to the limited number of studies and their low methodological quality. Therefore, our review provides valuable information regarding the importance of outdoor fitness equipment and a series of recommendations for improvement in the manufacturing of this equipment. There is a need for public health experts, local municipal authorities, and public health agencies to invest in safe and effective outdoor fitness equipment in open spaces.

The study also highlights the need for further research to examine the effectiveness of training in populations with special needs and to compare current outdoor fitness equipment with new equipment that allows for increased load and is safer and more effective. Future research should also examine ways to increase the long-term use of outdoor fitness equipment, assess long-term efficacy, and include measures of how impacts the health status of participants.

In the older people it is not enough to just go for a walk, we need other physical exercise interventions to help prevent muscle wasting, sarcopenia, dinapenia and other diseases and this is where the outdoor spaces and outdoor fitness equipment can help.

Furthermore, as a strength, to highlight that this study proposes this series of recommendations, based on the review carried out and, on the experience, gained in the experimental studies that have been conducted within the projects led by the principal investigator (PJMP): reference CFE/CO/05-17 and reference RTC-2017-6145-1, 2017 and which are in the process of publication.

VC - ESTUDIO 3: PHYSICAL AND PSYCHOLOGICAL EFFECTS OF OUTDOOR FITNESS EQUIPMENT TRAINING ON MIDDLE-AGED AND OLDER ADULTS: STUDY PROTOCOL OF A RANDOMISED CONTROLLED TRIAL

IVc - ESTUDIO 3: Physical and Psychological Effects of Outdoor Fitness Equipment Training on Middle-Aged and Older Adults: Study Protocol of a Randomised Controlled Trial

5.1. ABSTRACT

The aim of this project will be to investigate the effectiveness of an 8-weeks outdoor fitness equipment (OFE) program on health parameters in healthy community-dwelling middle and older adults, corresponding the present paper to the study protocol, which follow a single blind randomized controlled trial design. The training intervention will take part in a OFE program implemented over 8 weeks, 2 sessions/week. Rating of perceived exertion, heart rate, training volume and adherence to the exercise program will be register each session. The control group will not receive any structured exercise program. Blinded examiners will evaluate before and after the training program muscle strength with both maximum knee extension and elbow flexion isometric tests, handgrip strength test and five time sit-to-stand test; cardiovascular fitness with 400-meter walking test; postural stability with the balance tests of the Short Physical Performance Battery (SPPB) battery; dynamic balance with Timed Up and Go (TUG) test; body composition with Dual-energy X-ray absorptiometry; functional performance by gait speed, TUG and SPPB battery; blood pressure; and sagittal spine disposition and pelvic tilt. Information will be also collected about demographic characteristics, health-related quality of life, satisfaction with life, adherence of the Mediterranean diet by questionnaires. After that, sarcopenia, osteoporosis, and fracture risk will be calculated. The results derived from this research will increase the knowledge on the effectiveness of the OFE training for improving health of healthy community-dwelling middle and older adults.

5.2. INTRODUCTION

Practicing consistent physical activity is crucial to uphold optimal health and stave off chronic conditions and the effects of ageing in the older population. According to WHO (2015) physical activity can reduce the likelihood of middle-aged and older people developing chronic diseases that increase with age such as diabetes, sarcopenia, or certain types of cancer by approximately 30–40.

Among the different physical activity options for the prevention of the effects of ageing, resistance training has gained popularity in recent years. In this line, some researchers concludes that resistance and balance exercise with or without nutritional intervention are the most effective interventions for improving quality of life and physical function in older adults with sarcopenia (Shen et al., 2023).

Public areas are ideal for encouraging physical activity and resistance training since they encompass both green spaces and outdoor fitness equipment (García de Jalón et al., 2021). Furthermore, engaging in physical exercises within outdoor areas can contribute to improvements in pulmonary, cardiovascular, cognitive, musculoskeletal, and overall systemic health (Giles & Koehle, 2014). Despite this, few studies have examined the benefits of outdoor fitness equipment training for older adults (Jansson, Lubans, Smith, et al., 2019). A recent review demonstrates that OFE training programs have the potential to improve cardiovascular health, muscle strength, flexibility, balance, and reduce falls, while improving quality of life, alleviating depression, and anxiety, and increasing self-esteem (Marcos-Pardo et al., 2023). However, authors suggest that more rigorous research is needed to comprehensively understand the psychophysiological and social effects on health.

Therefore, it seems that outdoor fitness equipment training may serve as a free, feasible and timely way to address various health-related aspects relevant to the aging process. However, to date, no studies have been found that have analysed the effects of planned OFE training on health, in middle and older adults with a randomized controlled trial design. Thus, the aim of this project will be to investigate the effectiveness of an 8-weeks OFE program on health parameters in middle and older adults, corresponding the present paper to the design of the study protocol in which it is present an ongoing randomized controlled trial to investigate the effects of a circuit resistance training intervention with OFE on relevant physical and psychosocial performance in healthy community-dwelling middle and older adults.

The hypothesis is that the OFE training during 8-weeks, twice per week, improves physical fitness, body composition psychological state and prevention of the effects of ageing after the intervention period compared to daily activities control group (CG).

5.3. MATERIALS AND METHODS

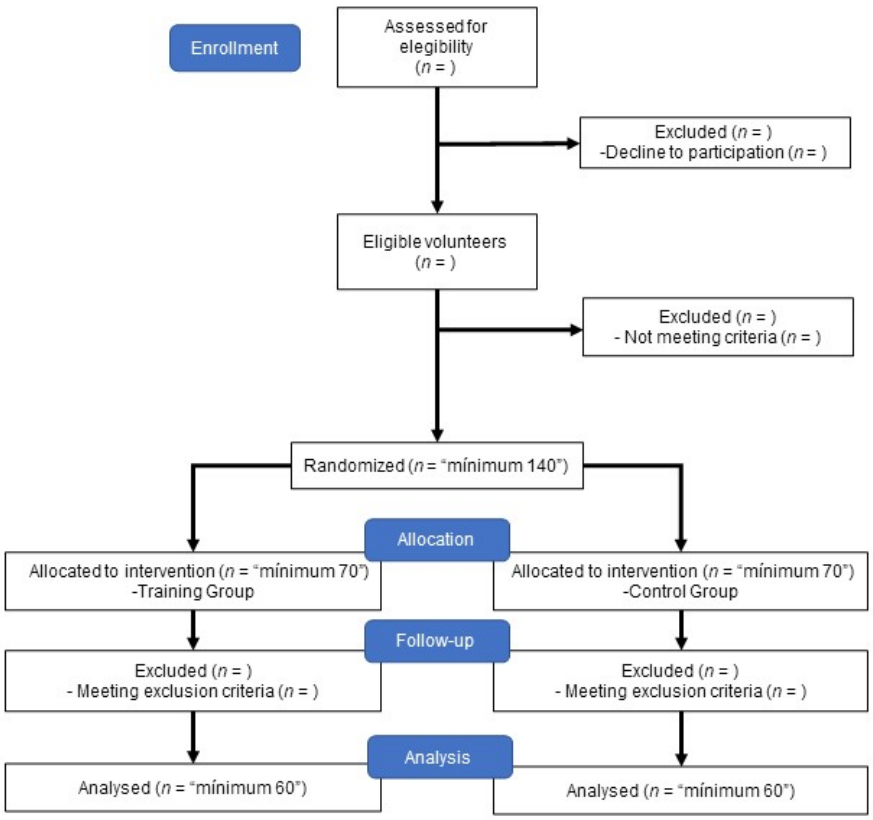
5.3.1. Study Design and Setting

This protocol describes an 8-weeks two-armed parallel single blind randomized controlled trial with blinded examiners (NCT04958499). This study is designed considering the recommendations of CONSORT (Moher et al., 2010) as well as SPIRIT statements (Chan et al., 2013).

Participants will be evenly and randomly divided between the training group (TG) and the CG. The overall study design is summarized in Figure 1. The choice of this design is related to the main objective and facilitating the interpretation of the data with intra-group and inter-group.

Figure 1

Consolidated Standards of Reporting Trials flow



5.3.2. Ethics Approval and Dissemination

All participants will be informed about the study procedures and will give their approval through informed consent prior to inclusion. All data collected during the study will be confidential. All participants receive a final report with their individual results to know their values at baseline and at the end of the study. The trial will be conducted in accordance with the Declaration of Helsinki and the study has been approved by the institutional ethics committee of the Catholic University of Murcia (CE111908).

Based on previous studies, groups larger than 30 were required for the result to reliably characterize precision error or change during clinical monitoring (Leslie & Moayyeri, 2006). A dropout rate of 16% will be assumed based on previous studies (Nayasista et al., 2022), so a minimum of 35 participants will be included per group. The Rstudio 3.15.0 software will be used for the calculation of the sample size. The sample size and statistical power were established considering the standard deviation (4.2) in the MVIC (Zaidi et al., 2023). A significance power of 95% ($1\text{-}\beta$ = .95), and a significance level of .05 will be considered. Ultimately, the sample consisted of a minimum of 60 participants per group. This resulted in an assumed error of 1.06.

5.3.3. Recruitment

Participants will be recruited through advertisements in health centers, older day care centers, senior centers, and women's centers in the municipality of Murcia (Spain). In addition, publications will be made on social networks with information about the trial. All potential participants will be contacted personally by telephone prior to their inclusion in the study.

5.3.4. Inclusion and Exclusion Procedures

To be included in the study, participants will have to meet the following criteria: will be male or female, aged 50 years or older, being physically independent, not having any pathology incompatible with the study, not having participated in a structured exercise program for at least 1 year and signing the informed consent form. The exclusion criteria will be: self-reported substance abuse

or dependence disorder (alcohol, non-prescribed medications, etc.), being under medical prescription for taking medications that could influence physical performance, suffering from any pathology contraindicated for the exercise program or requiring specialized medical attention (infectious, renal, pulmonary, coronary diseases, etc.), having low adherence during the program or performing physical exercise outside the study. During the pre-test phase, an electrocardiogram will be performed on each participant by health personnel to corroborate their cardiac health just after signing the informed consent and before the assessment tests.

5.3.5. Randomization and Allocation

After baseline measurements, participants will be randomly assigned to the TG or CG. A member of the research team will create a randomization sequence (1:1) before the trial began. The investigators who will conduct the assessments are not aware of which group the participants belong to, and participants will be instructed not to disclose the group to which they had been assigned.

5.3.6. Training Group

The TG will perform a circuit strength training with OFE in groups of 6-8 people. The training program will be supervised by two sports science graduates and will be carried out for eight weeks, with two training sessions per week on nonconsecutive days (Table 1). To increase adherence, a third weekly session will made available for participants who were unable to attend on their schedule.

Table 1

Progression in training during the study

Week	Workouts/ Week	Sets	Work/ rest time (s)	Execution time (s) (concentric-eccentric)	Rest Interval (s)
1	2	1	30/45	1-1	120
2	2	2	30/30	1-1	120
3	2	3	30/30	1-1	120
4	2	3	30/30	1-1	120
5	2	3	45/30	1-2	120
6	2	3	45/30	1-2	120
7	2	3	45/30	2-2	120
8	2	3	45/30	2-2	120

Over the 8-week period, both volume and intensity of the training will be progressively increased. Training load control consider variables such as time under tension, execution time, training density, rest between sets, and total volume.

The session structure will be based on timed circuit training. Each session will specify work time, rest time, execution time, and sets to perform (Table 1). Work and rest times will be monitored through TimeBirds Original V. 3.12 (Melbourne, Australia). A mobile app metronome (Metronome Beats, UK) programmed at 60 beats per minute will be used to indicate execution time with a series of beeps. Participants will perform repetitions at a constant speed, using the metronome information to control execution time during both the concentric and eccentric phases.

The warm-up will consist of aerobic exercises designed to elevate the heart rate (HR), which include 150 meters of walking, increasing the walking speed every 50 meters without transitioning to a run, 10 body-weight squats, and 10 standing push-ups against the wall. Following the aerobic exercises, participants will perform upper and lower joint mobility movements to further prepare them for the training. The cool-down phase will involve gentle stretches of the major muscles targeted during the session with 10 seconds of stretching per position. The training circuit will comprise 11 exercises conducted on 8 outdoor fitness equipment from the company Entorno Urbano S.L.U (Murcia, Spain), installed at the university facilities. These machines offer different usage modes by varying grips and limb positions. Accordingly, the training circuit will be composed of the following machines in sequence: Bonny rider (the handle will be pulled using both hands with a supine grip, with the elbow being flexed and the shoulder being extended), Gemini Low Grip (the handle will be pushed with grips held at a low height, with the elbow being extended and the shoulder being flexed), Air Walker (hip flexion-extensions will be performed on both platforms with the torso being kept upright. A brief isometric hold will be done at the end of the motion), Parallel Bars (the body's weight will be lifted by the elbow being extended from a flexed position. As an adaptation, triceps push-ups will be done sideways to the machine with a prone grip), Flyer Wheels circumduction's (circumductions will be performed on the Flyers Wheels apparatus with elbows kept straight and grips being held, utilizing shoulder mobility), Gemini Mid Grip (the handle will be pushed on the Gemini equipment with grips held at mid-level, by the elbow being extended and the

shoulder being flexed), Flyer Wheels external rotation (internal and external rotations will be executed on the side of the Flyers Wheels machine, with the elbow being supported and the grip being held), Swing ankle extension (with the knee kept straight, the metatarsal will be rested on the platform's lower edge, and the ankle will be alternately flexed and extended), Surfboard (a pendulum motion from the waist will be done in the frontal plane while the handle is being held on the platform. An isometric hold will be performed at the motion's furthest point), Swing leg press (Resistance will be pushed against on the Swing apparatus with the knees being extended, while seated with feet on the platforms), and Row (on the seat, the movement will be performed by bending the elbow and shoulder, keeping the torso upright) (Figure 2).

Each machine will be numbered with a sign to indicate the execution order to the participants (Figure 3), allowing for alternating work on different muscle groups to prevent excessive localized fatigue. The starting exercise for each participant and session will be randomized to avoid potential influences on Ratings of Perceived Exertion (RPE) and HR. The initial machine will be recorded for each participant in each session.

At the session's end, data on heart rate will be collected using a wrist-worn heart rate monitor, the Polar M430 (Polar Electro, Kempele, Finland), and participants' RPE after each exercise and at the end of the session will be recorded. Potential exercise adaptations will be based on participants' functional and physical capacity, assessed by an expert committee, and considering the machines' everyday use (Chow & Wu, 2019).

Figure 2

Images of the sequence and execution of the exercises on the different machines



Note. (1) Bonny rider; (2) Gemini Low Grip; (3) Air Walker; (4) Parallel Bars; (5) Flyer Wheels circumduction; (6) Gemini Mid Grip; (7) Flyer Wheels External Rotation; (8) Swing Anke Extension; (9) Surfboard; (10) Swing Leg Extension; (11) Row.

Figure 3

Images of flashcards indicating the sequence of use for the outdoor fitness equipment during the training programme



5.3.7. Control Group

Individuals assigned to the CG (Figure 3) will be instructed to continue their regular daily activities throughout the study. Habits and physical activity levels of participants will be monitored over the 8-week study period using specific inquiries incorporated within the sociodemographic questionnaire.

5.3.8. Data Collection and Measures

Measurements will be performed in the laboratory of the research group available at the university. Participants will be asked not to stretch or warm up before the tests. Measurers will be maintained from pre-test to post-test to avoid the influence of inter-rater error on the measurements made. All measurements will be evaluated by measurers who are experts in the performance of the specified tests. The tests will be performed in a random order. Variables collected and assessment schedule during the study is show in Table 4.

Table 2

Variables were collected, and assessments were scheduled during the study

	Training Group			Control Group		
	Baseline	**Intervention**	**Post**	**Baseline**	**Intervention**	**Post**
Consent	X			X		
Demographic survey: Age, sex, occupation, weekly physical activity, pathologies, and medication	X			X		
Health-related quality of life: 36-Item Short Form Survey (SF-36)	X		X	X		X
Satisfaction with life: Satisfaction with Life Scale (SWL)	X		X	X		X
Adherence of the Mediterranean diet: PREDIMED Score	X		X	X		X
Body composition: Height and weight; Full body composition (DXA); Bone mineral density (DXA)	X		X	X		X
Blood pressure	X		X	X		X
Heart electrical activity: Electrocardiogram (ECG)	X			X		
Muscular strength: Isometric handgrip strength test; Isometric knee extension test; Isometric elbow flexion test	X		X	X		X
Cardiovascular fitness: 400 meters walking test	X		X	X		X
Functional capacity: Short physical performance battery (SPPB); Time Up and Go Test	X		X	X		X

Postural stability: Center of pressure (COP) in Side-by-side test Center of pressure (COP) in Semi tandem test Center of pressure (COP) in Tandem test	X	X	X	X
Risk of falls: Gait speed test	X	X	X	X
Risk of sarcopenia: European Working Group on Sarcopenia in Older People (EWGSOP) Consensus	X	X	X	X
Sagittal spine disposition and pelvic tilt: Spinal Mouse relaxed standing position test Spinal Mouse relaxed siting position test	X	X	X	X
Rating of Perceived Exertion: 1-10 Borg rating of perceived exertion (RPE)		X		
Effort and heart rate		X		
Training volume		X		
Adherence		X		

5.3.9. Primary Outcomes

5.3.9.1. Maximum Muscular Strength

Both maximum knee extension and elbow flexion strengths will be evaluated under same isometric conditions. For the knee extension test, participants will be seated in a chair specifically designed for the measurement of isometric knee extension strength (ES-1295254) equipped with a force transducer (Musclelab, Ergotest, Norway), maintaining both a hip and knee angle at 90 degrees. Participants will be directed to exert maximal strength against a pad positioned above their ankle joint. For the elbow flexion test, participants will stand up-right,

holding a bar with both hands in a supine position, with the elbow at a 90-degree angle. Participants will be directed to exert maximal strength against the bar.

Participants will sustain their exertion for 2-3 seconds during both assessments following a previous protocol (Marcos-Pardo et al., 2022). The software (Musclelab, Ergotest, Norway) will quantify the maximum voluntary isometric contraction and the rate of force development. Each participant will complete three trials for each assessment and the best one will be used.

*5.3.9.2. **Handgrip Strength Test (HG)***

HG will be measured in a standing position with the arms at the sides. The participants will perform one repetition in each hand to familiarize themselves with the device and the test. Each participant will be asked to squeeze the grip with maximal strength for 3 seconds with both hands. The highest peak strength (kg) recorded between the three attempts will be considered for analysis. A digital grip strength dynamometer will be used for this (TKK 5401; Takei Scientific Instruments Co., Ltd., Tokyo, Japan). This measure has been associated with frailty in the older people (Marcos-Pardo et al., 2022; Albin et al., 2020).

*5.3.9.3. **Cardiorespiratory Fitness (CRF)***

The 400-meter walking examination is deemed a suitable and reliable test for approximating CRF (Albin et al., 2020). So CRF will be evaluated by measuring the time needed to complete ten laps as rapidly as feasible on a 20-meter-long track. Participants will be directed to walk at their maximum pace, refraining from running (Albin et al., 2020). The maximum and average HR during the test will be evaluated, as well as the HR with the test finish. Also, the HR at 2 minutes after the test will be recorded as CRF recovery variable. A single attempt at the test will be done.

*5.3.9.4. **Postural Stability***

Postural stability during quiet standing will be assessed using a force platform (Musclelab, Ergotest, Norway). The Short Physical Performance Battery (SPPB) balance protocol will be followed (Guralnik et al., 1994). Participants will be maintaining a stationary stance for 30 seconds with arms at their sides, repeated three times in each foot position, following this order: (i) feet together with eyes

open; (ii) semi-tandem stance (one foot's ankle behind the joint of the other foot) with eyes open; and (iii) tandem stance (one foot's ankle directly behind and touching the other foot's ankle) with eyes open. Measurements such as the total center of pressure displacement, anteroposterior and mediolateral amplitudes of the center of pressure, and the area of center of pressure displacement will be obtained from analyses conducted with Musclelab software (Musclelab, Ergotest, Norway).

*5.3.9.5. **Dynamic Balance***

Dynamic balance will be assessed with Timed Up and Go (TUG) test. During the TUG, participants will stand up from a chair, walked 3 meters, turned around and sat back down in the chair while being timed (Podsiadlo & Richardson, 1991). Two attempts will be done, and final value will be the best one.

*5.3.9.6. **Body Composition***

Kinanthropometric parameters related to height and body mass will be measured according to the guidelines of the International Society for the Advancement of Kinanthropometry (Esparza-Ros et al., 2019) by an accredited anthropometrist. The portable Leicester HR 001 stadiometer (Tanita, Illinois, USA) will be used to measure height (cm) with a precision of one millimeter, while body mass (kg) will be assessed in light clothing and barefoot using a Tanita BC-545N electronic scale (Tanita, Illinois, USA) with a precision of 0.1 kg. Each measurement will be taken twice. If both measurements have a difference of less than 1%, their average will be calculated. Conversely, if the difference exceeds 1%, a third measurement will be taken, and the median will be considered.

Body composition will be evaluated using Dual-energy X-ray absorptiometry (DXA) through a Hologic QDR 4500A densitometer (Hologic, Massachusetts, USA). A whole-body scan will be conducted to assess percentages of lean mass and fat mass.

Additionally, a second scan of the right proximal femur (femoral neck, trochanter region, and ward area) will be performed to evaluate bone mineral density levels, osteoporosis risk, and WHO-FRAX. All measurements and densitometry analyses will be conducted by the same certified technician following key guidelines (International Atomic Energy Agency, 2010). Participants will be

evaluated in a supine position with hips in internal rotation and feet in adduction to enhance femoral neck visibility. All participants will be instructed to use the restroom prior to the test and wear light clothing without metallic objects or shoes (International Atomic Energy Agency, 2010). A single attempt at the test will be done.

5.3.9.7. ***Functional Performance***

Functional performance will be measured by 10 meters gait speed, the TUG and the SPPB (Marcos-Pardo et al., 2020).

Gait speed will be assessed using a 10-meter test. Participants will be asked to walk at maximum speed without running, the total time taken to cover the 10-meter distance will be measured with two photocells (Witty, Microgate, Bolzano, Italy). The test will be performed twice, and the best one will be used.

The SPPB encompasses the postural stability assessment, five-time chair stand test, and 4-meter gait walk (Marcos-Pardo et al., 2020). The 5-times sit-to-stand test will evaluate the gauges the duration taken by the subject to transition five times from a seated posture to a standing posture with utmost speed, refraining from utilizing their arms. The test will be performed twice, and the best one will be used. In the 4-meter gait walk, participants will be asked to walk at maximum speed without running, and the total time taken to cover the 4-meter distance (Marcos-Pardo et al., 2020). To ensure a dependable measurement, will be measured by two photocells (Witty, Microgate, Bolzano, Italy). The test was performed twice, and the best one was used.

Of the tests included in the SPPB, each test allowed for a potential accumulation of up to four points, yielding a score spectrum of 0 to 12 points (Guralnik et al., 1994).

5.3.9.8. ***Sarcopenia***

Muscle strength (muscle quality) will be assessed with the HG and chair stand tests, muscle quantity will be measured through appendicular skeletal muscle mass with DXA values, and functional performance will be measured by 4m gait speed, TUG and the SPPB battery. The risk associated with each of these

variables will be defined in connection with the EWGSOP2 sarcopenia cut-off point (Fernandes et al., 2022; Marcos-Pardo et al., 2020).

5.3.10. Secondary Outcomes

5.3.10.1. ***Demographic Survey***

Participants will be asked in baseline about their basic sociodemographic data. They will be also asked about their daily physical activity level, number of falls and weight loss in the last year, as well as information regarding their health status, such as medication and pathologies.

5.3.10.2. ***Health-Related Quality of Life***

To assess Health-related quality of life, the 36-item Short-Form Health Survey (SF-36) will be employed. The SF-36 evaluates physical and mental health domains across eight concepts: physical functioning, physical role functioning, bodily pain, general health perceptions, vitality, social role functioning, mental health, and emotional role functioning. In this study, the validated Spanish version (Alonso et al., 1995), will be used. A higher score indicates better quality of life (Alonso et al., 1995).

5.3.10.3. ***Satisfaction with Life***

To assess life satisfaction, the Satisfaction with Life Scale questionnaire will be utilized, specifically in its Spanish version (Atienza et al., 2000). This instrument consists of 5 items responded to using a 5-point Likert scale. These items are related to an individual's perception of achievements in their life relative to their expectations. A higher value indicating greater life satisfaction (Atienza et al., 2000).

5.3.10.4. ***Adherence of the Mediterranean Diet***

Adherence to the Mediterranean diet will be assessed using the score obtained from the validated 14-item questionnaire of the Prevention of Mediterranean Diet (PREDIMED) study (Martínez-González et al., 2014). A higher

score indicates greater adherence to the Mediterranean diet, with a score of ≥ 9 considered as high adherence (Martínez-González et al., 2014).

5.3.10.5. ***Blood Pressure***

Blood pressure will be measured using an automatic blood pressure monitor (OMRON model HEM-7113, Osaka, Japan), following the general guidelines (Whelton et al., 2022). The participant will sit comfortably and quietly for 5 minutes before the first measurement, with the second measurement taken 2 minutes later. The final values of Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and Pulse Rate (PR) were the average of the two measurements. Subjects will be informed to abstain from vigorous exercise for 24 hours, avoid caffeine intake for 4 hours, and refrain from tobacco use 30 minutes prior to the measurements.

5.3.10.6. ***Leg Muscle Strength***

The chair stand test will be employed to quantify the leg muscle strength. This test will be carried out following the protocol of previous investigations (Marcos-Pardo et al., 2020).

5.3.10.7. ***Risk of Falls***

Gait speed is a powerful predictor of fall risk (Arjunan et al., 2019). Gait speed will be assessed using a 10-meter test.

5.3.10.8. ***Sagittal Spine Disposition and Pelvic Tilt***

The sagittal spine disposition and pelvic tilt will be measured using the Spinal Mouse system (Idiag, Fehraltdorf, Switzerland). This device allows the angular measurement of the different spinal curvatures in a non-invasive way. An assessment of the sagittal spine disposition in relaxed standing and sitting will be performed, following the protocol from previous studies (López-Miñarro et al., 2012). A positive value implies a kyphosis for thoracic and lumbar curvatures and an anteversion for pelvic tilt, while a negative value implies a lordosis for thoracic and lumbar curvatures and a retroversion for pelvic tilt. Each position will be evaluated three times, the final value being the mean of both values (López-Miñarro et al., 2012).

5.3.10.9. ***Rating of Perceived Exertion***

The Borg CR-10 Rating of Perceived Exertion (RPE) scale will be utilized to measure the perception of exertion among participants (Scherr et al., 2013). For each session, participants will be instructed to evaluate their perceived exertion for the entire session as well as their general perception of exertion for each individual machine immediately after the session conclusion.

5.3.10.10. ***Effort and Heart Rate***

The intensity of the training will be registered by monitoring the heart rate throughout the sessions. For this purpose, Polar M430 (Polar Electro, Kempele, Finland) wristband heart rate monitors will be employed. At the conclusion of each session, the average, peak, and final heart rates will be collected.

5.3.10.11. ***Training Volume***

The volume will be systematically registered for each training session. This includes the duration in seconds of the workout as well the associated rest intervals, the count of repetitions and sets performed by each participant.

5.3.10.12. ***Adherence to the Exercise Program***

In the TG, adherence to the exercise program by each participant will be monitored. Adherence will be measured as the percentage of exercise sessions actually performed / total number of scheduled exercise sessions.

5.4. STATISTICAL ANALYSIS

The qualitative variables will be summarized in terms of frequency, while the quantitative variables will be summarized using mean and standard deviation for both the TG and CG, across the assessment time points. To ensure rigorous statistical evaluation, special attention has been given to control the Type I (alpha) error and Bonferroni's correction will be used achieve p = .005 for statistical significance. To compare characteristics both between and within groups, the principle of intention to treat will be applied, with adjustments made for adherence to the exercise program. To assess baseline characteristic differences between the two groups, the following tests will be employed: Student's t-test for parametric

numerical variables; Mann–Whitney test for non-parametric variables; Chi-square test for categorical binary variables.

To compare changes within and between the TG and CG across baseline and follow-up assessments, the subsequent tests will be utilized: for variables exhibiting normal distribution, repeated measures analyses of variance. Given the multiple comparisons involved, post-hoc analyses will be conducted using t-tests with Sidak corrections to control the Type I error rate; for non-parametric variables, the Friedman test will be followed by the Wilcoxon test, and, to address the multiple comparisons, the Bonferroni correction will be applied.

SPSS 25.0 statistical software will be used in all the analyses. A p-value < .05 will be used to determine significant differences; however, this will be adjusted appropriately in the presence of multiple comparisons as detailed above.

5.5. CONCLUSIONS

This protocol presents a randomized controlled trial aimed at evaluating the efficacy and safety of an exercise program with OFE designed for improving physical and psychological health variables.

Exercise and strength training is essential to prevent or reverse disease, maintain or improve health, and prevent loss of function in the adult, middle-aged, and older people. This is where training with outdoor fitness equipment, free of charge and in outdoor spaces, can be of relevance to health. However, there are no specific indications available on the appropriate training program and which machinery can be safe and effective for their physical, psychological, and social health. A design study is presented in this research, the results of which are as follows could provide evidence to physicians, exercise trainers and policy makers on the best strategy to ensure safe and effective outdoor exercise, establishing parameters for prescribing and monitoring a training program with OFE, while respecting individual progress.

VD - ESTUDIO 4: THE EFFECT OF RESISTANCE TRAINING WITH OUTDOOR FITNESS EQUIPMENT ON THE BODY COMPOSITION, PHYSICAL FITNESS, AND PHYSICAL HEALTH OF MIDDLE-AGED AND OLDER ADULTS: A RANDOMIZED CONTROLLED TRIAL

Vd - ESTUDIO 4: The Effect of Resistance Training with Outdoor Fitness Equipment on the Body Composition, Physical Fitness, and Physical Health of Middle-Aged and Older Adults: A Randomized Controlled Trial

5.6. ABSTRACT

This study examined the effect of outdoor-fitness-equipment-based resistance training on the health parameters of middle-aged and older adults, as well as analyzing the effect of age on the results found. A total of 149 volunteers were randomly assigned to the training (TG) and control (CG) groups. The TG performed two weekly sessions of resistance training for 8 weeks using outdoor fitness equipment, while the CG continued with their regular daily activities. Body composition was measured using DXA, and the maximal isometric voluntary contraction in knee extension, elbow flexion, and hand grip were assessed, along with the 4 m walk test, the Timed Up and Go Test, and the Short Form 36 Health Survey Questionnaire. The TG showed a significant increase in the lean mass index ($p = .002$) and maximal isometric voluntary contraction in both legs ($p < .001$) and arms ($p < .001$), as well as in physical functioning ($p < .001$) and the role physical dimension ($p = .006$) of the Short Form 36 Health Survey Questionnaire, compared to the CG, which showed a decrease in all these variables. In addition, the TG showed a greater decrease in fat mass ($p < .001$), fat mass index ($p = .003$), and the Timed Up and Go Test ($p < .001$) than the CG. Age conditioned the evolution of most of the variables analyzed ($p < .05$). In conclusion, resistance training with outdoor fitness equipment may be useful for improving the health of middle-aged and older adults, although age is a factor that could influence the adaptations found.

5.7. INTRODUCTION

In an era where the emphasis on health and wellness has gained paramount importance, understanding the profound impact of physical activity on middle-aged and older adults has become increasingly crucial (WHO, 2015a). As age advances, optimizing body composition and enhancing physical fitness are essential components of sustaining an active and fulfilling lifestyle (Chodzko-Zajko et al., 2009).

According to the World Health Organization (WHO), moderate to vigorous physical activity can reduce the likelihood of middle-aged and older people developing chronic diseases such as heart disease, stroke, diabetes, sarcopenia, and certain types of cancer by approximately 30–40% (WHO, 2015a). Also, physical activity allows older adults to reduce their risk of mobility limitations and decreased quality of life (Gillison et al., 2009). Moreover, physical activity can attenuate changes in body composition, such as increased body fat and decreased lean muscle mass, which can contribute to a range of health issues, including metabolic disorders and reduced functional capacity (Oh et al., 2021).

Within the different modalities of physical activity, researchers and fitness experts have turned to progressive resistance training as a potential solution. Maintaining a regular commitment to resistance training regimens stands as a notable element in the aging journey, potentially functioning as both a proactive strategy and a therapeutic choice for a range of musculoskeletal conditions (Ciolac & Rodrigues-da-Silva, 2016). This form of exercise involves gradually increasing the resistance during workouts, thereby stimulating muscle growth, promoting overall strength, and helping to improve the functional capacity, muscle mass, and quality of life of older adults (Chen et al., 2021).

The importance of strength training in promoting healthy aging and improving the quality of life of adults and older adults has been widely documented (Chodzko-Zajko et al., 2009). It has been shown that training at least two days a week at moderate to vigorous intensity can have significant effects on body composition, physical fitness, physical health, and overall physical well-being (Izquierdo et al., 2021). Traditionally, strength training in middle and older adults has focused on self-weight bearing or the use of equipment such as resistance bands and on activities guided by monitors and performed mainly in specialized centers or indoor environments (Chodzko-Zajko et al., 2009; Marcos-Pardo et al., 2021). However, although these methods have been shown to be effective in improving health and physical function, this approach may present barriers in terms of accessibility and cost, which may limit their widespread adoption (Marcos-Pardo et al., 2021).

In this sense, public areas are ideal for encouraging physical activity and resistance training, as they encompass both green spaces and structures that are purpose-built to foster physical activity (García de Jalón et al., 2021). More

specifically, outdoor fitness equipment (OFE) refers to facilities or exercise equipment, adapted from traditional gym configurations, specially designed for outdoor use, which generally use the individual's own body weight for resistance (Chow & Ho, 2018; Jansson, Lubans, Smith, et al., 2019). OFE emerges as an innovative and accessible opportunity to integrate strength training into the daily lives of this population (Chow & Ho, 2018; García de Jalón et al., 2021). These free-to-use facilities, located in public spaces around the world, feature guided machines with clear instructions for use (Chow & Wu, 2019). This allows anyone, regardless of their prior knowledge or experience, to engage in physical activity. In addition, the outdoor and accessible nature of these environments encourages interaction and mutual support among users, enhancing their exercise experience (Marcos-Pardo, Espeso-García, Abelleira-Lamela, et al., 2023; Plotnikoff et al., 2023).

However, despite the growing amount of OFE in parks, studies on its specific effects on the health and well-being of adults and older adults are limited (Chow et al., 2021; Fyfe et al., 2022). Indeed, a recent narrative review suggests that while OFE may have the potential to improve the health of users, there is a great lack of rigorous experimental studies demonstrating its actual effects in the medium to long term (Marcos-Pardo, Espeso-García, Abelleira-Lamela, et al., 2023). In line with this, most of the previous research has been based on a small number of machines or on a small sample size or has not focused on health-related variables (Chow et al., 2021; Kim et al., 2018). Moreover, the design of OFE machines, mainly leveraging the user's body weight as unique external charge, raises considerations about their effectiveness in achieving the minimum intensity levels for significant health benefits and long-term training progression (Chow & Ho, 2018). Furthermore, while the potential of OFE to deliver effective fitness solutions deserves exploration, its distinct nature from traditional fitness centers, and in particular its reliance on the user's body weight, warrants a tailored investigation to ascertain its true efficacy.

In view of the above, this current study addresses these gaps. More specifically, the aims were to assess the impact of a resistance training program conducted in OFE on health-related variables, including the body composition, physical fitness, and physical health of middle-aged and older adults, as well as analyzing the effect of age on the results found.

5.8. MATERIALS AND METHODS

5.8.1. Experimental Approach to the Problem

The present study is an 8-week two-armed parallel single-blind randomized controlled trial with blinded examiners, which follows the methodology described in a protocol study already published in a previous research work (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023). The participants were divided equally and randomly between the training group (TG) and the control group (CG). The trial design was registered with ClinicalTrials.gov (identifier: NCT04958499) and followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines and Standard Protocol Items: Recommendations for Interventional Trials statements (Chan et al., 2013; Moher et al., 2010).

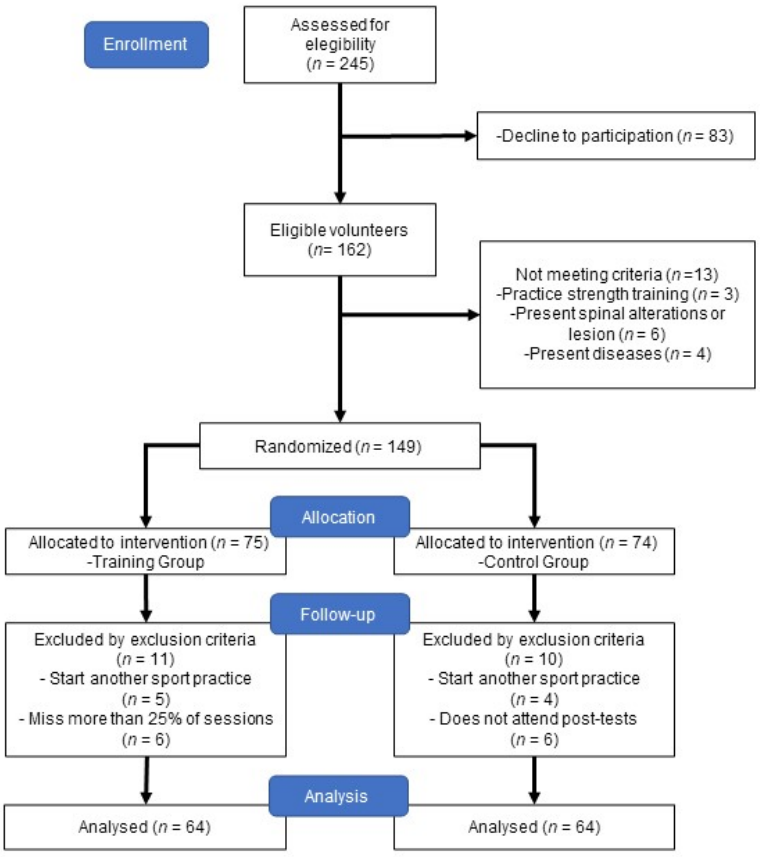
5.8.2. Subjects

Participants were recruited on a voluntary basis through informative conferences and advertising in senior centers located in the municipalities surrounding the university facilities in Murcia, Spain. The inclusion criteria were (a) being over 50 years of age; (b) being physically independent; (c) not performing resistance training or physical exercise systematically for at least 1 year before. The exclusion criteria were (a) self-reported substance abuse or dependence disorders; (b) suffering from any type of injury or pathology that prevented the performance of the measurements and/or training; (c) being medically prescribed to take medications that could have influenced physical performance; (d) having undergone surgery that would have prevented performing any of the tests and/or training or posed a risk. Moreover, further exclusion criteria were included for both groups: (a) absence in the post-test evaluations; (b) the initiation of other systematic physical exercise during the study period and for the TG participants specifically; (c) absence from more than 25% of the intervention program sessions. The final sample was composed of 128 middle aged and older adults, of which 28 were middle-aged men (age = 56.57 ± 3.91 years old, max = 64, min = 50; height = 169.17 ± 6.92 cm, max = 181.2, min = 158.1; body mass = 82.70 ± 9.82 kg, max = 106.60, min = 66.70; and BMI = 29.00 ± 3.91 kg/m^2, max = 37.90, min = 22.68); 18 were older adult men (age = 66.61 ± 2.17 years old, max = 72, min = 65; height = 166.28 ± 8.59 cm, max

= 174.50, min = 154.70; body mass = 77.96 ± 15.21 kg, max = 127.70, min = 64.10; and BMI = 28.18 ± 5.00 kg/m², max = 44.76, min = 24.04); 62 were middle-aged women (age = 54.58 ± 4.82 years old, max = 63, min = 50; height = 157.38 ± 6.25 cm, max = 180.40, min = 148.00; body mass = 63.87 ± 8.90 kg, max = 96.00, min = 45.70; BMI = 25.79 ± 3.23 kg/m², max = 33.61, min = 19.17); and 20 were older adult women (age = 68.75 ± 3.61 years old, max = 77, min = 65); height = 153.97 ± 3.98 cm, max = 159.00, min = 146.50; body mass = 67.94 ± 8.63 kg, max = 89.10, min = 55.20; and BMI = 28.72 ± 4.06 kg/m², max = 37.83, min = 22.62). Subsequently, the participants were randomized assigned to the TG (*n* = 64; 29 males and 35 females; age = 60.02 ± 7.25 years old; height = 163.96 ± 9.30 cm; body mass = 75.42 ± 15.06 kg; and BMI = 27.97 ± 4.77 kg/m2) and CG (*n* = 64; 17 males and 47 females; age = 57.83 ± 6.92 years old; height = 157.40 ± 6.37 cm; body mass = 65.79 ± 7.50 kg; and BMI = 26.60 ± 2.99 kg/m2). The CONSORT flow diagram is shown in Figure 1.

Figure 1

CONSORT flow diagram of participants through each stage of the study



5.8.3. Randomization and Blinding

Following recruitment and selection, the participants were randomized using a computer-generated random number table, ensuring that allocation was undertaken impartially. The chosen ratio for the randomized groups was 1:1. This process ensured that each participant had the same chance of being assigned to either of the two groups, removing any selection bias. Furthermore, a single-blind study design was adopted based on previous studies (Mateo-Orcajada et al., 2023), where the evaluators were blinded and unaware of the group assignments, as well as the individuals' results for previous measurements, which helps to avoid possible biases and improve the objectivity of the study findings.

5.8.4. Procedures

The TG participants engaged in an 8-week training program utilizing OFE, with two weekly sessions lasting one hour per session on non-consecutive days. The CG participants did not perform any training and were asked to maintain their usual lifestyle (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023). Attendance at the training sessions was monitored daily, with an average rate of 92.75%. Given this high attendance rate, only 6 participants were excluded from the study due to a lack of adherence to the training program.

The intervention program was carried out in an OFE circuit, consisting of 11 exercises performed on eight body weight OFE (Bonny rider, Air Walker, Surfboard, Row, Parallel bars, Gemini, Flyer wheels, and Swing) provided by the company Equipamientos para Entorno Urbano S.L. (Murcia, Spain) (Table 1), located in a private area annexed to the laboratory within the facilities of the Catholic University of Murcia (UCAM) (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023).

Table 1

Exercises to be performed in the outdoor fitness equipment circuit

Exercise	Method of Use	Representation
Bonny rider	Using a supine grip, pull the handle with both hands by flexing your elbows and extending your shoulders.	
Shoulder press	On the Gemini machine, grasping the grips at a low height, push the handle by extending your elbows and flexing your shoulders.	
Air Walker	Holding onto the bar and standing on both platforms, perform hip flexion extensions, keeping the trunk perpendicular. Hold briefly and isometrically at the end of the range of motion.	
Triceps dips	On the parallel bars, holding with both hands and starting with your elbows flexed, extend them by overcoming the load of your own weight. Adaptation: triceps push-ups with a prone grip sideways to the machine.	
Shoulder wheel	On the Flyer wheels machine, with your elbows fully extended and grasping the grips, perform circumduction through shoulder mobility.	
Chest press	On the Gemini machine, holding the grips at a middle height, push the handle by extending your elbows and flexing your shoulders.	

Rotator cuff wheel	With the Flyer wheels machine to your side, support your elbow and hold your grip. Perform internal and external rotation.	
Calf raises	On the Swing machine, with your knees extended, rest your metatarsals on the lower edge of the platform. Flex and extend your ankles.	
Surfboard	Standing on the platform and holding onto the handle, perform a pendulum movement from the waist in the frontal plane. Hold briefly and isometrically at the end of the range of motion.	
Leg press	On the Swing machine, while sitting with your feet on the platforms, push through knee extension to overcome the load.	
Row	Sitting on the seat and with your feet in position, pull on the grip by flexing your elbows and externally rotating your shoulders, keeping the trunk perpendicular to the ground.	

The training program was designed and concurrently supervised by two graduates in Sports Science with master's degrees in Strength and Conditioning Training, Healthy Aging, and Physical Activity and Health. Each resistance training session was preceded by a standardized warm-up routine, focused on joint mobility, cardiovascular, and body weight exercises, following a previous protocol (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023). The training protocol utilized is detailed in Table 2, which outlines the progression of the training over the 8 weeks of the intervention in terms of its volume and intensity. The circuit is based on the work time for each exercise and each set (T of work/exe), which indicates the exercise duration for each machine and each set, and the rest time between exercises (T of rest/exe), which denotes the rest interval between machines within the same set. The execution speed measured in seconds for the

concentric and eccentric phases is also included (concentric/eccentric), as well as the total number of repetitions participants had time to carry out for each exercise in each set (Reps exe). In addition, the table includes information on the rest pause between sets or circuit rounds (T rest/set), the total duration of the session in minutes (T session), and the total volume of repetitions per session (Total Reps/session). The training load was regulated by the muscle time under tension using a digital metronome to set the execution rhythm of the concentric and eccentric phases for each piece of OFE (Vargas-Molina et al., 2020). This approach ensured that all the repetitions were performed at a controlled and constant speed, with no variations in the execution velocity. To achieve this, the two program supervisors provided individual and continuous feedback to each participant. After each session, a cool-down period was provided, consisting of a series of static active stretches of each of the muscle groups involved in the training (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023).

Table 2

Training plan

Week	Sets	T of Work/Exe (s)	Reps Exe	Concentric/Eccentric (Repetition/s)	T Rest/Exe (s)	T Rest/Set (min)	T Session (min)	Total Reps/Session
1	1	30	15	1/1	45	-	13.75	165
2	2	30	15	1/1	30	2	27	330
3	3	30	15	1/1	30	4	43	495
4	3	30	15	1/1	30	4	43	495
5	3	45	15	1/2	30	4	51.25	495
6	3	45	15	1/2	30	4	51.25	495
7	3	45	11	2/2	30	4	51.25	371
8	3	45	11	2/2	30	4	51.25	371

Note. Exe: exercise; Reps: repetitions; T: time.

The measurements were performed in a sports science laboratory under standardized conditions. Firstly, the participants completed a sociodemographic questionnaire that was created ad hoc for this study, which included questions about age, gender, physical activity level, illness, and injuries. Furthermore, the dimensions of physical functioning and role physical from the Spanish validated version of the Short Form 36 Health Survey Questionnaire (SF-36) were used to measure health status (Vilagut et al., 2008; Ware, 2000; Ware & Sherbourne, 1992).

The participants completed the ad hoc and SF-36 questionnaires anonymously and individually as hard copies. The participants did not receive any additional explanation about the purpose of the questionnaires, other than that contained in the questionnaire itself.

After completing the questionnaires, body mass and height were measured according to the protocol from the International Society for the Advancement of Anthropometry (ISAK) (Esparza-Ros et al., 2019), performed by an ISAK Level 1 accredited anthropometrist and in accordance with previous studies (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023). Subsequently, body composition was determined using dual-energy X-ray absorptiometry (DXA) following the protocol used previously (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023; Marcos-Pardo, González-Gálvez, Espeso-García, et al., 2020), which was used for the measurement of fat mass (kg), fat mass index (kg/m2), lean mass (kg), and lean mass index (kg/m2).

This was followed by a warm-up similar to that of the training sessions, as previously described (Cabo et al., 2022). After this, a maximum voluntary isometric contraction (MVIC) leg extension test, a MVIC elbow flexion test, a 4 m gait walk, and a Timed Up and Go test (TUG) were performed in a randomized order, following a previous protocol (Marcos-Pardo, Espeso-García, Vaquero-Cristóbal, et al., 2023). Before starting the MVIC tests, familiarization was performed, after which a 5 min rest period was allowed before two non-consecutive maximal attempts were performed, with 2 min of rest between tests. The maximum peak force in Newtons (N) between the two attempts of each test was recorded for the MVIC test, and the best time was registered for the 4 m and TUG tests.

5.8.5. Statistical Analyses

Based on previous studies, groups larger than 30 were required for the results to reliably characterize precision errors or changes during clinical monitoring (Leslie & Moayyeri, 2006). A dropout rate of 16% was assumed based on previous studies (Nayasista et al., 2022), so a minimum of 35 participants had to be included per group. The RStudio 3.15.0 (Rstudio Inc., Boston, MA, USA) software was used for calculation of the sample size. The sample size and statistical power were established considering the standard deviation (167.46 N) in the maximum

voluntary isometric contraction (MVIC) leg extension test (Marcos-Pardo et al., 2022). A significance power of 95% ($1\text{-}\beta$ = .95) and a significance level of .05 were considered. Ultimately, the sample consisted of 64 participants, resulting in an assumed error of 41.02 N. Due to the use of a convenience sampling method, a significantly larger sample than required was utilized since the recruitment of participants was conducted across several senior centers and many individuals enrolled together. This approach ensured a sufficient sample size in case of low adherence to the program, improving the generalizability and reliability of the results.

After analyzing the normality of the variables using the Kolmogorov–Smirnov test, as well as kurtosis, skewness, and variance, two-way ANOVAs with one-way repeated measures were carried out to analyze the inter- and intra-group differences. A two-way ANCOVA with one-way repeated measures was also performed to determine the influence of the covariate of age on the results obtained on the study variables. Partial eta squared ($\eta 2$) was used to calculate the effect size and was defined as small: $ES \geq 0.10$; moderate: $ES \geq 0.30$; large: $ES \geq 1.2$; or very large: $ES \geq 2.0$, with an error of $p < .05$ (Hopkins et al., 2009). A value of $p < .05$ was set to determine the statistical significance. The statistical analysis was performed using the SPSS statistical package (v. 25.0; SPSS Inc., Chicago, IL, USA).

5.9. RESULTS

Prior to the beginning of this study, all the participants were inactive and had not undergone systematic resistance training in the last year, thus fulfilling the established inclusion and exclusion criteria. The sample included 9 individuals with controlled high blood pressure, 11 with controlled cholesterol levels, 2 with controlled diabetes, 8 with lumbar discomfort, 3 with asthma, and 4 with osteoporosis. These conditions were thoroughly reviewed by healthcare professionals and were determined to meet the inclusion criteria, as they were controlled and did not interfere with the participants' ability to engage in the study's activities or measurements. This allowed us to proceed with the training and measurements in a normal manner.

Table 3 shows the pre- and post-intervention differences in body composition, physical fitness, and physical health of the groups. In terms of the

body composition variables, the TG showed a significant decrease in fat mass (p < .001, ES = 0.257) and the fat mass index (p < .001, ES = 0.221) and a significant increase in the lean mass index (p = .045, ES = 0.044). In contrast, the CG showed a significant decrease in lean mass (p = .024, ES = 0.012) and the lean mass index (p = .008, ES = 0.037) with a small effect size on all these variables. In terms of the physical fitness variables, the TG showed a significant increase in MVIC in both legs (p < .001) with a moderate effect size (ES = 0.207 for the right, ES = 0.154 for the left) and MVIC in the arms (p < .001, ES = 0.521) with a large effect size; the TUG test (p < .001, ES = 0.393) indicated a large effect size; and the 4 m gait walk (p = .006, ES = 0.057) showed a small effect size, whereas the CG showed a significant decrease in MVIC of the left leg (p = .019, ES = 0.051) and MVIC of the arms (p < .001, ES = 0.073), both with a small effect size, and a significant increase in the TUG test (p < .001, ES = 0.102) with a moderate effect size. As for the physical health results according to the SF-36 scores, the CG showed a significant decrease in the physical functioning and role physical dimensions.

Table 3

Intra-group changes in body composition, physical fitness, and physical health variables

					Unadjusted			Adjusted by Age		
Variable	**Group**	**Pre-Intervention (*X* ± *SD*)**	**Post-Intervention (*X* ± *SD*)**	**Mean Dif.**	**95% CI**	***p*-Value**	***ES***	**95% CI**	***p*-Value**	***ES***
Fat mass (kg)	TG	29.37 ± 8.35	28.47 ± 8.00	0.904 ± 1.297	0.577; 1.231	< .001	0.257	0.645; 1.193	< .001	0.263
	CG	26.51 ± 4.84	26.36 ± 4.83	0.144 ± 0.841	−0.066; 0.035	.175	0.009	−0.141; 0.401	.347	0.007
Fat mass index (kg/m²)	TG	10.99 ± 3.32	10.71 ± 3.22	0.283 ± 0.408	0.181; 0.386	< .001	0.221	0.195; 0.384	< .001	0.230
	CG	10.80 ± 2.27	10.72 ± 2.24	0.080 ± 0.345	−0.006; 0.166	.067	0.023	−0.020; 0.168	.120	0.019
Lean mass (kg)	TG	44.15 ± 9.94	44.33 ± 9.58	−0.183 ± 1.859	−0.652; 0.285	.437	0.008	−0.542; 0.170	.304	0.009
	CG	37.61 ± 5.83	37.39 ± 6.23	0.219 ± 0.758	0.030; 0.408	.024	0.012	−0.131; 0.575	.217	0.012
Lean mass index (kg/m²)	TG	15.42 ± 2.27	15.53 ± 2.20	−0.114 ± 0.443	−0.226; −0.003	.045	0.044	−0.207; −0.017	.022	0.042
	CG	14.36 ± 1.75	14.26 ± 1.88	0.103 ± 0.301	0.028; 0.178	.008	0.037	0.006; 0.195	.037	0.035
MVIC right leg (N)	TG	384.16 ± 127.56	419.15 ± 135.30	−34.993 ± 48.745	−47.169; −22.816	< .001	0.207	−45.993; −21.876	< .001	0.199
	CG	314.27 ± 128.63	311.01 ± 116.87	3.263 ± 48.742	−8.912; 15.439	.594	0.002	−9.854; 14.264	.718	0.001

MVIC left leg (N)	TG	381.98 ± 132.50	422.16 ± 139.64	−40.174 ± 61.150	−55.449; −24.899	< .001	0.154	−55.807; −22.394	< .001	0.146
	CG	328.74 ± 126.68	306.80 ± 118.25	21.937 ± 72.785	3.756; 40.118	.019	0.051	4.157; 37.571	.015	0.047
MVIC arms (N)	TG	252.69 ± 99.42	306.19 ± 109.47	−53.499 ± 44.576	7.848; 20.801	< .001	0.521	−63.370; −45.254	< .001	0.532
	CG	226.31 ± 72.41	211.98 ± 85.46	14.325 ± 25.929	−64.726; −42.273	< .001	0.073	6.139; 24.111	.001	0.082
TUG (s)	TG	5.33 ± 1.04	4.65 ± 0.89	0.683 ± 0.695	0.509; 0.857	< .001	0.393	0.533; 0.835	< .001	0.391
	CG	5.68 ± 1.06	5.39 ± 1.09	0.291 ± 0.497	0.166; 0.415	< .001	0.105	0.139; 0.441	< .001	0.104
4 m gait walk (s)	TG	1.97 ± 0.40	1.89 ± 0.36	0.086 ± 0.242	0.025; 0.146	.006	0.057	0.015; 0.135	.014	0.047
	CG	2.07 ± 0.42	2.06 ± 0.34	0.011 ± 0.256	−0.053; 0.075	.723	0.001	−0.038; 0.082	.472	0.004
PH physical functioning	TG	88.75 ± 12.05	90.47 ± 11.08	−1.719 ± 7.083	−3.488; 0.051	.057	0.011	−4.787; 1.042	.206	0.013
	CG	90.08 ± 12.23	84.53 ± 14.60	5.547 ± 14.963	1.809; 9.285	.004	0.102	2.786; 8.615	< .001	0.107
PH role physical	TG	88.28 ± 23.97	94.53 ± 19.14	−6.250 ± 30.861	−13.959; 1.459	.110	0.016	−16.163; 0.534	.066	0.027
	CG	88.28 ± 27.08	77.34 ± 34.13	10.938 ± 38.544	1.310; 20.565	.027	0.047	4.154; 20.850	.004	0.066

Note. TG: training group; CG: control group; MVIC: maximum voluntary isometric contraction; TUG: Timed Up and Go test; PH: physical health.

The age-adjusted analysis revealed significant changes in the TG for fat mass ($p < .001$, $ES = 0.263$), the fat mass index ($p < .001$, $ES = 0.230$), and the lean mass index ($p = .022$, $ES = 0.042$), all showing a small effect size; for MVIC for both the right ($p < .001$, $ES = 0.199$) and left legs ($p < .001$, $ES = 0.146$), with a small effect size; for MVIC in the arms ($p < .001$, $ES = 0.532$), with a large effect size; for the TUG test ($p < .001$; $ES = 0.391$), with a moderate effect size; and for the 4 m gait walk ($p = .014$, $ES = 0.047$), with a small effect size. Age also influenced the within-group changes in the CG in the variables of the lean mass index ($p = .037$, $ES = 0.035$), MVIC left leg ($p = .015$, $ES = 0.047$), MVIC arms ($p = .001$, $ES = 0.082$), the TUG test ($p < .001$, $ES = 0.104$), PH physical functioning ($p < .001$, $ES = 0.107$), and PH role physical ($p = .004$, $ES = 0.066$), all with small effect sizes.

Table 4 compares the changes observed before and after the intervention between the TG and the CG. The pre-post change showed in the TG was significant compared to the pre-post change in the CG in the lean mass index, with a small effect size ($p = .002$, $ES = 0.077$); fat mass ($p < .001$, $ES = 0.109$) and the fat mass index ($p = .003$, $ES = 0.069$), both with small effect sizes; MVIC for both the legs and arms, with small effect sizes for the legs ($p < .001$, $ES = 0.135$ for the right leg and $p < .001$, $ES = 0.178$ for the left leg) and a moderate effect size for the arms ($p < .001$, $ES = 0.469$); the TUG test, with a small effect size ($p < .001$, $ES = 0.097$); as well as in the physical functioning ($p < .001$, $ES = 0.089$) and role physical dimensions ($p = .006$, $ES = 0.058$), both with small effect sizes. Age had a significant influence on the inter-group differences in the pre-post change for all the analyzed variables ($p < .001$–0.002; $ES = 0.073$–0.481), except for lean mass ($p = .115$, $ES = 0.020$) and the 4 m gait walk test ($p = .219$, $ES = 0.012$).

Table 4

Intra-group changes in body composition, physical fitness, and physical health variables

			Unadjusted			Adjusted by Age		
Variable	**Group**	**Mean Dif.**	***p*-Value**	***F*/*Z***	***ES***	***p*-Value**	***F*/*Z***	***ES***
Fat mass (kg)	TG CG	−0.759	< .001	15.368	0.109	< .001	16.055	0.115
Fat mass index (kg/m²)	TG CG	−0.203	.003	9.204	0.069	.002	9.999	0.075
Lean mass (kg)	TG CG	0.402	.112	2.561	0.020	.115	2.514	0.020
Lean mass index (kg/m²)	TG CG	0.217	.002	10.481	0.077	.002	9.662	0.073
MVIC right leg (N)	TG CG	38.256	< .001	19.711	0.135	< .001	17.341	0.124
MVIC left leg (N)	TG CG	62.111	< .001	27.321	0.178	< .001	24.454	0.166
MVIC arms (N)	TG CG	67.824	< .001	110.269	0.469	< .001	113.947	0.481
TUG (s)	TG CG	−0.392	< .001	13.486	0.097	< .001	14.288	0.104
4 m gait walk (s)	TG CG	−0.074	.094	2.846	0.022	.219	1.528	0.012
PH physical functioning	TG CG	7.266	.001	12.327	0.089	< .001	12.570	0.093
PH role physical	TG CG	17.188	.006	7.755	0.058	.002	10.423	0.078

5.10. DISCUSSION

The main aim of the present study was to analyze the effect of resistance training with OFE on health-related variables in middle-aged and older adults. The present investigation showed a significant increase in lean mass and a decrease in fat mass in the group that received resistance training with OFE, while the CG showed a decrease in lean mass and no change in fat mass. Only two studies have applied intervention programs with OFE, both in older adults. One of them applied an intervention program that included seven types of OFE (two cardiovascular training, two strength, two mobility, and two balance machines), three sets, 8–12 repetitions, and 12 weeks of training (Chow et al., 2021), while the other study applied a 6-week program that included five types of OFE (three strength and two cardiovascular training machines), three sets, and 12–15 repetitions (Kim et al., 2018). The study by Chow (2021) showed no changes in the body composition variables, but as the study did not include a control group, no comparisons could be made with it. The results found in the present study may be due to the fact that it included middle-aged adults and not only older adults. Some research has shown different effects according to age, with significant changes observed in the body composition of middle-aged adults, while older adults did not show significant changes in body composition (Khalafi et al., 2023), or a larger effect size in middle-aged adults than in older adults (López et al., 2022), suggesting that OFE training may improve body composition in middle-aged adults and slow age-associated changes in body composition in older adults.

In addition, the difference between the results could also be due to the different prescribed volumes of the programs. Both Chow's (2021) study and Kim´s et al. (2018) study included a much lower number of strength exercises (2–3, respectively, vs. 11 exercises in the present study). Research studies on resistance training usually utilize at least six exercises (Ramos-Campo et al., 2021), and a minimum dose has been identified as necessary to produce adaptations, ranging from low-volume and high-intensity to high-volume and low-intensity. However, resistance training with OFE is considered to be low- to moderate-intensity resistance training (Chow & Ho, 2018), and it is therefore considered necessary to utilize a sufficient volume in order to achieve body adaptations (Marcos-Pardo, Espeso-García, Abelleira-Lamela, et al., 2023). More research is needed to

determine what the minimum volume of OFE training should be to produce adaptations.

Most of the research examining the effect of resistance training programs on body composition has been focused on middle-aged adults (Ramos-Campo et al., 2021), older adults (O'Bryan et al., 2022), overweight and obese people (López et al., 2022), people with sarcopenia (Chen et al., 2021), people with sarcopenia and obesity (Yang et al., 2022), or postmenopausal women (Khalafi et al., 2023). Although all of them have shown improvements in most of the variables related to body composition, some of them do not show improvements in lean mass (Chen et al., 2021). This could be due to the dose applied in resistance training.

Another objective of the present study was to analyze the effect of resistance training with OFE on the physical fitness of middle-aged and older adults. Improvements were observed in upper and lower limb strength, as well as in the Timed Up and Go test and gait speed. Resistance training programs have shown improvements in muscle strength and muscle function (Chen et al., 2021) or show a trend towards improvement, as well as improvements in strength and muscle performance (Chen et al., 2021). In this sense, this shows that neural mechanisms and muscle innervation, such as adaptations in activation, timing, and rhythm coding, and not muscle hypertrophy, are the most likely reasons for the increase in muscle strength, mainly in beginners during the first 8 weeks (Chelly et al., 2009). It has been reported that improvements in muscle performance are mainly associated with an increase in muscle strength rather than muscle mass after resistance training. In this sense, resistance training with OFE could be of added benefit to resistance training using other machines or other equipment given the reports of an improvement not only in muscle strength and function but also an increase in muscle mass in the first 8 weeks (Kwon et al., 2015).

Resistance training has been shown to change skeletal muscle properties, leading to an increase in lean body mass and a reduction in exercise-induced oxidative stress (Strasser & Schobersberger, 2011). The main reason for the increase in lean mass is the increase in muscle mass, which may be due to intramuscular anabolic signaling, the maximization of the response of muscle fiber recruitment, the time under tension, or the metabolic stress (Gonzalez et al., 2016). Some research indicates that there seems to be evidence that moderate–high loads (> 60% 1RM) and lower–moderate volumes (< 12 repetitions) produce a better response in

muscle mass, although in both cases (moderate–high vs. low loads), adaptations have been observed (Chen et al., 2021). A repetition continuum or strength–endurance continuum proposes that the adaptations produced will depend on the number of repetitions and the intensity of the load (Triplett, 2015). However, it appears that muscle mass improvements can be achieved with loads greater than 30% 1RM, indicating that there is no ideal zone from a practical point of view (Schoenfeld et al., 2021). In contrast, in relation to the effect on fat mass, there seems to be more evidence about the need for low to moderate intensity and high volumes (López et al., 2022). A possible explanation could be the relationship between lipolysis with low intensity training and some volume because the optimal intensity for fat oxidation has been described as around 60% (Achten & Jeukendrup, 2004). In this sense, it has been described how resistance training programs of low–moderate intensity and moderate–high volume are the most suitable when the objective is both to reduce fat mass and increase muscle mass without changes in body mass (Ramos-Campo et al., 2021). The present program utilizes between 12 and 15 repetitions, and it is therefore considered moderate intensity, as well as optimal training for both a muscle mass increase and fat mass reduction.

In relation to the concept "strength–endurance continuum", it is considered that the adaptations produced by light load protocols are specific to endurance muscle adaptations and that the ability to improve maximal strength is minimal (Triplett, 2015). This may be because studies that have used 1RM testing do support the repetition continuum with respect to muscle strength in dynamic constant resistance exercise, and studies that used a device to assess isometric strength showed no difference, which may be due to the specificity of the test with respect to training (Schoenfeld et al., 2021).

Both previous studies discussed, and the present research have shown improvements in strength using moderate loads (Chen et al., 2021; O'Bryan et al., 2022; Yang et al., 2022). Early adaptations to strength training in strength improvement occur through motor learning and neural enhancement, and it is possible for any load to influence strength. However, maximizing the strength-related results requires heavier loads for experienced individuals (Schoenfeld et al., 2016). In this sense, the effect of OFE should also be investigated in experienced individuals.

OFE resistance training involves moderate intensities and a number of repetitions. These intensities are interesting for the sedentary population, because, as described, they produce improvements in body composition, strength, and muscle function. Furthermore, it seems reasonable to prescribe moderate loads given that training with light loads involves performing many repetitions, increases the training time, and produces high levels of metabolic acidosis, which tends to cause discomfort, affecting adherence. On the other hand, the minimum dose approach to resistance training minimizes the barriers to physical activity practice, favoring adherence and reducing negative affective responses, such as increased discomfort and reduced satisfaction (Fyfe et al., 2022).

Another aim of the present study was to analyze the effect of resistance training with OFE on the physical health and quality of life of middle-aged and older adults. Previous meta-analyses have reported improvements in quality of life, specifically in the physical domains, after resistance training (Khodadad Kashi et al., 2023). These quality-of-life domains have been influenced by aspects such as disability, diseases, and socioeconomic status; thus, these domains decrease with age 48 (Baernholdt et al., 2012). In this sense, the present research showed no changes in physical functioning, although improvements were observed in the role physical dimension. At the same time, a decline was observed in the group that did not train (CG). This could be due to the fact that in our study, the volunteers were relatively healthy and had high values in these domains. Previous research has indicated that quality of life improved with training in older adults with various chronic conditions as compared to healthy controls (Gillison et al., 2009) and those with low quality of life values prior to the intervention (Kwon et al., 2015).

Likewise, improvements or decreases in deterioration could be related to improvements in muscle mass, strength, and muscle function, as well as an improvement in energy and the ability to perform the activities of daily living (Angulo et al., 2020). Therefore, the present research suggests that training with OFE could prevent a decline in these domains of quality of life in healthy middle-aged and older age adults.

Another important objective of the present study was to analyze the influence of age on the findings of the present research. It was found that age had a significant influence on the intergroup changes for almost all the variables analyzed, as well as on the differences found when comparing the changes in the TG and CG for

most of the variables analyzed. Previous research has suggested that age may influence body composition, showing an increase in fat mass and a decrease in muscle mass with increasing age (Al-Sofiani et al., 2019; Jackson et al., 2012), which may be related to the appearance of numerous chronic diseases (Donini et al., 2022). Other research has found that strength, resistance, and power decrease during the aging period (Suetta et al., 2019), which could result in reduced functionality, autonomy, and quality of life (Shen et al., 2023; Wanderley et al., 2015). Moreover, investigations reveal that as individuals age, there is a decline in both speed and agility (Sloot et al., 2021; Soltani et al., 2021), factors also associated with functionality and autonomy (Binotto et al., 2018; Custodero et al., 2023). Indeed, the combination of losses of muscle mass, strength, and physical fitness that occur during the aging period has been referred to as sarcopenia (Cruz-Jentoft et al., 2019), being a pathology that affects between 10 and 16% of older people (Yuan & Larsson, 2023). Therefore, it is not surprising that the covariate of age showed a significant influence on the evolution of these variables of body composition and physical condition, including other more subjective variables, such as the participant's perception of their physical functioning and role physical dimensions. In fact, previous research has shown that the effects of a circuit strength training program on body composition and fitness may be different depending on whether it is performed by middle-aged adults (Paoli et al., 2010) or older people (Marcos-Pardo, Orquin-Castrillón, et al., 2019).

The strength of the present study is its pioneering nature in demonstrating that an outdoor training circuit with OFE, consisting of 11 exercises performed on eight types of OFE, can induce adaptations in health-related variables (body composition, physical fitness, and physical health) in middle-aged and older adults, despite relying on the principle of body weight resistance. This finding is significant given that it enhances and expands the range of tools available for improving health and physical function in middle-aged and older adults, offering an accessible alternative that overcomes the traditional barriers associated with strength training, such as the need for expensive equipment or indoor facilities. Leveraging OFE placed in public spaces, this study not only highlights the possibility of effectively incorporating strength training into the lifestyle of this population group but also emphasizes the importance of inclusive and easily

accessible training facilities that encourage the adoption of an active and healthy lifestyle.

While this study provides valuable insights, there are areas for further exploration that could enhance our understanding. One such area is the short duration of the intervention. Although improvements in some parameters were observed, it is conceivable that longer intervention durations could have had a greater impact on the results. Future studies must carry out interventions of longer durations to be able to provide long-term results. Another limitation could be the contaminating variable of nutrition. Nutrition was not monitored, and the volunteers were only given guidelines to maintain their nutritional habits. A further limitation concerns the quantification of the training load, which was performed using time under tension instead of traditional sets and repetitions since OFE does not allow for load adjustments. In addition, the lack of inclusion of a third group using traditional resistance training in the gym could be considered a limitation, as it would have been interesting to directly compare the effects of OFE training with conventional strength training methods. This approach could make it difficult to compare the results obtained with other studies that use different methods to quantify the training load. Another limitation was that the low number of participants prevented the separation of the TG and CG data between middle-aged and older adults. Given that the present research has found that age may influence the evolution of health-related variables in both TG and CG, this is an issue to be addressed in future studies. Furthermore, some of the participants had chronic illnesses or injuries, but the number of participants was not sufficient to analyze the influence of this issue on the evolution of the intervention. Future studies should aim to include a larger cohort of individuals with these medical backgrounds to facilitate a more comprehensive examination of the effects of training in these specific populations. Finally, attention must be paid to the limitation of the study regarding the replication of the equipment setup. It is important to note that if training is not conducted with the machines or training program used in this study, the results may not be extrapolatable. Finally, a possible limitation of the study is the small number of participants with pathologies or injuries, which precluded a detailed analysis of the effects of these conditions on the study variables due to their low incidence.

5.11. CONCLUSIONS

The present study found that resistance training with OFE twice a week for 8 weeks, despite only allowing self-loading, led to significant improvements in body composition, physical fitness, health, and quality of life among middle-aged and older adults compared to a control group that continued with their usual daily activities. The age of the participants influenced the evolution of the variables analyzed. The significant improvements observed through the use of OFE, based on the principle of body weight resistance, highlight an opportunity in the areas of clinical practice, public health, and physical fitness. This approach removes traditional barriers to resistance training, such as the costs of equipment and the need for indoor spaces, thereby democratizing health and fitness benefits. The detailed training program provided within this article ensures direct practical applicability and marks a fundamental break-through, promising a more inclusive future in health promotion and disease prevention strategies, making health improvements accessible to a wider population.

VI – DISCUSIÓN

VI -DISCUSIÓN

En la presente tesis por compendio, se presentan cuatro artículos que exploran el efecto del entrenamiento de fuerza con diferentes tipos de materiales en personas adultas y mayores. Estos estudios contribuyen a comprender cómo distintas modalidades de entrenamiento de fuerza pueden mejorar la salud física y psicosocial de las personas, reduciendo los efectos del envejecimiento.

El primer artículo se centra en la utilidad de las bandas elásticas de resistencia como herramienta para el entrenamiento de fuerza en casa. Este material es accesible, seguro y favorece la motivación y la adherencia al ejercicio. La facilidad de uso y la baja necesidad de supervisión hacen de las bandas elásticas una opción para mantener un estilo de vida activo en esta población.

El ejercicio se destaca como una herramienta clave para contrarrestar el deterioro físico y psicosocial asociado al envejecimiento, especialmente en contextos de movilidad reducida como en la pandemia de COVID-19 (Chen et al., 2019; Raafs et al., 2019). Los materiales como las bandas elásticas de resistencia ofrecen una opción segura, económica y efectiva para realizar ejercicios de fuerza en casa o al aire libre, ayudando a mantener la condición física y mejorar la masa y la fuerza muscular, siendo esenciales para reducir el riesgo de sarcopenia y el deterioro asociado al envejecimiento (Cadore et al., 2014; Chodzko-Zajko, 2014; Marcos-Pardo, Orquin-Castrillón, et al., 2019).

Estudios han comparado los efectos del entrenamiento de fuerza usando bandas elásticas de resistencia con métodos de entrenamiento tradicionales como máquinas de gimnasio, mostrando niveles similares de activación en la musculatura agonista (Andersen et al., 2010; Colado et al., 2010; Melchiorri & Rainoldi, 2011). Lo que sugiere que las bandas pueden ser tan efectivas para mejorar la fuerza y reducir la pérdida muscular como los materiales de entrenamiento de fuerza más tradicionales.

Además de los beneficios físicos, el entrenamiento de fuerza con bandas elásticas de resistencia puede mejorar aspectos psicosociales en los adultos mayores, tales como la calidad de vida, autoestima, calidad del sueño o la

reducción de síntomas de depresión y ansiedad (Fragala et al., 2019; O'Connor et al., 2010; Singh et al., 2005). Reportándose también mejoras en la función cognitiva de adultos mayores, lo que puede mejorar la función ejecutiva en contextos de deterioro cognitivo leve o demencia (Chen et al., 2017; Herold et al., 2019).

En base a esto, se recomienda realizar entrenamiento con bandas elásticas de resistencia de 2-3 días a la semana, empezando con sesiones cortas de 15-20 minutos y progresando hasta 45-60 minutos. Los ejercicios deben incluir movimientos que mejoren la fuerza e imiten las actividades diarias (Fragala et al., 2019). En este sentido, para controlar la intensidad del ejercicio se recomienda usar la escala RISE, que permite ajustar las cargas y evaluar el esfuerzo percibido, ayudando a progresar de forma segura (Colado et al., 2020). Tras las primeras semanas de adaptación, se recomienda incrementar la intensidad y volumen del entrenamiento. En este sentido, la supervisión de un educador físico-deportivo puede ser beneficiosa para asegurar la ejecución segura y efectiva de los diferentes ejercicios (de Alencar Silva et al., 2018; Fritz et al., 2018).

El segundo estudio analiza los beneficios y limitaciones del uso de maquinaria biosaludable en población adulta y mayor en base a la literatura existente. A pesar de su popularidad, se evidencia la necesidad de realizar más investigaciones que evalúen su efectividad y seguridad más rigurosamente.

Estudios indican que los OFE son usados principalmente por la población mayor debido a la interacción social y a los beneficios para la salud (Chow et al., 2017; Veitch et al., 2021; Ng et al., 2020). Sin embargo, la evidencia sobre los beneficios a largo plazo comparado con el entrenamiento tradicional en interior no es concluyente y requiere de estudios más rigurosos (Noseworthy et al., 2023).

De manera similar, la calidad y la satisfacción con la vida mejoran significativamente cuando se realizan actividades en grupo en ambientes que permiten una interacción social (Parra-Rizo et al., 2022). Por lo que estos espacios no solo fomentan un estilo de vida saludable, sino que también promueven la socialización y la convivencia, aumentando la adherencia al entrenamiento.

Sin embargo, otros estudios han señalado ciertas limitaciones de estas máquinas, como la falta de resistencia adecuada y problemas en el diseño, que pueden llevar a riesgos de seguridad, como desalineaciones espinales, adopción de posturas lesivas o riesgo de caídas (Abelleira-Lamela et al, 2021, Chow & Wu, 2019;

Liu et al., 2020; Sanchooli et al., 2021). Esto sugiere la necesidad de mejorar el diseño de estos equipos para optimizar los resultados del entrenamiento.

Por este motivo, es fundamental adaptar este tipo de maquinaria para incluir resistencia ajustable y considerar las características ergonómicas y biomecánicas de los usuarios, asegurando así un entrenamiento seguro y efectivo, involucrando a profesionales del ejercicio, la salud, la ingeniería y la administración pública (Bedimo-Rung et al., 2005).

Finalmente, en el tercer y cuarto artículo se presenta un ensayo controlado aleatorizado de 8 semanas que examinó los efectos de un programa de entrenamiento con OFE en la composición corporal, la condición física y la salud de adultos y mayores.

Este estudio mostró mejoras significativas en la composición corporal en el grupo que entrenó con maquinaria biosaludable. Los participantes mostraron un aumento en la masa magra y una reducción en la masa grasa, a diferencia del grupo de control, que no presentó cambios significativos. Otros estudios indican que los beneficios del entrenamiento con OFE pueden ser más pronunciados en adultos de mediana edad en comparación con mayores, posiblemente debido a diferencias en la respuesta corporal al ejercicio (Khalafi et al., 2023; López et al., 2022). Esto sugiere que el entrenamiento con OFE puede mejorar la composición corporal en adultos de mediana edad y que podría ralentizar los cambios asociados con la edad en la composición corporal en adultos mayores.

La investigación comparó sus resultados con otros dos estudios anteriores, encontrando diferencias significativas. Estas variaciones podrían atribuirse a la falta de grupos control, así como a diferencias en el volúmen de entrenamiento, y en el número y tipo de maquinaria biosaludable utilizada (Chow et al., 2021; Kim et al., 2018). Por este motivo, considerando que el entrenamiento de resistencia con OFE se clasifica de intensidad baja a moderada (Chow & Ho, 2018), es necesario garantizar un volumen de entrenamiento suficiente para conseguir adaptaciones (Marcos-Pardo, Espeso-García, Abelleira-Lamela, et al., 2023).

Además de los cambios en la composición corporal, el estudio observó mejoras en la fuerza de las extremidades y en pruebas de funcionalidad como TUG y la prueba de caminar 4 metros. Los programas de entrenamiento de fuerza han mostrado mejoras en la fuerza y la función muscular (Chen et al., 2021). Estas

mejoras pueden atribuirse a adaptaciones neuronales y la inervación muscular, más que a la hipertrofia, especialmente notables en las primeras semanas de entrenamiento (Chelly et al., 2009).

Investigaciones previas han sugerido que la edad puede influir en la composición corporal, aumentando la masa grasa y disminuyendo la masa muscular a medida que se envejece (Al-Sofiani et al., 2019; Cruz-Jentoft et al., 2019; Jackson et al., 2012). Estos cambios pueden estar relacionado con la aparición de numerosas enfermedades crónicas (Donini et al., 2022; Shen et al., 2023; Wanderley et al., 2015). En el presente estudio, la edad mostró una influencia significativa en los resultados, afectando a las variables de composición corporal y condición física, así como otras medidas más subjetivas como la percepción del funcionamiento físico y del rol físico.

La forzaleza de este estudio radica en su enfoque pionero al analizar los efectos de un programa de entrenamiento en circuito al aire libre con OFE, consistente en 11 ejercicios realizados en ocho tipos de OFE. Este enfoque ha demostrado que puede inducir adaptaciones en variables relacionadas con la composición corporal, condición física y la salud física y psicológica en adultos y mayores, a pesar de basarse en el principio de resistencia con el peso corporal. La efectividad del entrenamiento con OFE es una opción accesible y eficaz para mejorar la salud en adultos y mayores. Sin embargo, se recomienda que investigaciones futuras exploren intervenciones de mayor duración y que monitoreen variables adicionales como la nutrición para poder generalizar los resultados y proporcionar recomendaciones más específicas.

VII – CONCLUSIONES

VII - CONCLUSIONES

7.1. CONCLUSIONES GENERALES

Dando respuesta al primer objetivo general, según la literatura científica analizada, se concluye que ambos métodos de entrenamiento son efectivos para mejorar la salud física y psicológica, confirmando que el uso de este tipo de material puede ser beneficioso en la población adulta y mayor.

Respecto al segundo objetivo general, se puede concluir que una intervención de entrenamiento de 8 semanas en maquinaria biosaludable, con dos sesiones semanales, permite mejorar la salud física y psicológica, la composición corporal y la condición física, en comparación con aquellos que solo realizaron sus actividades diarias.

7.2. CONCLUSIONES ESPECÍFICAS

Se recomienda que las personas mayores realicen entrenamiento de fuerza con bandas elásticas 2-3 días a la semana, comenzando con sesiones de 15-20 minutos y progresando hasta 45-60 minutos. Los ejercicios deben enfocarse en movimientos que imiten las actividades cotidianas y deben incluir los principales grupos musculares del tronco y las extremidades. Siguiendo estas recomendaciones durante el período de confinamiento, se puede ayudar a reducir la pérdida de masa y fuerza muscular, controlar y/o reducir el peso corporal, evitar la acumulación de tejido graso y combatir la aparición de enfermedades crónicas o reducir las ya existentes en personas adultas y mayores. El entrenamiento de fuerza en casa utilizando bandas elásticas de resistencia es una opción beneficiosa y necesaria para el mantenimiento de la salud musculoesquelética y psicosocial.

Los programas de ejercicio en maquinaria biosaludable tienen el potencial de mejorar la salud psicofisiológica y social en los adultos y mayores, pero se requiere más investigación para comprender los beneficios y desafíos de su uso seguro y efectivo. Se necesitan estudios más rigurosos y ensayos clínicos aleatorizados para investigar la frecuencia, intensidad y duración óptimas del entrenamiento con este tipo de equipamiento para los adultos y mayores. Las barreras para el uso de

programas de entrenamiento con maquinaria biosaludable entre los adultos y mayores, la falta de medición estandarizada de los resultados y los estudios limitados existentes sobre los efectos a largo plazo, son desafíos que deben superarse para comprender plenamente los beneficios y desafíos de su utilización. La maquinaria biosaludable actual requiere rigurosas modificaciones, para maximizar la efectividad y la seguridad del entrenamiento con él.

Se ha diseñado un protocolo de estudio para un ensayo controlado aleatorizado que valora el efecto del entrenamiento de fuerza-resistencia en circuito con maquinaria biosaludable sobre la condición física, la composición corporal, la funcionalidad, la percepción de salud y la calidad de vida en adultos y mayores. El estudio se compone de dos brazos paralelos, con un grupo experimental que realiza un programa de entrenamiento de fuerza en circuito utilizando maquinaria biosaludable durante 8 semanas y un grupo control que realiza sus actividades diarias habituales. Se presenta un estudio de diseño cuyos resultados podrían proporcionar evidencia a médicos, educadores físico-deportivos y responsables de políticas sobre la mejor estrategia para asegurar un ejercicio al aire libre seguro y efectivo, estableciendo parámetros para prescribir y monitorear un programa de entrenamiento con maquinaria biosaludable, respetando el progreso individual.

El entrenamiento de fuerza con maquinaria biosaludable dos veces por semana durante 8 semanas, produjo mejoras significativas en la composición corporal, la condición física, la salud y la calidad de vida de adultos y mayores en comparación con un grupo de control que continuó con sus actividades diarias habituales. La edad de los participantes influyó en la evolución de las variables analizadas. Las mejoras significativas observadas mediante el entrenamiento en la maquinaria biosaludable, basadas en el peso corporal, destacan como una oportunidad en las áreas de práctica clínica, salud pública y condición física. Este enfoque elimina las barreras tradicionales al entrenamiento de fuerza muscular, como los costes del equipo y la necesidad de espacios interiores, democratizando así los beneficios para la salud y la condición física. El programa de entrenamiento detallado proporcionado en este artículo asegura una aplicabilidad práctica directa.

7.3. GENERAL CONCLUSIONS

Through the studies that comprise this doctoral thesis, the effectiveness and safety of resistance band training and outdoor fitness equipment on the health of adults and older people have been evaluated. According to the scientific literature analyzed, it is concluded that both training methods are effective in improving physical and psychological health, confirming that the use of this type of equipment can be beneficial in this population.

Additionally, the effects of circuit strength training performed with outdoor fitness equipment have been analyzed. Regarding this objective, it can be concluded that an 8-week training intervention using outdoor fitness equipment, with two sessions per week, improves physical and psychological health, body composition, and physical condition, compared to those who only performed their daily activities.

7.4. SPECIFIC CONCLUSIONS

It is recommended that older adults perform resistance training with elastic bands 2-3 days a week, starting with sessions of 15-20 minutes and progressing to 45-60 minutes. The exercises should focus on movements that imitate daily activities and should include the major muscle groups of the trunk and limbs. Following these recommendations can help during the confinement period to reduce the loss of muscle mass and strength, control and/or reduce body weight, avoid the accumulation of fatty tissue, and combat the occurrence of or reduce existing chronic diseases in adults and older people. Home resistance training using elastic materials is a beneficial and necessary option for the maintenance of musculoskeletal and psychosocial health.

Outdoor fitness equipment programs have the potential for improve psychophysiological and social health in older adults, but further research is required to understand the benefits and challenges of their use. More rigorous and randomized clinical trial studies are needed to investigate the optimal frequency, intensity, and duration of training with this equipment for older adults. Barriers to outdoor fitness equipment programs use among older adults, lack of standardized measurement of outcomes and limited studies on long-term effects are challenges that must be overcome to fully understand the benefits and

challenges of their use. Current outdoor fitness equipment requires several modifications such as those suggested in this study to maximize the effectiveness and safety of training on it.

A study protocol has been designed for a randomized controlled trial to evaluate the effect of circuit strength training with outdoor fitness equipment on physical fitness, body composition, functionality, health perception and quality of life in adults and older adults. The study comprises two parallel arms, with an experimental group that performs a circuit strength training program using outdoor fitness equipment for 8 weeks and a control group that performs its usual daily activities. A study design is presented whose results could provide evidence to health care providers, exercise trainers and policy makers on the best strategy to ensure safe and effective outdoor exercise, establishing parameters for prescribing and monitoring a training program with outdoor fitness equipment, with respect for individual progress.

Resistance training with OFE twice a week for 8 weeks, despite only allowing self-loading, led to significant improvements in body composition, physical fitness, health, and quality of life among middle-aged and older adults compared to a control group that continued with their usual daily activities. The age of the participants influenced the evolution of the variables analyzed. The significant improvements observed through the use of OFE, based on the principle of body weight resistance, highlight an opportunity in the areas of clinical practice, public health, and physical fitness. This approach removes traditional barriers to resistance training, such as the costs of equipment and the need for indoor spaces, thereby democratizing health and fitness benefits. The detailed training program provided within this article ensures direct practical applicability.

VIII – APLICACIONES PRÁCTICAS

VIII -APLICACIONES PRÁCTICAS

Las aplicaciones prácticas derivadas de la presente tesis doctoral tienen el potencial de generar un impacto positivo en la salud y la calidad de vida de personas adultas y mayores. La implementación de entrenamientos con bandas elásticas de resistencia y en parques biosaludables puede contribuir a la creación de comunidades más saludables. Estas iniciativas, además de mejorar la condición física y la funcionalidad de los individuos, fomentan la integración social y el bienestar psicológico, contribuyendo así a un envejecimiento activo y saludable. A continuación, se detallan las principales aplicaciones prácticas derivadas de estos hallazgos:

1. Los resultados obtenidos respaldan la importancia de fomentar la realización de ejercicio físico con bandas elásticas de resistencia y maquinaria biosaludable. Las administraciones deben promover el uso de estos materiales, así como la instalación de parques biosaludables en áreas urbanas, facilitando el acceso de la población adulta y mayor a una práctica de actividad física regular. Estas iniciativas pueden ayudar a reducir el sedentarismo y la inactividad física, previniendo enfermedades crónicas asociadas a la inactividad física y el envejecimiento.
2. Se propone un protocolo de entrenamiento de fuerza en circuito utilizando maquinaria biosaludable que puede ser adoptado por entrenadores y educadores físico-deportivos. Este protocolo, validado por la investigación científica, ofrece una estructura clara y efectiva para mejorar la salud física y psicológica de las personas adultas y mayores.
3. La implementación de programas de entrenamiento con maquinaria biosaludable debe ir acompañada de una evaluación continua que permita asegurar la efectividad y el control de los entrenamientos. Los entrenadores y educadores físico-deportivos pueden utilizar el protocolo de medición desarrollado en esta tesis doctoral para monitorizar el progreso de los participantes y ajustar los programas según sea necesario, garantizando que se mantengan alineados con sus objetivos.

XI - LIMITACIONES Y FUTURAS LÍNEAS DE INVESTIGACIÓN

IX - LIMITACIONES Y FUTURAS LÍNEAS DE INVESTIGACIÓN

A pesar de las aportaciones de la presente tesis doctoral al conocimiento sobre el entrenamiento de fuerza con bandas elásticas de resistencia y con maquinaria biosaludable, es importante reconocer ciertas limitaciones que pueden haber influido en los resultados y su interpretación. Abordar estas limitaciones en investigaciones futuras no solo fortalecería la validez de los hallazgos actuales, sino que también proporcionaría una comprensión más amplia y precisa de los efectos de este tipo de entrenamiento en la salud y calidad de vida de la población adulta y mayor. A continuación, se detallan las principales limitaciones identificadas en este estudio.

Las revisiones de la literatura presentadas en esta tesis son de carácter bibliográfico, lo que puede limitar la capacidad de sintetizar los resultados de diferentes estudios. Una revisión sistemática con metaanálisis proporcionaría una evaluación de la evidencia disponible más rigurosa, permitiendo una mejor comparación de los resultados de múltiples estudios y fortaleciendo las conclusiones.

Una de las principales limitaciones es la duración de la intervención del programa de entrenamiento. Aunque los resultados obtenidos son prometedores, aumentar la duración de la intervención permitiría observar los efectos a largo plazo del entrenamiento con maquinaria biosaludable, proporcionando una visión más completa y detallada. No obstante, otras investigaciones señalan que 8 semanas podría ser tiempo suficiente para obtener beneficios, sobre todo en población mayor (Casas et al., 2022).

Otra limitación es la falta de un control riguroso de los hábitos alimentarios de los participantes. La variabilidad en la alimentación de los sujetos podría haber introducido variables contaminantes que afecten los resultados. En futuros estudios, sería esencial implementar un control sistemático de la alimentación de los participantes. Aunque se usó el cuestionario de Adherencia a la dieta mediterránea (PREDIMED), este cuestionario no permite calcular la ingesta calórica, cuestión que podría afectar a los cambios en la composición corporal de los participantes (Schröder et al., 2011).

El método de cuantificación de la carga de entrenamiento utilizado podría diferir de los métodos tradicionales basados en series y repeticiones debido a las características de la maquinaria, lo que podría dificultar la comparación directa con otros estudios. Utilizar métodos estandarizados de cuantificación de la carga en investigaciones futuras facilitaría la comparación de los resultados con la literatura existente.

La replicabilidad de este estudio podría verse limitada al requerirse el mismo tipo y modelo de maquinaria biosaludable que fue utilizada en la intervención. Aunque los hallazgos obtenidos son relevantes, la generalización de los resultados a otros contextos o a la utilización de diferentes equipos de fitness al aire libre (OFE) podría no ser directamente aplicable. Por tanto, es importante considerar estas diferencias al interpretar y comparar los resultados.

Teniendo en cuenta las presentes limitaciones y a partir de los hallazgos y conclusiones, se identifican diversas áreas de investigación que merecen una atención más profunda para seguir avanzando en el conocimiento sobre el entrenamiento con materiales sencillos y accesibles como las bandas elásticas de resistencia y la maquinaria biosaludable. A continuación, se presentan diferentes líneas y acciones que podrían tenerse en cuenta para futuros estudios.

Llevar a cabo estudios longitudinales que evalúen tanto los efectos agudos como los efectos a largo plazo del entrenamiento con maquinaria biosaludable en adultos y mayores. Es esencial determinar si los beneficios observados en estudios a corto-medio plazo se mantienen en el tiempo y si existen efectos acumulativos positivos sobre la salud física y psicológica.

Comparar la efectividad de diferentes protocolos de entrenamiento, además de los ejercicios de fuerza muscular en circuito, como el entrenamiento multicomponente, el de resistencia, el de flexibilidad o el de equilibrio realizados en parques biosaludables. Estos estudios permitirán identificar cuáles son más beneficiosos para las distintas poblaciones y las condiciones de salud, optimizando así los programas de ejercicio y adaptándolos según las necesidades específicas de los participantes.

Investigar sobre nuevos diseños de maquinaria biosaludable que puedan satisfacer las necesidades de personas con diferente capacidad funcional o niveles de condición física. Esta investigación permitiría optimizar el diseño de los

equipos, asegurando que sean efectivos y seguros para una mayor cantidad de usuarios.

Ampliar la investigación sobre los beneficios psicológicos y sociales del entrenamiento en parques biosaludables. Es necesario explorar cómo la reducción del estrés, la mejora del estado de ánimo o el fomento de la integración social pueden contribuir al bienestar general de los participantes y cómo estos factores pueden potenciar los efectos positivos del ejercicio físico en parques biosaludables.

Evaluar variables relacionadas con aspectos biomecánicos y fisiológicos durante el entrenamiento en maquinaria biosaludable. Es fundamental considerar parámetros como el lactato, el gasto energético, la variabilidad de la frecuencia cardiaca y otras variables fisiológicas para comprender mejor el impacto del entrenamiento en el organismo. Además, un análisis detallado de la biomecánica del movimiento podría proporcionar información valiosa para mejorar la ergonomía y la seguridad, reduciendo el riesgo de lesiones y aumentando la eficacia del entrenamiento en este equipamiento.

Teniendo en cuenta las limitaciones y las futuras líneas de investigación mencionadas, es importante señalar que se están llevando a cabo varios estudios que abordan estas áreas y que no se han llegado a incluir en la presente tesis doctoral. Entre las investigaciones en desarrollo se encuentran: el análisis biomecánico y electromiográfico del entrenamiento en maquinaria biosaludable para determinar el nivel de activación muscular bajo condiciones reales de entrenamiento; el estudio de los efectos agudos del entrenamiento sobre variables fisiológicas y sus efectos sobre el organismo; y el diseño y fabricación de una nueva gama de maquinaria BIOFIT-Park, diseñada para superar estas limitaciones y adaptarse a las necesidades de los usuarios. Los resultados de estas investigaciones tendrán un impacto significativo en la mejora de los beneficios para la salud en esta población, abriendo nuevas oportunidades para investigaciones futuras y aplicaciones prácticas en el ámbito del entrenamiento en parques biosaludables.

X - REFERENCIAS BIBLIOGRÁFICAS

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XI – ANEXOS

XI - ANEXOS

ANEXO 1. APROBACIÓN DEL COMITÉ DE ÉTICA

UCAM
UNIVERSIDAD CATÓLICA SAN ANTONIO

COMITÉ DE ÉTICA DE LA UCAM

DATOS DEL PROYECTO

Título:	"Maquinaria Bio-saludable Inteligente: Diseño y fabricación de nueva maquinaria de fitness outdoor ergonómica, eficiente, saludable y con aplicación para dispositivos móviles (App) de valoración y control del entrenamiento"

Investigador Principal	**Nombre**	**Correo-e**
Dr.	Pablo Jorge Marcos Pardo	pmarcos@ucam.edu

INFORME DEL COMITÉ

Fecha	**29/11/2019**	**Código**	**CE111908**

Tipo de Experimentación

Investigación experimental clínica con seres humanos	
Utilización de tejidos humanos procedentes de pacientes, tejidos embrionarios o fetales	
Utilización de tejidos humanos, tejidos embrionarios o fetales procedentes de bancos de muestras o tejidos	
Investigación observacional con seres humanos, 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 CATOLICA SAN ANTONIO • COMITE DE ETICA •

Universidad Católica San Antonio. Vicerrectorado de Investigación. Salida nº 7526 29/11/2019 18:42:40

ANEXO 2. CONSENTIMIENTO INFORMADO

PRELEDE
GRUPO DE INVESTIGACIÓN PREVENCIÓN DE LESIONES DEPORTIVAS. UCAM

UCAM
UNIVERSIDAD CATÓLICA DE MURCIA

CONSENTIMIENTO INFORMADO

Código: .....

Yo, D. / Dª ....., con DNI .....

DECLARO:

- Haber sido informado/a del estudio y procedimiento de investigación del Proyecto: Maquinaria bio-saludable inteligente: Diseño y fabricación de nueva maquinaria de fitness Outdoor ergonómica, eficiente, saludable y con aplicación para dispositivos móviles (APP) de valoración y control del entrenamiento.
- He podido hacer preguntas del estudio, comprendiendo que me presto de forma voluntaria y que en cualquier momento puedo abandonar sin que me suponga prejuicio de ningún tipo.

PRESTO CONSENTIMIENTO:

- Al tratamiento de los datos que deriven del presente proyecto, con fines estadísticos, científicos o docentes, lo cual se llevará a cabo mediante procesos adecuados de disociación de datos que impidan su identificación.
- A la toma de imágenes (fotos y/o vídeos) a efectos de documentar el caso durante la realización del Estudio y para fines docentes y de investigación de difusión del conocimiento científico del presente Proyecto de Investigación.
- Para someterme a las siguientes pruebas:
  - Cuestionarios básicos de recogida de información sociodemográfica.
  - Cuestionario para la valoración de la Calidad de vida relacionada con la Salud (SF-36), cuestionario de adherencia a la dieta mediterránea y satisfacción con la vida.
  - Valoración de la composición corporal mediante densitometría (DEXA).
  - Valoración de la talla, peso y tensión arterial.
  - Valoración de la fuerza isométrica máxima de extensión de rodilla y flexión de bíceps.
  - Valoración de la fuerza de prensión manual.
  - Valoración de la capacidad funcional mediante los test Chair Satnd test, velocidad de la marcha, Time up and Go test y la Batería de test de funcionalidad Short Physical Performance Battery (SPPB).
  - Valoración de la disposición sagital del raquis en bipedestación y sedestación.

Entiendo que seré asignado a un grupo experimental de práctica de actividad física o grupo control para el desarrollo de la fase experimental que tendrá una duración de 8 semanas aproximadamente.

USO DE LOS DATOS DERIVADOS DEL ESTUDIO

De acuerdo con lo dispuesto en la Ley Orgánica 15/1999, de Protección de Datos de Carácter Personal, en cualquier momento usted puede ejercitar sus derechos de acceso, rectificación, cancelación y oposición, enviando una solicitud por escrito acompaña de una fotocopia de documento oficial que lo identifique a la Universidad Católica San Antonio de Murcia, Avenida de los Jerónimos, 135, 30107 Guadalupe (Murcia).

En Guadalupe (Murcia) a ..... de ..... De 2021



Dra. Noelia González Gálvez

Firma de voluntario

Firma investigador principal 1

Dra. Ciencias de la Actividad Física y del Deporte



Dr. Pablo J. Marcos Pardo

Firma investigador principal 2

Dr. Ciencias de la Actividad Física y del Deporte

ANEXO 3. CUESTIONARIO SOCIODEMOGRÁFICO

PRELEDE
GRUPO DE INVESTIGACIÓN PREVENCIÓN DE LESIONES DEPORTIVAS. UCAM

UCAM UNIVERSIDAD CATÓLICA DE MURCIA

CUESTIONARIOS

Responda a las siguientes preguntas con la mayor sinceridad. No existen preguntas bien o mal contestadas. No dejes ninguna pregunta sin responder.

¡Muchas gracias!

1. Género **2. Edad:** ____años

- ☐ Masculino
- ☐ Femenino

4. Nacionalidad: _____

Municipio de residencia:_____

5. Actividad física

¿Práctica algún tipo de actividad física (caminar, aeróbic, gimnasia, centro deportivo, Pilates, correr, etc.)? _____

¿Cuál?_____

¿Con qué frecuencia?_____

¿Cuánto tiempo?_____

6. Ocupación laboral

- ☐ Empleado a tiempo completo
- ☐ Empleado a tiempo parcial
- ☐ Desempleado
- ☐ Trabajador por cuenta propia
- ☐ Retirado

3. Estado civil

- ☐ Soltero/a
- ☐ Casado/a o Pareja de hecho
- ☐ Separado/a o divorciado/a
- ☐ Viudo/a

7. Nivel de estudios

- ☐ Sin estudios
- ☐ Básicos (Graduado escolar)
- ☐ Secundarios (ESO, bachillerato)
- ☐ Superiores (ciclos formativos/grado medio o superior)
- ☐ Estudios universitarios

8. Viviendo o no en compañía

- ☐ Con su esposo/a
- ☐ Con un compañero/a
- ☐ Sólo/a

9. Número de caídas en el último año (desde este momento): _____

10. Pérdida de peso corporal en el último año (desde este momento): _____Kg

11. Indica los medicamentos que toma usualmente, la frecuencia y con qué objetivo los toma (si no recuerda el nombre del medicamento indique su objetivo y frecuencia. Ejemplo: Medicación diaria para controlar la tensión arterial; ibuprofeno unas tres veces al mes para dolor de espalda).

_____

_____

_____

12. Indique si ha padecido o padece alguna de las siguientes enfermedades.

	¿Alguna vez ha padecido?		¿La ha padecido en los últimos 12 meses?		¿Le ha dicho un médico que la padece?	
	Si	No	Si	No	Si	No
1. Tensión alta						
2. Infarto de miocardio						
3. Otras enfermedades del corazón						
4.Varices en las piernas						
5. Artrosis, artritis o reumatismo						
6. Dolor de espalda crónico (cervical)						
7.Dolor de espalda crónico (lumbar)						
8.Alergia crónica (asma alérgica excluida)						
9. Asma						
10. Bronquitis crónica, enfisema, enfermedad pulmonar obstructiva crónica (EPOC)						
11. Diabetes						
12.Úlceras de estómago y duodeno						
13. Incontinencia urinaria						

	¿Alguna vez ha padecido?		¿La ha padecido en los últimos 12 meses?		¿Le ha dicho un médico que la padece?	
	Si	No	Si	No	Si	No
14. Colesterol alto						
15. Cataratas						
16. Problemas crónicos de piel						
17. Estreñimiento crónico						
18. Cirrosis, disfunción hepática						
19. Depresión crónica						
20. Ansiedad crónica						
21. Parkinson						
22. Demencia/Alzheimer						
23. Embolia, infarto cerebral, hemorragia cerebral						
24. Migraña o dolor de cabeza frecuente						
25. Hemorroides						
26. Cáncer/tumores malignos						
26. ¿Dónde? (indicar origen)						
27. Osteoporosis						
28. Problemas de tiroides						
29. Problemas de próstata (solo hombres)						

ANEXO 4. CUESTIONARIO PREDIMED

CUESTIONARIO DE ADHERENCIA A LA DIETA MEDITERRÁNEA

1	¿Usa usted el aceite de oliva principalmente para cocinar?	Si / No
2	¿Toma más de dos cucharadas de aceite de oliva al día (incluyendo el usado para freír, el de las comidas fuera de casa, las ensaladas, etc.)?	Si / No
3	¿Toma más de dos raciones de verdura u hortalizas (al menos una de ellas en ensaladas o crudas) al día (las guarniciones o acompañamientos contabilizan como ½ ración)?	Si / No
4	¿Toma más de 3 piezas de fruta (incluyendo zumo natural) al día?	Si / No
5	¿Toma menos de una ración de carnes rojas, hamburguesas, salchichas o embutidos consume al día (una ración equivale a 100-150 gr)?	Si / No
6	¿Toma menos de una porción al día de mantequilla, margarina o nata consume al día (una porción individual equivale a 12 gr)?	Si / No
7	¿Toma menos de una bebidas carbonatadas y/o azucaradas (refrescos, colas, tónicas, bitter) al día?	Si / No
8	¿Bebe 3 o más vasos a la semana de vino?	Si / No
9	¿Toma 3 o más raciones de legumbres consume a la semana (una ración o plato equivale a 150 gr)?	Si / No
10	¿Toma tres o más raciones de pescado o mariscos a la semana (un plato, pieza o ración equivale a 100-150 gr de pescado ó 4-5 piezas de marisco)?	Si / No
11	¿Toma menos de tres piezas de repostería comercial (no casera) como galletas, flanes, dulces o pasteles a la semana?	Si / No
12	¿Toma una o más veces frutos secos a la semana (una ración equivale a 30 gr)?	Si / No
13	¿Consume preferentemente carne de pollo, pavo o conejo en vez de ternera, cerdo, hamburguesas o salchichas (carne de pollo: una pieza o ración equivale a 100-150 gr)?	Si / No
14	¿Toma dos o más veces por semana vegetales cocinados, la pasta, el arroz u otros platos aderezados con una salsa de tomate, ajo, cebolla o puerro elaborada a fuego lento con aceite de oliva (sofrito)?	Si / No

ANEXO 5. CUESTIONARIO 36-ITEM SHORT FORM

CUESTIONARIO "SF-36" SOBRE EL ESTADO DE SALUD

Las preguntas que siguen se refieren a lo que usted piensa sobre su salud. Sus respuestas permitirán saber cómo se encuentra usted y hasta qué punto es capaz de hacer sus actividades habituales.

Conteste cada pregunta tal como se indica. Si no está seguro/a de cómo responder a una pregunta, por favor conteste lo que le parezca más cierto.

1. En general, usted diría que su salud es: (marque un solo número)

Excelente 1
Muy buena 2
Buena 3
Regular 4
Mala 5

2. ¿Cómo diría usted que es su salud actual, comparada con la de hace un año?
(marque un solo número)

Mucho mejor ahora que hace un año 1
Algo mejor ahora que hace un año..... 2
Más o menos igual que hace un año 3
Algo peor ahora que hace un año 4
Mucho peor ahora que hace un año 5

3. Las siguientes preguntas se refieren a actividades o cosas que usted podría hacer en un día normal. Su salud actual, ¿le limita para hacer esas actividades o cosas? Si es así, ¿cuánto?

ACTIVIDADES	Sí, me limita	Sí, me limita un poco	No, no me limita nada
a. **Esfuerzos intensos**, tales como correr, levantar objetos pesados, o participar en deportes agotadores	1	2	3
b. **Esfuerzos moderados**, como mover una mesa, pasar la aspiradora, jugar a los bolos o caminar más de una hora	1	2	3
c. Coger o llevar la bolsa de la compra	1	2	3
d. Subir **varios** pisos por la escalera	1	2	3
e. Subir **un solo** piso por la escalera	1	2	3
f. Agacharse, arrodillarse o ponerse en cuclillas	1	2	3
g. Caminar **un kilómetro o más**	1	2	3
h. Caminar **varias manzanas** (varios centenares de metros)	1	2	3
i. Caminar **una sola manzana** (unos 100 metros)	1	2	3
j. Bañarse o vestirse por sí mismo	1	2	3

4. Durante las 4 últimas semanas, ¿ha tenido alguno de los siguientes problemas en su trabajo o en sus actividades cotidianas, a causa su salud física?

	SÍ	NO
a. ¿Tuvo que **reducir el tiempo** dedicado al trabajo o a sus actividades cotidianas?	1	2
b. ¿**Hizo menos** de lo que hubiera querido hacer?	1	2
c. ¿Tuvo que **dejar de hacer algunas tareas** en su trabajo o en sus actividades cotidianas?	1	2
d. ¿Tuvo **dificultad** para hacer su trabajo o sus actividades cotidianas (por ejemplo, le costó más de lo normal)?	1	2

5. Durante las 4 últimas semanas, ¿ha tenido alguno de los siguientes problemas en su trabajo o en sus actividades cotidianas, a causa de algún problema emocional (como estar triste, deprimido, o nervioso)?

	SÍ	NO
a. ¿Tuvo que **reducir el tiempo** dedicado al trabajo o a sus actividades cotidianas, **por algún problema emocional**?	1	2
b. ¿**Hizo menos** de lo que hubiera querido hacer, **por algún problema emocional**?	1	2
c. ¿No hizo su trabajo o sus actividades cotidianas tan **cuidadosamente** como de costumbre, **por algún problema emocional**?	1	2

6. Durante las 4 últimas semanas, ¿hasta qué punto su salud física o los problemas emocionales han dificultado sus actividades sociales habituales con la familia, los amigos, los vecinos u otras personas? (marque un solo número)

Nada.....1
Un poco 2
Regular.....3
Bastante 4
Mucho.....5

7. ¿Tuvo dolor en alguna parte del cuerpo durante las 4 últimas semanas? (marque un solo número)

No, ninguno 1
Sí, muy poco 2
Sí, un poco 3
Sí, moderado.....4
Sí, mucho.....5
Sí, muchísimo 6

8. Durante las 4 últimas semanas, ¿hasta qué punto el dolor le ha dificultado su trabajo habitual (incluido el trabajo fuera de casa y las tareas domésticas)? (marque un solo número)

Nada 1
Un poco 2
Regular 3
Bastante.....4
Mucho 5

9. Las preguntas que siguen se refieren a cómo se ha sentido y cómo le han ido las cosas durante las 4 últimas semanas. En cada pregunta responda lo que se parezca más a cómo se ha sentido usted. Durante las últimas 4 semanas ¿cuánto tiempo...

	Siempre	Casi siempre	Muchas veces	Algunas veces	Sólo alguna vez	Nunca
a. se sintió lleno de vitalidad?	1	2	3	4	5	6
b. estuvo muy nervioso?	1	2	3	4	5	6
c. se sintió tan bajo de moral que nada podía animarle?	1	2	3	4	5	6
d. se sintió calmado y tranquilo?	1	2	3	4	5	6
e. tuvo mucha energía?	1	2	3	4	5	6
f. se sintió desanimado y triste?	1	2	3	4	5	6
g. se sintió agotado?	1	2	3	4	5	6
h. se sintió feliz?	1	2	3	4	5	6
i. se sintió cansado?	1	2	3	4	5	6

10. Durante las 4 últimas semanas, ¿con qué frecuencia la salud física o los problemas emocionales le han dificultado sus actividades sociales (como visitar a los amigos o familiares)?

(marque un solo número)
Siempre 1
Casi siempre 2
Algunas veces 3
Sólo alguna vez.....4
Nunca.....5

11. Por favor, diga si le parece CIERTA o FALSA cada una de las siguientes frases:

	Totalmente cierta	Bastante cierta	No lo sé	Bastante falsa	Totalmente falsa
a. Creo que me pongo enfermo más fácilmente que otras personas	1	2	3	4	5
b. Estoy tan sano como cualquiera	1	2	3	4	5
c. Creo que mi salud va a empeorar	1	2	3	4	5
d. Mi salud es excelente	1	2	3	4	5

SWL
Por favor, indica tu grado de acuerdo con cada frase rodeando con un círculo el número apropiado (SATISFACCIÓN CON LA VIDA):

	LA PERCEPCIÓN QUE TENGO DE MI VIDA ES QUE...	No estoy de acuerdo				Totalmente de acuerdo
1	En la mayoría de los aspectos de mi vida es como yo quiero que sea	1	2	3	4	5
2	Las circunstancias de mi vida son muy buenas	1	2	3	4	5
3	Estoy satisfecho con mi vida	1	2	3	4	5
4	Hasta ahora he conseguido de la vida las cosas que considero importantes	1	2	3	4	5
5	Si pudiera vivir mi vida otra vez no cambiaría casi nada	1	2	3	4	5

ANEXO 6. HOJA DE REGISTRO DE VALORACIÓN

A PARTIR DE ESTA SECIÓN LA INFORMACIÓN SERÁ COMPLETADA POR NOSOTROS. POR FAVOR, INDÍQUENOS QUE HA TERMINADO DE COMPLETAR EL CUESTIONARIO:

1. Talla:_____ 2.Peso: _____ 3.Dexa: _____

4.Tensión arterial sistólica: _____ 5.Tensión arterial diastólica: _____FC:___

6.FIM

Extensión rodilla derecha: _____

Extensión rodilla izquierda: _____

Flexión bíceps: _____

7. Disposición sagital Bipedestación

1. Dorsal:_____Lumbar:_____Sacro:_____

2. Dorsal:_____Lumbar:_____Sacro:_____

Disposición sagital Sedestación

1.Dorsal:_____Lumbar:_____Sacro:_____

2.Dorsal:_____Lumbar:_____Sacro:_____

8.Dinamometria

Derecha 1: _____ Derecha 2: _____

Izquierda 1: _____ Izquierda 2: _____

9.Chair stand test

1: _____

2: _____

10.Velocidad marcha 4, 6 y 10 m

1._____

2._____

11.Time up and go test

1._____

2._____

12. Equilibrio

Paralelo 1:_____2:_____

Semitandem 1:_____ 2:_____

Tandem 1:_____2:_____

13. 400 metros

Tiempo vuelta:

1	9	16	
2	10	17	FC final:_____
3	11	18	FC media:_____
4	12	19	FC máxima: _____
5	13	20	FC 2 minutos:_____
6	14		
7	15	Tiempo acumulado total: _____	
8	16		

ANEXO 7. FICHA DE PERCEPCIÓN DEL ESFUERZO

BIOFIT-Park

Ficha análisis de la percepción del esfuerzo

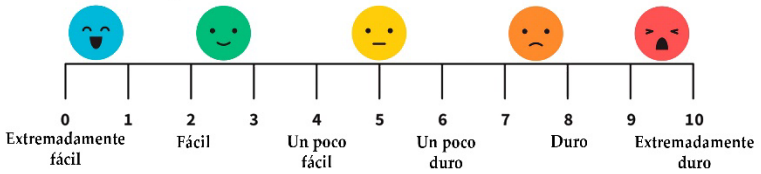
(RTC-2017-6145-1)

UCAM UNIVERSIDAD CATÓLICA DE MURCIA

Nombre:..... Código: ..... Fecha: ..... Sesión Número: .....

En general, ¿Cómo califica el esfuerzo que ha realizado en la sesión de hoy?

En esta ficha debe indicar con un círculo el esfuerzo que ha sentido al realizar cada uno de los ejercicios.



0 significa no sentir ningún esfuerzo.

10 significa que se ha llegado la máximo de nuestra capacidad para continuar.

Percepción del esfuerzo en relación a cada una de las máquinas:



(1). Jinete:

1 2 3 4 5 6 7 8 9 10



(2). Géminis Bajo:

1 2 3 4 5 6 7 8 9 10



(3). Paseo:

1 2 3 4 5 6 7 8 9 10



(4). Fondos:

1 2 3 4 5 6 7 8 9 10



(5). Volantes Círculos:

1 2 3 4 5 6 7 8 9 10



(6). Géminis Alto:

1 2 3 4 5 6 7 8 9 10



(7). Volantes Rotación:

1 2 3 4 5 6 7 8 9 10



(8). C. Gemelos:

1 2 3 4 5 6 7 8 9 10



(9). Surf:

1 2 3 4 5 6 7 8 9 10



(10). Columpio Press:

1 2 3 4 5 6 7 8 9 10



(11). Remo:

1 2 3 4 5 6 7 8 9 10

PRELEDE GRUPO DE INVESTIGACIÓN PREVENCIÓN DE LESIONES EN EL DEPORTE. UCAM

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

ANEXO 8. PRODUCTIVIDAD CIENTÍFICA

Durante la presente tesis doctoral se han llevado a cabo múltiples investigaciones y publicaciones, tanto relacionadas directamente con la temática de estudio como en áreas afines. A continuación, se detallan los diferentes trabajos y publicaciones que se ha realizado a lo largo del desarrollo de esta investigación.

A continuación, se describen los contratos, ayudas y becas obtenidas durante la duración de la tesis doctoral:

1. Contrato de Ayudante de Investigación asociado al proyecto RETOS-Colaboración (RTC-2017-6145-1). Ministerio de Ciencia e Innovación. Fecha de inicio-fin: 20/12/2018-31/10/2020. Importe del contrato: 47,865.30 €. Responsable: Dr. Pablo J. Marcos-Pardo.
2. Ayuda para la Formación del Profesorado Universitario (FPU-19/00488). Ministerio de Universidades. Fecha de inicio-fin: 28/07/2020-05/11/2024. Importe de la ayuda: 71,134.14 €. Responsables: Dr. Pablo J. Marcos-Pardo (28/07/2020-31/12/2020) y Dra. Noelia González-Gálvez (01/01/2021-05/11/2024).
3. Ayudas complementarias de movilidad destinadas a beneficiarios del programa de Formación del Profesorado Universitario (FPU): Estancias Breves y Traslados Temporales. 2021. Ministerio de Universidades. Fecha de inicio-fin: 29/07/2022-14/12/2022. Importe de la ayuda: 3,480 €.

A continuación, se enumera la participación en proyectos durante la realización de la tesis doctoral:

1. Maquinaria Bio-Saludable Inteligente: Diseño y fabricación de nueva maquinaria de fitness outdoor ergonómica, eficiente, saludable y con aplicación para dispositivos móviles (App) de valoración y control del entrenamiento (RTC-2017-6145-1). Fecha de inicio-fin: 01/12/2018-30/11/2021. Cuantía total: 621,591 €. Investigadores principales: Dr. Pablo J. Marcos-Pardo (01/12/2018- 31/12/2020) y Dra. Noelia González Gálvez (01/01/2021- 30/11/2021).
2. Promoting the shift sedentary Lifestyle towards active Ageing – LifeAge (603121-EPP-1-2018-1-ES-SPO-SCP). Fecha de inicio-fin: 01/01/2019-

31/12/2020. Cuantía total: 389,830 €. Investigador principal: Dr. Pablo J. Marcos-Pardo.

3. H2 Physical Education: Promoting cardiometabolic health by 2 HIIT protocol, twice a week at Physical Education. Fecha de inicio-fin: 03/11/2019-03/11/2021. Cuantía total: 9,986 €. Investigador principal: Dra. Noelia González Gálvez.
4. COVID-19 y aislamiento social: efectos sobre la condición física y la salud psico-fisiológica en adultos mayores. Fecha de inicio-fin: 18/05/2020-18/05/2021. Cuantía total: 9,986 €. Investigador principal: Dr. Pablo J. Marcos-Pardo.
5. Convenio entre el Ayuntamiento de Archena y la Universidad Católica de Murcia: Archena Respira y se Cuida. Fecha de inicio-fin: 26/10/2020-26/12/2021. Cuantía total: 4,840 €. Investigador principal: Dra. Noelia González Gálvez.
6. Creación de un sistema de apoyo para el éxito académico destinado a alumnos de carrera dual -ApoyoCarreraDual- (PID-13/22). Fecha de inicio-fin: 01/09/2022-01/09/2023. Cuantía total: 600 €. Investigador principal: Dra. Raquel Vaquero Cristóbal.
7. Modelo para comparación de resultados de masa grasa de diferentes métodos de evaluación corporal (INV/23/8/ESP). Fecha de inicio-fin: 02/01/2023-02/01/2024. Cuantía total: 374,217.56 €. Investigador principal: Dr. Francisco Esparza Ros y Dra. Raquel Vaquero Cristóbal.
8. Fomento de la actividad física diaria recomendada para la salud en adolescentes mediante Apps móviles, wearables y una TAC gamificada (PID2022-140245OA-I00). Fecha de inicio-fin: 01/09/2023-31/08/2026. Cuantía total: 124,750 €. Investigador principal: Dra. Raquel Vaquero Cristóbal y Dra. Lucía Abenza Cano.

A continuación, se enumeran las publicaciones en forma de artículos científicos, libros y capítulos de libro:

1. Gea-García, Gemma M., Espeso-García, A., Marcos-Pardo, P. J., & Menayo-Antúnez, R. (2020). Fin type and flutter technique: a study to optimise the oxygen consumption in divers. *Ergonomics, 63*(6), 756–768. https://doi.org/10.1080/00140139.2020.1745899

2. Gea-García, Gemma María, González-Gálvez, N., Espeso-García, A., Marcos-Pardo, P. J., González-Fernández, F. T., & Martínez-Aranda, L. M. (2020). Relationship between the practice of physical activity and physical fitness in physical education students: The integrated regulation as a mediating variable. *Frontiers in psychology, 11*. https://doi.org/10.3389/fpsyg.2020.01910

3. Marcos-Pardo, P.J., González-Gálvez, N., Vaquero-Cristóbal, R., Martínez-Aranda, L.M., Gea-García, G.M., Orquín-Castrillón, F.J., López-Vivancos, A., & Espeso-García, A. (2020). Middle-age adults Exercise Prescription Recommendations: Physical Fitness (resistance, cardiovascular and Flexibility Training). In P.J. Marcos-Pardo, D. Jiménez-Pavón, E. Isidori, N. González-Gálvez, & R. Vaquero-Cristóbal, *Exercise Prescription for Healthy Active Ageing: LifeAge Guide* (pp. 101-110). Zenodo. https://doi.org/10.5281/zenodo.4395762

4. Marcos-Pardo, P.J., González-Gálvez, N., Vaquero-Cristóbal, R., Gea-García, G.M., Martínez-Aranda, L.M., Orquín-Castrillón, F.J., López-Vivancos, A., & Espeso-García, A. (2020). Motivational Strategies to Increase Adherence to Exercise Programs with Age. In P.J. Marcos-Pardo, D. Jiménez-Pavón, E. Isidori, N. González-Gálvez, & R. Vaquero-Cristóbal, *Exercise Prescription for Healthy Active Ageing: LifeAge Guide* (pp. 119-130). Zenodo. https://doi.org/10.5281/zenodo.4395762

5. Marcos-Pardo, P.J., Vaquero-Cristóbal, R., González-Gálvez, N., Espeso-García, A., López-Vivancos, A., Orquín-Castrillón, F.J., Gea-García, G.M., Martínez-Aranda, L.M., Velázquez-Díaz, D., Ponce-González, J.G., Cadenas-Sánchez, C., Carbonell-Baeza, A., & Jiménez-Pavón, D. (2020). Multidomain LifeAge Program. In P.J. Marcos-Pardo, D. Jiménez-Pavón, E. Isidori, N. González-Gálvez, & R. Vaquero-Cristóbal, *Exercise Prescription*

for Healthy Active Ageing: LifeAge Guide (pp. 129-138). Zenodo. https://doi.org/10.5281/zenodo.4395762

6. Marcos-Pardo, Pablo J., González-Gálvez, N., Espeso-García, A., Abelleira-Lamela, T., López-Vivancos, A., & Vaquero-Cristóbal, R. (2020). Association among adherence to the Mediterranean diet, cardiorespiratory fitness, cardiovascular, obesity, and anthropometric variables of overweight and obese middle-aged and older adults. *Nutrients, 12*(9), 2750. https://doi.org/10.3390/nu12092750

7. Marcos-Pardo, P. J., González-Gálvez, N., Gea-García, G. M., López-Vivancos, A., Espeso-García, A., & Gomes de Souza Vale, R. (2020). Sarcopenia as a mediator of the effect of a gerontogymnastics program on cardiorespiratory fitness of overweight and obese older women: A randomized controlled trial. *International Journal of Environmental Research and Public Health, 17*(19), 7064. https://doi.org/10.3390/ijerph17197064

8. Marcos-Pardo, P. J., González-Gálvez, N., López-Vivancos, A., Espeso-García, A., Martínez-Aranda, L. M., Gea-García, G. M., Orquín-Castrillón, F. J., Carbonell-Baeza, A., Jiménez-García, J. D., Velázquez-Díaz, D., Cadenas-Sanchez, C., Isidori, E., Fossati, C., Pigozzi, F., Rum, L., Norton, C., Tierney, A., Äbelkalns, I., Klempere-Sipjagina, A., … Vaquero-Cristóbal, R. (2020). Sarcopenia, diet, physical activity and obesity in European middle-aged and older adults: The LifeAge study. *Nutrients, 13*(1), 8. https://doi.org/10.3390/nu13010008

9. Marcos-Pardo, P. J., González-Gálvez, N., Vaquero-Cristóbal, R., Gea-García, G. M., López-Vivancos, A., Espeso-García, A., Velázquez-Díaz, D., Carbonell-Baeza, A., Jiménez-Pavón, D., Brandão Pinto de Castro, J., & Vale, R. G. de S. (2020). Functional autonomy evaluation levels in middle-aged and older Spanish women: On behalf of the healthy-age network. *Sustainability, 12*(21), 9208. https://doi.org/10.3390/su12219208

10. Abelleira-Lamela, T., Vaquero-Cristóbal, R., González-Gálvez, N., Esparza-Ros, F., Espeso-García, A., & Marcos-Pardo, P. J. (2021). Sagittal spine disposition and pelvic tilt during outdoor fitness equipment use and their associations with kinanthropometry proportions in middle-aged and older adults. *PeerJ, 9*(e12657), e12657. https://doi.org/10.7717/peerj.12657

11. Marcos-Pardo, P. J., Espeso-García, A., López-Vivancos, A., Abelleira Lamela, T., & Keogh, J. W. L. (2021). COVID-19 and social isolation: A case for why home-based resistance training is needed to maintain musculoskeletal and psychosocial health for older adults. *Journal of aging and physical activity, 29*(2), 353–359. https://doi.org/10.1123/japa.2020-0131

12. Marcos-Pardo, P. J., Abelleira-Lamela, T., González-Gálvez, N., Esparza-Ros, F., Espeso-García, A., & Vaquero-Cristóbal, R. (2022). Impact of COVID-19 lockdown on health parameters and muscle strength of older women: A longitudinal study. *Experimental Gerontology, 164*(111814), 111814. https://doi.org/10.1016/j.exger.2022.111814

13. Marcos-Pardo, P. J., Espeso-García, A., Abelleira-Lamela, T., & Machado, D. R. L. (2023). Optimizing outdoor fitness equipment training for older adults: Benefits and future directions for healthy aging. *Experimental Gerontology, 181*(112279), 112279. https://doi.org/10.1016/j.exger.2023.112279

14. Marcos-Pardo, P. J., Espeso-García, A., Vaquero-Cristóbal, R., Abelleira-Lamela, T., Esparza-Ros, F., & González-Gálvez, N. (2023). Physical and psychological effects of outdoor fitness equipment training on middle-aged and older adults: study protocol of a randomised controlled trial. *BMJ Open Sport & Exercise Medicine, 9*(4), e001829. https://doi.org/10.1136/bmjsem-2023-001829

15. Marcos-Pardo, Pablo J., Espeso-García, A., Vaquero-Cristóbal, R., Abelleira-Lamela, T., & González-Gálvez, N. (2024). The effect of resistance training with outdoor fitness equipment on the body composition, physical fitness, and physical health of middle-aged and older adults: A randomized controlled trial. *Healthcare, 12*(7), 726. https://doi.org/10.3390/healthcare12070726

Para la realización de las evaluaciones del ensayo controlado aleatorizado se ha diseñado, fabricado y patentado un dispositivo de medición para la evaluación de la fuerza isométrica máxima en flexión y extensión de rodilla. Este aparato permite ajustar la posición de la célula de carga según las características antropométricas del usuario y los requisitos específicos de la prueba, permitiendo realizar valoraciones de fuerza en función de un ángulo determinado, asegurando la pierna del usuario mediante una tobillera sin piezas móviles. Esta innovación representa un avance significativo en la evaluación de la fuerza muscular, aumentando la validez y fiabilidad de los resultados.

Gracias a los resultados obtenidos y al análisis de las limitaciones de la maquinaria biosaludable actual, se ha iniciado el desarrollo de una nueva gama de maquinaria BIOFIT-Park. Este proyecto, realizado en colaboración con Equipamientos para Entorno Urbano S.L., COPELE S.L., y el Centro Tecnológico del Metal de la Región de Murcia, está vinculado al proyecto RTC-2017-6145-1. De esta colaboración se derivan dos patentes ES1296848 (U) y ES1296869 (U) correspondientes a dos nuevas máquinas biosaludables diseñadas para el entrenamiento de la musculatura pectoral y de la espalda, así como un registro de propiedad intelectual de una App móvil (765-968118). Estas máquinas incorporan un sistema de selección de la carga y disponen de un diseño más ergonómico que mejora la biomecánica del movimiento, aumentando la seguridad y la efectividad del entrenamiento y beneficiando a un mayor número de usuarios.

A continuación, se enumeran las publicaciones en forma de registro de la propiedad industrial e intelectual:

1. Aparato para la medición de la fuerza isométrica en extensión de rodilla (ES1295254 (U)).
2. Máquina para el entrenamiento físico de la musculatura pectoral en exteriores (ES 1296848 Y).
3. Máquina para el entrenamiento físico de la musculatura de la espalda en exteriores (ES 1296869 Y).
4. BiofitParkApp (765-968118).

A continuación, se presentan las comunicaciones orales y posters derivados tanto de la investigación realizada durante el desarrollo de esta tesis doctoral, como de otros estudios relacionados y realizados en el grupo de investigación. Estos trabajos han sido presentados en jornadas y congresos internacionales, reflejando el impacto y la relevancia de los resultados obtenidos:

1. Espeso-García, A., Gea-García, G.M., & González-Gálvez, N. (2019). *Aproximación Metodológica a las actividades subacuáticas: Modelo híbrido de Educación-Aventura y Aprendizaje Cooperativo* [Comunicación Oral]. V Congreso Internacional Universitario de Trail Running y Raids de Aventura "Ruta de las Fortalezas", Cartagena, España.

2. Espeso-García, A., Gea-García, G.M., & González-Gálvez, N. (2019). *Relación del IMC con la capacidad cardiorrespiratoria, la fuerza muscular y la prensión manual en escolares* [Comunicación Oral]. V Congreso Internacional Universitario de Trail Running y Raids de Aventura "Ruta de las Fortalezas", Cartagena, España.

3. Espeso-García, A., Gea-García, G.M., & González-Gálvez, N. (2019). *Condición física e índice de masa corporal como factores de riesgo cardiovascular en escolares: diferencias entre sexos* [Póster]. I Congreso Internacional de Ciencias de la Actividad Física y el Deporte, Valencia, España.

4. Espeso-García, A., Gea-García, G.M., & González-Gálvez, N. (2019). *Evaluación de la condición física en escolares en función de las características antropométricas: diferencias entre sexos* [Póster]. I Congreso Internacional de Ciencias de la Actividad Física y el Deporte, Valencia, España.

5. Espeso-García, A., Gea-García, G.M., González-Gálvez, N., & Marcos-Pardo, P.J. (2019). *Diseño y desarrollo de maquinaria biosaludable. Un estudio a nivel de ergonomía, seguridad y eficacia* [Póster]. V Jornadas de Investigación y Doctorado: Ciencia sin Fronteras, Murcia, España.

6. Espeso-García, A. (2019). *Does the use of outdoor fitness equipment by older adults qualify as moderate to vigorous physical activity?* [Comunicación Oral]. V Jornadas de Investigación y Doctorado: Ciencia sin Fronteras, Murcia, España.

7. López-Vivancos, A., Orquín-Castrillón, F.J., Espeso-García, A., Abelleira-Lamela, T., & Marcos-Pardo, P.J. (2020). *Análisis de la fuerza y riesgo de caídas en la población con y sin demencia* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

8. Abelleira-Lamela, T., Vaquero-Cristóbal, R., Espeso-García, A., González-Gálvez, N., López-Vivancos, A., & Marcos-Pardo, P.J. (2020). *Análisis de las curvaturas torácica y lumbar en tres tipos de maquinaria biosaludable* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

9. López-Vivancos, A., Orquín-Castrillón, F.J., Espeso-García, A., Abelleira-Lamela, T., González-Gálvez, N., Vaquero-Cristóbal, R., & Marcos-Pardo, P.J. (2020). *Análisis electromiográfico del deltoides en el press de pecho presente en los parques biosaludables* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

10. Espeso-García, A., Marcos-Pardo, P.J., González-Gálvez, N., Vaquero-Cristóbal, R., López-Vivancos, A., & Abelleira-Lamela, T. (2020). *Diferencias en fuerza de prensión manual entre mujeres adultas y mayores* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

11. Espeso-García, A., Marcos-Pardo, P.J., González-Gálvez, N., Vaquero-Cristóbal, R., López-Vivancos, A., & Abelleira-Lamela, T. (2020). *Diferencias entre protocolos de prensión manual en mujeres adultas y mayores* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

12. Abelleira-Lamela, T., Vaquero-Cristóbal, R., Espeso-García, A., González-Gálvez, N., López-Vivancos, A., & Marcos-Pardo, P.J. (2020). *Influencia de la maquinaria biosaludable en la disposición sagital del raquis en bipedestación: comparativa entre diferentes máquinas* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

13. Abelleira-Lamela, T., Vaquero-Cristóbal, R., Espeso-García, A., González-Gálvez, N., López-Vivancos, A., & Marcos-Pardo, P.J. (2020). *Relación entre condición física, masa grasa y edad de mujeres mayores* [Comunicación Oral]. International Congress LifeAge: Exercise Prescription for Healthy Active Ageing, Murcia, España.

14. López-Vivancos, A., Orquín-Castrillón, F.J., Espeso-García, A., Abelleira-Lamela, T., Marcos-Pardo, P.J. (2020). *Fall Prevention: Relationship of Timed Up and Go and CMJ Test in People with Dementia* [Comunicación Oral]. I Congreso Internacional en Salud, Ejercicio Físico y Ciencias de la Alimentación, Concentaina, España.

15. López-Vivancos, A., Orquín-Castrillón, F.J., Espeso-García, A., Abelleira-Lamela, T., Marcos-Pardo, P.J. (2020). *Manual Gripping Force and Fall Prevention in People with Dementia* [Comunicación Oral]. I Congreso Internacional en Salud, Ejercicio Físico y Ciencias de la Alimentación, Concentaina, España.

16. Espeso-García, A., Marcos-Pardo, P.J., Gea-García, G.M., González-Gálvez, N., & López-Vivancos, A. (2020). *Proyecto Biofit-Park. Fabricación de maquinaria biosaludable. Un análisis del efecto del entrenamiento sobre la salud en parques biosaludables* [Comunicación Oral]. I Congreso Internacional en Salud, Ejercicio Físico y Ciencias de la Alimentación, Concentaina, España.

17. Espeso-García, A., González-Gálvez, N., Vaquero-Cristóbal, R., Abelleira-Lamela, T., Esparza-Ros, F., & Marcos-Pardo, P.J. (2020*). Efectos de la combinación de diferentes modalidades de ejercicio sobre factores cognitivos en personas mayores: una revisión sistemática* [Comunicación Oral]. VI Jornadas de Investigación y Doctorado: ODS con Ciencia, Murcia, España.

18. Abelleira-Lamela, T., Espeso-García, A., González-Gálvez, N., Vaquero-Cristóbal, R., Esparza-Ros, F., & Marcos-Pardo, P.J. (2021). *Diseño de un programa de entrenamiento en parques biosaludables* [Comunicación Oral]. II Jornadas Internacionales "HEALTHY-AGE: Envejecimiento activo, ejercicio y salud", Almería, España.

19. Espeso-García, A., Marcos-Pardo, P.J., González-Gálvez, N., & Gea-García, G.M. (2021). *Diseño y desarrollo de nueva maquinaria biosaludable "BIOFIT-*

Park" [Comunicación Oral]. VII Jornadas de Investigación y Doctorado, Murcia, España.

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Desde 2022 formo parte de la sección técnica del equipo editorial de la revista científica Cultura, Ciencia y Deporte. Esta revista, gestionada por la Universidad Católica San Antonio de Murcia (UCAM), se ha convertido en una referencia internacional en las áreas de Educación Física y Deportes, destacándose en índices como SCImago Journal Rank (SJR) donde está clasificada como Q1 (CULTURAL STUDIES) y Journal Citation Reports (JCR) donde está clasificada como Q3 (HOSPITALITY, LEISURE, SPORT & TOURISM), y obteniendo reconocimientos de la Fundación Española para la Ciencia y la Tecnología (FECYT).

Asimismo, he participado en la organización de congresos científicos y de actividades de divulgación y transferencia de conocimiento, las cuales se detallan a continuación:

1. Miembro del comité organizador del International Congress LifeAge: Exercise prescription for healthy active ageing (2020).
2. Miembro del comité organizador de la Facultad de Deporte UCAM en la Semana de la Ciencia y la Tecnología de la Región de Murcia (2018-2023).
3. Miembro del comité organizador de las Olimpiadas Científicas UCAM Murcia y Cartagena (2024).
4. Miembro del comité organizador de la Facultad de Deporte UCAM en el II Congreso Internacional y XIII Congreso Español de Medicina y Enfermería del Trabajo (2024).
5. Miembro del comité organizador de las Jornadas de Orientación Educativa de la Facultad de Deporte UCAM (2024).
6. Miembro del comité organizador de las Jornadas UCAM Olympic Zone (2024).

7. Miembro del comité organizador de la Facultad de Deporte UCAM en las Jornadas ITINERE (2024).
8. Miembro del comité organizador de la Facultad de Deporte UCAM en el Salón Internacional del estudiante AULA (2024).
9. Miembro del comité organizador del Congreso SCS 7th Annual Conference (2024).
10. Colaborador como experto en ciencias del deporte en programas de televisión de divulgación científica (2024).
11. Colaborador en actividades de promoción y captación de alumnos de la Facultad de Deporte de la UCAM (2021 – Presente).
12. Responsable de Comunicación y Redes Sociales institucionales de la Facultad de Deporte UCAM (2021 - Presente).

ANEXO 9. ESTUDIO 1

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PRACTICAL APPLICATION

COVID-19 and Social Isolation: A Case for Why Home-Based Resistance Training Is Needed to Maintain Musculoskeletal and Psychosocial Health for Older Adults

Pablo Jorge Marcos-Pardo, Alejandro Espeso-García, Abraham López-Vivancos, Tomás Abelleira Lamela, and Justin W.L. Keogh

The coronavirus disease outbreak in China has become the world's leading health headline and is causing major panic and public concerns. Public health guidelines in many countries are suggesting that people stay at home to avoid human-to-human transmission of the virus, which may lead to reduced physical activity and greater feelings of isolation. Such effects may be particularly problematic in older adults due to their reduced physical capacities and their potential for increased mental health issues, such as anxiety and depression. A potential way to minimize many of these side effects of stay-at-home guidelines may be progressive home-based resistance training. A simple way to provide progressive overload in home-based resistance training may involve elastic resistance, which has been demonstrated to provide similar benefits to traditional resistance training equipment typically found in gymnasiums. Recommendations on how older adults can safely and effectively perform elastic resistance training at home are provided.

Keywords: coronavirus, elastic resistance training, exercise, older people

The coronavirus disease (COVID-19) outbreak in China has become the world's leading health headline and is causing major panic and public concerns. On January 30, 2020, the World Health Organization declared that the new coronavirus outbreak is a public health emergency of international concern (World Health Organization, n.d.). The virus has already had a direct impact on millions of people around the world, posing a health threat of unknown magnitude at the global level. As of March 26, 2020, the pandemic, one of the biggest health crises in recent years whose consequences are still unpredictable, has spread to more than 170 countries, resulting in ~470,000 cases and more than 20,000 deaths. In Spain, the number of positive cases of COVID-19 exceeds 56,000, ranking it as the second highest in Europe, with only Italy having a greater number of confirmed cases. Spain is also currently ranked second in the world in terms of the number of confirmed deaths from coronavirus. Specifically, Spain has already recorded 4,145 deaths, whereas China has had 3,293 confirmed deaths so far. Italy, with at least 7,500, has already doubled the number (Ministerio de Sanidad del Gobierno de España, 2020). Currently, there is no vaccine for the prevention or treatment of the disease caused by the virus; its origins and the ultimate scope of this pandemic are unknown. The causes or mechanisms of transmission, the incubation period, risk assessments, and effective treatment or intervention options for the virus are also currently poorly understood.

Health authorities in countries such as China, Italy, the United States, Australia, and Spain, among others, have advised the public to reduce travel, stay home, and maintain social distancing when in public as a basic means of limiting people's exposure to the virus. Unfortunately, travel restrictions and directives against participation in outdoor activities, including sport, physical activity, and regular exercise, will inevitably disrupt the daily activities of tens of millions of people.

Issues for Older Adults

While containing the virus as quickly as possible is the urgent public health priority, there have been few public health guidelines as to what people, especially older adults, can or should do in terms of maintaining their daily exercise or physical activity routines. This is a concern as a large percentage of adults and older people do not meet the global recommendations for physical activity, especially resistance training, needed to reduce morbidity and maintain functional capacity (Sun, Norman, & While, 2013; Winett, Williams, & Davy, 2009). Arguably, staying home, while a safe measure, may have unintended negative consequences since such efforts to avoid human-to-human transmission of the virus may lead to reduced physical activity (Chen et al., 2020). Long hours in the home may lead to increased sedentary behavior and inactivity or little physical activity and long periods of sitting and lying down, all of which increase the risk of developing or exacerbating chronic diseases (Owen, Sparling, Healy, Dunstan, & Matthews, 2010). Staying at home can also be socially isolating, particularly for older adults who may already have a reduced network of friends compared with younger adults and children (Freedman & Nicolle, 2020; Santini et al., 2020). This

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isolation for older adults may exacerbate issues related to their mental health, with increased levels of anxiety and depression the likely result (Freedman & Nicolle, 2020; Santini et al., 2020).

As many older adults are already highly concerned about contracting COVID-19 and the serious adverse events or even death that may result from contracting the virus, such self-isolation has the potential to cause a host of psychosocial and physical problems. Aging is a complex process characterized by structural and physiological changes in various systems of the human body that can compromise anthropometric (e.g., muscle mass, regional adiposity) and neurovascular (muscle strength and motor control) variables and reduce the physical independence of older adults (Chodzko-Zajko et al., 2009).

Aging is associated with a progressive decrease of muscle mass and a reduced capacity of the muscles to produce strength and power that, ultimately, results in a decline in the ability to perform a range of functional tasks, including standing up from a chair or walking, particularly upstairs or while carrying additional handheld loads (Aagaard, Suetta, Caserotti, Magnusson, & Kjær, 2010; Guizelini, de Aguiar, Denadai, Caputo, & Greco, 2018). The ability of the lower extremity muscles to generate force and muscular power is a fundamental component for maintaining balance (Li et al., 2018), with the assessment of the force–velocity ratio advocated to determine the maximum capacities of older adults to produce force, speed, and power (Marcos-Pardo, González-Hernández, García-Ramos, López-Vivancos, & Jiménez-Reyes, 2019). These age-related losses of muscle mass, strength, and physical performance are now referred to as the geriatric syndrome, sarcopenia (Cruz-Jentoft et al., 2019). These sarcopenia-related changes may increase the risk of falls and fractures, which could contribute to the loss of independence and deterioration in the physical function and quality of life of older adults (Gadelha et al., 2018; Ma et al., 2018; Trombetti et al., 2016).

This relative disability and increase in falls and fall-related fractures may require additional health care services and costs, with the available health care services and funding already stretched due to the COVID-19 pandemic. In particular, public health programs need to ensure that older adults can maintain their levels of muscular strength to minimize these major health care cost implications. Specifically, Pinedo-Villanueva et al. reported that each older adult with muscle weakness (defined as having handgrip strength <26 kg for men or <16 kg for women) cost the U.K. healthcare system an additional U.S. $3,372 at current exchange rates per year (Pinedo-Villanueva et al., 2019).

Exercise Benefits for Older Adults

One way to counteract the potential psychosocial and physical deterioration as well as increased health care costs that may be associated with the reduced level of physical activity that may occur with social distancing and stay-at-home policies currently being advocated by many governments is exercise (Hetherington et al., 2019; Raafs et al., 2019); although, in the current climate, it is recommended that such exercise be home based. Exercise at home using various safe, simple, and easily implementable exercises is well suited to avoid the airborne coronavirus and maintain fitness levels. Such forms of exercise may include, but are not limited to, strengthening (resistance training) exercises, activities for balance and control, cardiovascular activity, stretching exercises, or a combination of these (Chen et al., 2020).

Resistance training is widely recommended to slow down the negative effects of aging in sarcopenia-related decline because it is considered the most effective method for improving muscle mass, strength, and power, which are key to counteracting disability in older adults (Cadore et al., 2014; Chodzko-zajko, 2014; Marcos-Pardo, Orquin-Castrillón, et al., 2019). In addition, individuals undertaking resistance training demonstrate an increased motivation and adherence to training (Kekäläinen, Kokko, Tammelin, Sipilä, & Walker, 2018; Marcos-Pardo, Martínez-Rodríguez & Gil-Arias, 2018). Due to the confined state of adults and older people, safe and effective strategies for resistance training at home are needed.

Home resistance training with minimal supervision is a safe, effective, and low-cost exercise option for increasing muscle strength and functional capacity in healthy older adults as well as older subjects with a variety of health conditions who can overcome some of the common barriers to exercise (Henwood et al., 2019). It is an attractive, viable, and, from a public health perspective, feasible alternative to supervised resistance training in gymnasiums (Kis, Buch, Stern, & Moran, 2019), which are now largely unavailable due to the risk of spreading the virus to vulnerable older adults. Training with small overload materials, such as bottles or dumbbells available at home, as well as elastic resistance training are effective resistance training materials and easy to use for this age group (Andersen et al., 2011; Jensen et al., 2014). Elastic resistance exercises are often used during unsupervised home training wherein the exercise professional or instructional web-based video provides the patient with initial instruction on how to perform the exercise. These instructions may focus on exercise prescription variables including loading, range of motion, number of repetitions, sets, pauses between exercises, and proper starting position (Faber et al., 2015).

The use of elastic resistance training during confinement has multiple advantages for training at home; the elastic bands are easy to use, can be adjusted to different loads, and are less expensive and do not take up as much space as dumbbells or specialized resistance training machines. Multiple studies have compared elastic band training with traditional free weights-based resistance training (e.g., dumbbells) in terms of the muscle activation levels (Andersen et al., 2010; Colado et al., 2010; Melchiorri & Rainoldi, 2011). These studies generally demonstrated that exercise training with elastic resistance activates the agonists at a similar level to that achieved with dumbbells or weight machines, suggesting that bands can be as effective in improving strength and reducing muscle loss as more traditional resistance training tools. Such a viewpoint is supported by a number of training studies demonstrating similarity in training-related adaptations to elastic and traditional resistance training in middle-aged to older healthy adults (Lima et al., 2018; Mikesky, Topp, Wigglesworth, Harsha, & Edwards, 1994; Yasuda, Fukumura, Tomaru, & Nakajima, 2016).

Psychosocial Benefits of Resistance Exercise for Older Adults

The National Strength and Conditioning Association has recently released a position statement (Fragala et al., 2019) outlining the

physical and psychosocial benefits of resistance training for older adults. A major psychosocial benefit is improved quality of life, which can be defined as the subjective view of an individual about their general well-being and ability to participate in enjoyable life events (Dionigi, 2007; Kekäläinen, Kokko, Sipilä, & Walker, 2018; Pedersen et al., 2017). These improvements in older adults' quality of life with resistance training may reflect a range of other psychosocial benefits, including improved self-esteem/confidence (O'Connor, Herring, & Caravalho, 2010), sense of coherence (Kekäläinen, Kokko, Sipilä, & Walker, 2018), and sleep quality (O'Connor et al., 2010) as well as a reduction in depression and/or anxiety (O'Connor et al., 2010; Tsutsumi, Don, Zaichkowsky, & Delizonna, 1997). It has even been reported that the improvements in depression that may be observed with resistance training are similar in magnitude to standard pharmacotherapy interventions for older adults with depression (Singh et al., 2005). Furthermore, there is even evidence that some forms of resistance training improve older adults' cognitive function, with enhancements in executive function accompanied by functional changes in the frontal lobe (Herold, Törpel, Schega, & Müller, 2019). Such improvements in cognitive function may even have the potential to offset some of the behavioral issues associated with advanced age dementia (Chen, Kuo, Chang, Huang, & Cheng, 2017).

Therefore, exercise during quarantine can help to combat many of the negative physical and mental consequences of the social isolation policies adopted in many countries due to the COVID-19 pandemic (Jiménez-Pavón, Carbonell-Baeza, & Lavie, 2020). The participation of older people in resistance training programs can serve as a prophylactic to delay or prevent the appearance of biological aging. The physical and psychological benefits have been demonstrated with a minimum dose of 2 days a week and 60 min of training (Fisher, Steele, Gentil, Giessing, & Westcott, 2017).

Home Elastic Resistance Training Recommendations

Consistent with exercise guidelines for older adults (Fragala et al., 2019), it would be recommended that older people perform elastic resistance training 2–3 days a week, with such sessions, perhaps, starting off with a duration of 15 or 20 min, but progressing up to 45–60 min. In the first few training sessions, the older adult should become familiar with the different movements, learn how the use of elastics or other forms of resistance (e.g., additional household objects) increases the difficulty of the exercise, and become comfortable with the potential delayed-onset muscle soreness that may occur for a few days postexercise.

The muscle groups and movements to be trained should focus on movements that replicate many common activities of daily living and involve the major trunk and limb muscle groups. These exercises should seek to improve lower body muscle mass, strength, and power as well as balance so that the older adult can minimize their fall risk and maintain their independence in performing common activities such as the sit-to-stand movement and walking, particularly up or down stairs or carrying additional loads, such as groceries. Older adults also need to maintain or improve upper body strength so that they can to continue to hold loads in their hands, lift objects from lower to higher positions, such as onto shelves, and so that they are able to get off the floor if they experience a fall. Each elastic resistance training session should consist of a warm-up at the beginning and general stretching at the end. In particular, we would recommend that the following movements be performed with adequate resistance: (a) elbow curl, (b) squat, (c) elbow extension, (d) knee extension, (e) chest press, (f) leg press, (g) shoulder overhead press, (h) knee curl, and (i) shoulder seated row. An example of the execution of the elastic resistance training can be seen in Figure 1.

The resistance of the elastics training varies from brand to brand and differs by color. Each color offers a different level of resistance to the practitioner. It is very important that, for the safety and effectiveness of the training, the practitioner is familiar with the load (strength of the band), the range of motion including the starting and finishing positions, the number of repetitions per set, and the optimal speed of execution. To control the intensity of exercise with elastic bands, it is advisable to use the Resistance Intensity Scale for Exercise (RISE) in older people (Colado, Furtado, Teixeira, Flandez, & Naclerio, 2020). The RISE scale (see Figure 2) is a valid method for assessing the perceived exertion during resistance exercises performed with elastic bands, which better discriminates in older adults between medium and low intensities than the Exercise Scale of Perceived Exertion (Colado et al., 2012, 2018).

One way to perform the resistance training program that may also provide some cardiovascular health benefit, which is also important because of the potential for reduced opportunities for cardiovascular exercise, such as walking, during self-isolation, is to perform the resistance training exercises in a circuit training format (Fritz et al., 2018; Souza et al., 2019). The following recommendations for how the elastic resistance training exercises may be performed, progressed, and incorporated into a circuit format for older adults are based on the literature (Colado et al., 2020; de Alencar Silva et al., 2018; de Oliveira, Pereira Moro, Polito, Helena de Jesus, & de Souza Bezerra, 2020; Fritz et al., 2018; Krause et al., 2019; Osuka et al., 2019; Rieping et al., 2019; Souza et al., 2019). An older adult with little resistance training experience may initially perform one to two series of the circuit with a load that allows 12–15 repetitions per set at a low to moderate level effort on the RISE. As each repetition should be performed under control with a 2-s concentric (lifting the weight) and 2-s eccentric (lowering the weight) phase, each set of an exercise may last up to 60 s. The older adult can increase the intensity of the exercises as assessed by the RISE, increasing toward a perception of hard level effort between the second and fourth week. After 4 weeks of training, it is advisable to progressively increase the number of training series, ultimately looking to perform three or four series of the exercise circuit. As the weeks go by, and the older adult adapts to the load, he or she should, optionally, increase the repetitions or increase the load, in this case changing to another elastic of greater resistance. Older adults with some resistance training experience can start with a moderate intensity level with a higher resistance elastic and perform 10–12 repetitions per series with a hard level of effort perception by performing three or four sets of training, progressing up to 3–4 days a week.

Where possible, we recommend older adults seek some supervision from an exercise specialist with experience in working with older adults. Nowadays, a host of telehealth/video conferences can

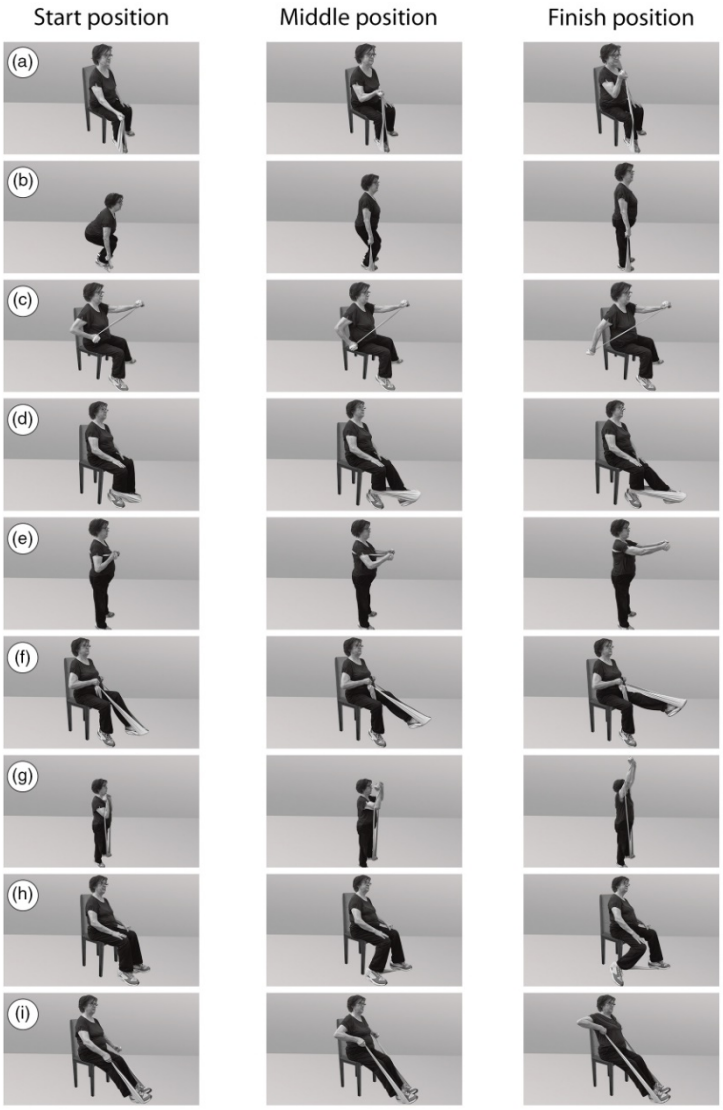


Figure 1 — Home elastic resistance training exercises. *Note.* (a) Elbow curl, (b) squat, (c) elbow extension, (d) knee extension, (e) chest press, (f) leg press, (g) shoulder overhead press, (h) knee curl, and (i) shoulder seated row.

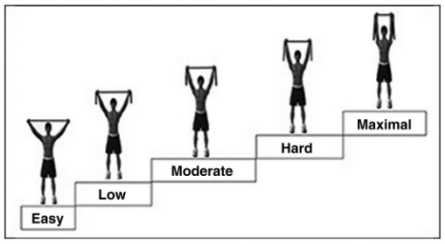


Figure 2 — RISE in older people (Colado et al., 2020). *Note.* This pictorial demonstrates how the intensity of the exercise can be increased from easy to maximal by placing the hands closer together on the exercise band. In order to standardize this progressive increase in intensity, it is recommended to mark set distances on the bands. When the required number of repetitions and sets are performed with a given intensity, progression of the exercise can be achieved by placing the hands on the next closer marked distance. RISE = Resistance Intensity Scale for Exercise. Reprinted from *Journal of Sports Science & Medicine*, Vol. 19, Colado, J.C., Furtado, G.E., Teixeira, A.M., Flandez, J., & Naclerio, F., "Concurrent and Construct Validation of a New Scale of Rating Perceived Exertion During Elastic Resistance Training in the Elderly," 175–186, Copyright (2020), with permission from the *JOURNAL OF SPORTS SCIENCE AND MEDICINE*.

be incorporated whereby these exercise specialists can help older adults to safely and effectively perform these home-based progressive resistance training sessions.

Conclusions

Following these recommendations can help during the confinement period to reduce the loss of muscle mass and strength, control and/or reduce body weight, avoid the accumulation of fatty tissue, and combat the occurrence of or reduce existing chronic diseases in adults and older people. Home resistance training using elastic materials is a beneficial and necessary option for the maintenance of musculoskeletal and psychosocial health.

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ANEXO 10. ESTUDIO 2

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Review

Optimizing outdoor fitness equipment training for older adults: Benefits and future directions for healthy aging

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ABSTRACT

Regular physical activity is vital for the health and disease prevention of older adults. Outdoor fitness equipment has gained popularity for natural exercise spaces among middle-aged and older individuals.

This narrative review demonstrates that these programs have the potential to improve cardiovascular health, muscle strength, flexibility, balance, and reduce falls, while also enhancing quality of life, alleviating depression and anxiety, and boosting self-esteem. However, our understanding is hindered by limited rigorous experimental studies.

Future directions include implementing standardized measurements, conducting long-term studies, and addressing equipment limitations to enable better adjustment of training intensity and promote correct postures on machines.

New, more rigorous research is needed to comprehensively understand the psychophysiological and social effects on health. Additionally, suggested modifications could render the machines more effective and safer. The primary objective is to enhance this type of machinery to encourage its use in outdoor spaces, thus aiding adults and older individuals in achieving overall health and enjoying a healthy aging process.

1. Introduction

For more than 20 years, we have had scientific evidence of the role of physical activity in the primary prevention of cardiovascular disease, diabetes and some types of cancer (Brown et al., 2007). According to the World Health Organization (WHO), physical activity can reduce the risk of developing chronic diseases such as heart disease, stroke, diabetes, and some cancers by as much as 30–40 % in older adults (World Health Organization, 2015). Regular physical activity is essential for maintaining good health and preventing chronic diseases among older adults, different studies have been demonstrated to decrease morbidity and mortality by reducing the risk of heart disease, diabetes, high blood pressure, colon cancer, depression/anxiety, and weight gain while promoting and maintaining healthy bones, muscles, and joints (Anderson and Durstine, 2019; Paluch et al., 2022; Thacker et al., 2005; Warburton et al., 2006). Physical activity is advised to attain cardiometabolic advantages and to safeguard or enhance bone health, particularly for older adults with an elevated risk of fractures (Wherry et al., 2022). Consistent

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involvement in resistance training programs is a significant factor in the process of aging and could potentially serve as both a preventative measure and treatment option for numerous musculoskeletal disorders (Ciolac and Rodrigues-da-Silva, 2016). The decline in skeletal muscle mass, decrease in motor unit discharge rate, and diminished function are mainly linked with the process of aging. This can be classified as either sarcopenia, which refers to the age-related loss of skeletal muscle mass and function, or dynapenia, which is characterized by the age-associated reduction in muscle strength that is not caused by neurological or muscular diseases (Maestroni et al., 2020). Mobility and physical activity of the upper and lower extremities decrease with age (Tatangelo et al., 2022), leading to sarcopenia and loss of muscle strength, so strength training is very important.

As a result of the growing number of sedentary jobs and increased reliance on motorized transportation, leisure-time physical activity has become a crucial factor in achieving recommended levels of physical activity worldwide. Participation in leisure-time physical activity can occur in various community settings, such as nearby parks, which are often available to the public at little or no cost (Edwards and Tsouros, 2006).

Public spaces are optimal for promoting physical activity as they comprise green spaces and structures (e.g., playgrounds and outdoor fitness equipment) that are purpose-built to foster physical activity (Bedimo-Rung et al., 2005; García de Jalón et al., 2021; McKenzie et al., 2006). Physical activity in the outdoors spaces can provide benefits for pulmonary, cardiovascular, cognitive, and systemic health (Giles and Koehle, 2014). Few studies have examined the benefits of outdoor fitness equipment training for older adults (Grigoletto et al., 2021; Jansson et al., 2019b). Thus, this narrative review aimed to contextualize the psychophysiological and social advantages of such training. Then, our primary objective was to understand how outdoor fitness equipment can enhance the health of older people. The secondary objective was to analyze the limitations of the machines and suggest modifications for safer and more effective training.

2. Methods

2.1. Eligibility criteria

The selection of scientific studies was based on the following inclusion criteria: a) experimental or quasi-experimental designs, systematic reviews, study protocols or observational studies; b) intervention based on the systematic performance of outdoor fitness equipment. We applied the exclusion criteria established in previous reviews (Bustamante-Sanchez et al., 2022; Clemente-Suárez et al., 2021c; Clemente-Suárez et al., 2021a): a. Analysis conducted outside of the designated time frame; b. Topics covered that were not within the scope of the review; c. Utilized unpublished materials such as conference proceedings, abstracts, and PhD dissertations.

2.2. Search methods and strategies for research identification

In order to achieve our research goal, we carried out a comprehensive evaluation and analysis by scrutinizing primary sources like scholarly research and secondary sources including databases, web pages, and bibliographic indexes, using the same procedures as those applied in previous critical narrative reviews. (Bustamante-Sanchez et al., 2022; Clemente-Suárez et al., 2021c; Clemente-Suárez et al., 2021a; Clemente-Suárez et al., 2021b). Peer-reviewed articles published in the English language were acquired via online data base searches of the following data bases: EBSCO, SPORT discus, Medline, PsycINFO, Web of Science and Scopus searching for MeSH-compliant keywords such as: (outdoor fitness equipment OR outdoor gyms OR bio-healthy parks OR outdoor exercise equipment OR outdoor green spaces OR senior exercise park OR outdoor exercise park OR outdoor gyms OR outdoor fitness equipment in parks OR fitness equipment in public parks OR outdoor playground equipment OR outdoor gym resistance training OR fitness parks). The search encompassed time frames from 2000 to June 2023. Research endeavors that documented the effectiveness of utilizing outdoor fitness equipment use for physical activity, fitness, or health-related results, as well as portrayals of outdoor gyms and their users, met the criteria for inclusion.

2.3. Study selection and data extraction

We included studies that met rigorous scientific methodological standards and were relevant to the subsections addressed in this review. Data analysis was carried out by the review's four authors. The principal investigator assessed the eligibility of the studies according to their title and abstract in a first review, with an assistant in a second review to jointly verify these criteria and the results obtained. In this second review, the full text of the articles was reviewed. Research that did not meet the inclusion and exclusion criteria was excluded.

3. Why did outdoor fitness equipment spaces emerge?

The idea of creating outdoor fitness equipment spaces began to gain popularity in the 1990s and 2000s, as more research was conducted on the health benefits of physical activity and the importance of access to green spaces (Takano et al., 2002). In 2009, Europe introduced this new type of exercise space which was designed specifically to improve muscular strength, flexibility, coordination, and balance in a fun and engaging way. It was built with the intention of encouraging physical activity among older adults by providing an accessible and enjoyable environment for exercise (Sales et al., 2015).

Outdoor fitness equipment spaces have emerged as a response to the growing interest in promoting physical activity and healthy lifestyles. Green spaces, such as parks or public gardens, are safe, accessible, and attractive environments that generally allow people to be physically active (Gladwell et al., 2013; Mytton et al., 2012; Vich et al., 2021). In particular, the concept of "green exercise" emerged, which refers to physical activity undertaken in natural environments, such as parks or forests (Barton and Pretty, 2010; Pretty et al., 2007; Pretty et al., 2005). Outdoor fitness equipment spaces typically feature a range of exercise equipment that is designed to be used in an outdoor setting, such as resistance machines, ellipticals, and other cardio machines.

Outdoor fitness equipment is usually installed in municipal and public parks and places, residential complexes, resorts, schools, and beaches and should even be installed in health centers, at the doors of hospitals, women's social centers, old people's homes, and geriatric residences. Outdoor spaces and parks are ideal places to promote physical activity, they are freely accessible, and most of the users observed in the studies in this review performed with moderate to vigorous intensity (Joseph and Maddock, 2016).

Creating an age-friendly environment is a crucial approach towards promoting healthy aging. The WHO Global Network for Age-friendly Cities and Communities Network (https://extranet.who.int/agefriendlyworld/) is a clear example of this. As a response to global population aging and rapid urbanization, this Network focuses on action at the local level that fosters the full participation of older people in community life and promotes healthy and active aging. Despite this, this recent study affirms the scarcity of studies that measure the impact of training with outdoor fitness equipment and the use of an outdoor multi-sports court on physical activity with different age groups, and also evidences the need to improve these spaces and this equipment (Veitch et al., 2021).

To achieve this, it is necessary to encourage people of all ages to engage in outdoor community activities. This can be done by designing public or urban spaces that are friendly to older adults, making them more accessible and accommodating for people of all ages to participate in physical activities (Levinger et al., 2018; Pleson et al., 2014). Research has shown that older adults perceive outdoor fitness

equipment in parks to contribute to their overall health promotion, providing not only physical but also social and psychological benefits (Chow, 2013). Furthermore, in addition to physical activity, it's important to recognize other essential benefits of park use, including psychological, social, economic, and environmental aspects (Bedimo-Rung et al., 2005).

This "outdoor fitness equipment" (Abelleira-Lamela et al., 2021; Chow and Ho, 2018; Chow, 2013; Chow et al., 2021; Chow et al., 2017; Chow and Wu, 2019; Liu et al., 2020) is also known as "bio-healthy parks" (Arufe et al., 2013), "outdoor exercise equipment" (Leavy et al., 2022; Sami et al., 2020), "outdoor green spaces" (Czembrowski et al., 2019; Pleson et al., 2014; Takano et al., 2002), "senior exercise park" (Levinger et al., 2018; Ng et al., 2023), "outdoor exercise park" (Ng et al., 2020), "outdoor fitness equipment in parks" (Chow, 2013; Liu et al., 2020), "outdoor gyms" (Cranney et al., 2018; Lee et al., 2018; Stride et al., 2017), "fitness equipment in public parks" (Copeland et al., 2017), "outdoor playground equipment" (Grozdanovic et al., 2014), "outdoor gym resistance training" (Plotnikoff et al., 2023) or simply "fitness parks" (Copeland et al., 2017).

Outdoor fitness equipment, such as exercise equipment is becoming increasingly popular as a way for older adults to be physically active in natural settings. These programs have the potential to provide older adults with a fun, free and accessible way to improve their health. However, there is still a lack of research on the effects of outdoor fitness equipment programs on psychophysiological and social health in older adults. (Ng et al., 2020) A strategic objective of public health policies should be to prevent the diseases that cause the most deaths, identifying the main diseases that shorten the lives of older people, their geographical variability, and the associated factors. Promoting healthy aging would save inappropriate polymedication and its risks, as well as considerable drug costs to the healthcare system (Mangin et al., 2018; Rambhade et al., 2012). Thus, a recent study, highlights the use of a smartphone application with standardized workouts adapted to 12 outdoor gyms and an introductory session, where participants are informed of the importance of performing at least 2 workouts per week in outdoor fitness parks to obtain health benefits (Plotnikoff et al., 2023).

Outdoor fitness equipment spaces are a public solution to promote the wellness and health of adults, middle-aged and older adults, and other age groups through exercise. In addition, they are a way for institutions to meet their objectives, raise awareness of the importance of care for health and maintenance of physical fitness, improve quality of life, provide meeting places and fun for all, and help preserve municipal green areas, all free of charge.

4. Physiological health benefits of training with outdoor fitness equipment

Training with outdoor fitness equipment has become increasingly popular, particularly among older adults. There is growing interest in understanding the physiological health benefits of this training, including improvements in cardiovascular health, muscle strength, flexibility, and balance. In this subtopic, we will explore some of the various physiological health benefits associated with outdoor fitness equipment training.

- Improved muscle mass and strength: Studies have shown that outdoor fitness equipment training can lead to improvements in muscle mass and strength in older adults (Chow et al., 2021; Chow et al., 2017; Grigoletto et al., 2021; Jansson et al., 2019b; Jansson et al., 2019a; Kim et al., 2018; Sales et al., 2018; Sales et al., 2015).
- Improved balance, coordination, and physical function: Regular participation in outdoor fitness equipment training can help older adults improve balance and coordination, which can reduce the risk of falls (Chow et al., 2017; Jansson et al., 2019b; Sales et al., 2018; Sales et al., 2016; Sales et al., 2015).
- Improved cardiovascular health: Studies have found that participating in outdoor fitness equipment training can lead to improved cardiovascular health (Chow and Ho, 2018; Chow et al., 2021; Grigoletto et al., 2021; Jansson et al., 2019b; Kim et al., 2018; Sales et al., 2015).
- Improved flexibility: Studies have found that participating in outdoor fitness equipment training can lead to improved flexibility (Chow et al., 2021; Chow et al., 2017; Sales et al., 2018).

Table 1 shows the characteristics of the different studies.

In Addition, in this recent study, resistance training intervention with outdoor fitness equipment resulted in improved self-assessment and training self-efficacy. Although conducted primarily during a global pandemic, this study shows the population health potential of using mhealth technology and utilizing outdoor fitness training spaces for the general population (Plotnikoff et al., 2023).

It is important to note that the effects of resistance training with outdoor fitness equipment may be influenced by a variety of factors, such as the specific type of equipment used, the intensity and frequency of the program, and the characteristics of the older adults participating. More research is needed to fully understand the benefits and challenges of these types of programs, particularly their long-term effects.

5. Psychological and social health benefits of training with outdoor fitness equipment

Despite the scarcity of studies on the subject, there is also evidence of psychological and social health benefits associated with outdoor fitness equipment training. The social aspect of exercising in a community setting can lead to increased socialization and a sense of belonging (Davis et al., 2021; Komatsu et al., 2017; Suragarn et al., 2021). In this subtopic, we will explore the psychological and social health benefits of training with outdoor fitness equipment.

- Reduced symptoms of depression and anxiety: Older adults who participate in outdoor fitness equipment training have reported reduced symptoms of depression and anxiety (Sales et al., 2018).
- Reduced fear of falling and improved self-perception: A study has also shown that participation in outdoor fitness equipment training can lead to reducing fear of falling and improved self-perception (Sales et al., 2015).
- Increased social participation: Studies have shown that participation in outdoor fitness equipment training can improve social relations (Chow et al., 2017; Furber et al., 2014; Sales et al., 2018; Sales et al., 2015; Stride et al., 2017).
- Increased mood and self-esteem and self-efficacy: A study has also shown that participation in outdoor fitness equipment training can lead to increased self-esteem and self-efficacy among older adults (Vancampfort et al., 2011).
- Improved positive impacts on well-being: A study has also shown that participation in outdoor fitness equipment training can lead to an increased sense of well-being (Bowler et al., 2010; Sales et al., 2015).
- Improved quality of life: Other studies have shown that participation in outdoor fitness equipment training can lead to improved quality of life perception (Sales et al., 2015).

Table 1 shows the characteristics of the different studies.

6. Discussion and future directions

Recent studies indicate that current outdoor fitness equipment is mostly used by the older population (Chow et al., 2017; Veitch et al., 2021). Another recent systematic review indicates that there is inconclusive evidence of the benefits of longitudinal outdoor versus indoor exercise, due to a high risk of bias in most articles and a need for more

Table 1
Characteristics of the different studies.

Studies	Type	Variables	Frequency	Exercise prescription	Duration	Instruments/tests
Bowler et al. (2010)	Systematic review	–	–	–	–	–
Chow et al. (2021)	Intervention study	Cardiorespiratory	5 days/ week	Operation tempo 60 bpm	40 min.	-2 min. Step test
		Muscle strength	2 days/ week	Week 1–6, 8 reps 3 sets/ Week 7–12, 12 reps 3 sets	10 min.	-Hand grip test and 30 s chair stand -Back scratch
		Flexibility		Per stretching time for 30 s/ Operation tempo 60 bpm	10 min. 10 min.	-Single leg stand -8 ft up and go
		Balance	2 days/ week 2 days/ week	Week 1–4, 2 ft for 10 min Week 5–8, 2 ft for 10 min, 1 ft for 2 min Week 6–12, 2 ft for 6 min, 1 ft for 4 min		
Chow et al. (2017)	Observational study	–	–	–	–	-Observing Play and Recreation in Communities (SOPARC questionnaire) -Peak Hour Observation Using Video Camera
Furber et al. (2014)	Intervention study	–	–	–	–	-Face-to-face questionnaire
Grigoletto et al. (2021)	Systematic review	–	–	–	–	–
Jansson et al. (2019a)	Observational study	–	–	–		-Observing Play and Recreation in Communities (SOPARC questionnaire)
Jansson et al. (2019b)	Systematic review	–	–	–	–	–
Sales et al. (2015)	Study protocol	Muscle strength Balance Coordination Flexibility	2 days/ week	Level 1 to 9 Level 1 to 13 Level 1 to 3 Level 1 to 11 The intensity of each level is explained in the document. Week number 1 to 18/ set time 60 s to 90 s/ rest time 60 s to change over and rest to 30 s change over and rest	60–90 min.	-Functional Reach Test -Static Balance Standing -Step test -Timed Up and Go test -Hand grip strength test -2 min. Walk test -Lower limb strength -Strength of the knee extensor muscles -Spatio-Temporal Gait Parameters -Short Form (12) Health Survey Version 2 (SF-12v2™) -The Incidental and Planned Activity Questionnaire (IPAQ) -The falls efficacy scale (Short FES—I) questionnaire -Falls and physical activity calendar
Sales et al. (2016)	Intervention study	Muscle strength Balance Coordination Flexibility	2 days/ week	5 to 10 min of warm-up exercises 45 to 75 min on the equipment stations 5 to10 min of cool-down exercises The exercise classes were circuit based with the warm-up and cool-down exercises being performed in a group and the core part of the session being carried out in training pairs. The intensity of each level is explained in the document.	60–90 min.	-The Balance Outcome Measure for Elder Rehabilitation (BOOMER) -Single leg stance test standing on the dominant leg with eyes open was used to measure static balance -Hand grip strength test - 2 min. Walk test -30-s sit-to-stand test -Knee extensor muscles test -Gait speed test -Short Form (12) Health Survey Version 2 (SF-12v2™) -Falls and physical activity calendar
Sales et al. (2018)	Intervention study	Muscle strength Balance Coordination Flexibility	2 days/ week	5 to 10 min of warm-up exercises 45 to 75 min on the equipment stations 5 to10 min of cool-down exercises The exercise classes were circuit based with the warm-up and cool-down exercises being performed in a group and the core part of the session being carried out in training pairs. The intensity of each level is explained in the document.	60–90 min.	- Face-to-face interview about confidence and well-being, depression symptom, social interaction, supervision, frequency, duration, progression of exercises, level of difficulty of exercises, changes to their life in general, and general level of satisfaction
Stride et al. (2017)	Observational study	Cardiorrespiratory Strength Balance Flexibility	–	12 separate equipment pieces on a soft-fall rubber surface providing aerobic, strength, balance and flexibility exercise. Park users were free to use the outdoor fitness machines.	–	Interview questions included: place of usual exercise; frequency and purpose of park use; frequency and purpose of outdoor gym use; preferred equipment pieces; enablers and barriers to outdoor gym use; physical activity (using the validated 3Q-PA) and demographics
Vancampfort et al. (2011)	Systematic review	–	–	–	–	–

rigorous trials and more complete reporting (Noseworthy et al., 2023). This review with meta-analysis shows that older adults value the health and social interaction benefits of using outdoor exercise parks, but the findings should be interpreted with caution due to small sample sizes and a limited number of studies (Ng et al., 2020). In addition, quality of life and life satisfaction are very important aspects in the older people, one of the important determinants for to improve the quality of life is the adoption of sports practice, as well as the creation of a conducive social environment and the promotion of conviviality, which have a significant influence on the adoption of a healthy lifestyle, particularly in terms of commitment to physical activity and sports (Parra-Rizo et al., 2022). Therefore, training in outdoor fitness equipment can promote engagement in the practice and socialization, which can lead to the creation of a healthy lifestyle. Also, it is essential to consider several variables that affect the perception of self-satisfaction with health in the older population, such as well-developed functional, physical and psychological capacities, along with the regular practice of physical activity (Agustí et al., 2023), and properly designed training programs with outdoor fitness equipment can favor the improvement of functional, physical and psychological capacity.

A rigorous randomized controlled trial study indicates that there were no significant changes between the experimental group that trained with outdoor fitness equipment and the control group and that the possible reasons for the limited training effects could be the lack of resistance components and the diversity of the design of this equipment (Liu et al., 2020), this study, in contrast to the studies included in Table 1 that show physical, psychological or social health benefits of training with outdoor fitness equipment, supports the need for more rigorous studies with a better protocol to control the intensity of training and where a progression in the intensity of training loads is planned. These findings suggest the need for further research and improvements in outdoor fitness equipment design to optimize training outcomes. One approach could be to conduct studies comparing the effectiveness of different types of outdoor fitness equipment and their impact on training outcomes. Additionally, feedback from older adults who regularly use outdoor fitness equipment could be collected to identify specific design features that are most beneficial and areas for improvement. This approach can help ensure that the new designs are more effective, user-friendly, and enjoyable for older adults, leading to greater adherence and long-term benefits. Another study presents tangible proof suggesting that the way numerous individuals utilize outdoor fitness equipment may pose potential hazards to safety, potentially resulting in accidents and injuries that could lead to liability concerns for manufacturers or relevant authorities (Chow and Wu, 2019).

Also, in order to optimize the utilization of outdoor fitness areas by older adults, we propose the installation of a diverse range of apparatuses that cater to cardiovascular fitness, muscular strength, balance, and flexibility. These installations should be positioned in convenient and visually pleasing spots, in proximity to other centers for physical pursuits and conveniences. A strategic promotional approach, encompassing informative workout sessions and guidance, could effectively encourage secure and enduring engagement with the outdoor gym facilities (Scott et al., 2014).

Middle-aged and older adults have spinal misalignments when using outdoor fitness equipment to train in the standing position, so these machines should be able to be adapted to allow for safe and effective training (Abelleira-Lamela et al., 2021). This study concludes that the biomechanical characteristics of adults and older adults must be considered in the design of outdoor fitness equipment programs, specifically to minimize the risk of falls and injuries, as well as to maximize the benefits of exercise. Another study measuring the ergonomic properties of outdoor leg press, chest press and pull chair fitness machines indicates that they could play an important role in the occurrence of musculoskeletal injuries among users of these machines and highlights the need to follow ergonomic standards in the design and production of these types of outdoor fitness equipment (Sanchooli et al., 2021). In addition, current outdoor fitness equipment only provides resistance through the individual's own body weight, which may not be sufficient for some and may be injurious to others. The lack of ability to increase the resistance provided by the machines may limit the potential for older adults to increase their training loads and generate improvements in muscle mass and strength.

Also, outdoor fitness equipment should have clear, easy-to-understand instructions and labels. Older adults may have difficulty understanding complex instructions and labels on outdoor training machines, which can lead to improper use and increased risk of injury. Manufacturers should provide clear user manuals (or demonstration videos) on the correct use of their equipment and warning labels on risky behaviors. Manufacturers can design and develop equipment that meets certain principles of safety, ergonomics, and ease of maintenance. Park authorities can organize sessions to provide useful guidelines to the public in the community and implement effective promotional strategies. Manufacturers can place a label on equipment with a quick response (QR) code linking to a video demonstrating how to properly use each piece of equipment. Park managers can post warning signs to prevent children from using the equipment and regularly monitor and manage equipment areas. Companies should offer a training app that provides information for their equipment's safe and effective use. In addition, training courses should be held for physical exercise and health professionals for the correct use of the machinery and for them to learn how to plan training programs adapted to the characteristics of the user.

Older adults have a higher risk of falling and therefore need greater stability and safety on the outdoor fitness equipment. That is why they should have non-slip surfaces and handrails for greater stability and safety for them. In summary, outdoor fitness equipment for use by older people should have adjustable resistance levels, clear and easy-to-understand instructions and labels, non-slip surfaces and handrails for added stability and safety.

Outdoor fitness equipment presents some challenges and limitations that should be considered in the development of new, safer, and more effective machines. Table 2 shows a series of recommendations for improvement outdoor fitness equipment.

Therefore, to design feasible interventions and improve physical activity levels in parks, effective collaboration among various professionals is essential. This includes public health experts, of parks and recreational facility planners and managers, sociologists, psychologists, economists, urban planners, architects, landscapers, trainers, researchers, and public safety officers (Bedimo-Rung et al., 2005). In addition, health training should always be under the prescription of a medical professional and a sports physical educator.

7. Conclusions

To our knowledge, this is the first narrative review that updates the psychophysiological and social effects of training with outdoor fitness equipment. At present, there are limited experimental studies, probably due to the limitations of current outdoor fitness equipment. Outdoor fitness equipment programs have the potential for improve psychophysiological and social health in older adults, but further research is required to understand the benefits and challenges of their use. More rigorous and randomized clinical trial studies are needed to investigate the optimal frequency, intensity, and duration of training with this equipment for older adults. Barriers to outdoor fitness equipment programs use among older adults, lack of standardized measurement of outcomes and limited studies on long-term effects are challenges that must be overcome to fully understand the benefits and challenges of their use. Current outdoor fitness equipment requires several modifications such as those suggested in this study to maximize the effectiveness and safety of training on it.

The present study has certain limitations. As already indicated, there are few rigorous studies with outdoor fitness equipment. In addition, the

Table 2
Recommendations for improvement new outdoor fitness equipment:

Aspects	Recommendations
Ergonomics	Equipment should be designed to be adjustable to different body sizes and to allow for spinal alignment that preserves physiological curves during execution. It is advisable to include comfortable handles and grips that reduce stress on hands and wrists.
Biomechanics	The lever system should provide a resistance that can be regulated according to the strength and capacity of the user, allowing movement patterns and muscle activation, reducing the risk of injury and increasing the effectiveness of the exercise. Current machines are not adaptable for older adults to improve their psychophysiological and social health.
Effectiveness	Equipment should be designed with multiple resistance levels and allow for progression. It is advisable to use machines that train polyarticular exercises and that involve large muscle groups involved in the activities of daily living and the functionality of the person.
Standardization	The diversity of brands, designs and functions hinders the correct use of outdoor fitness equipment, which underlines the importance of standardization and uniformity of outdoor fitness equipment to ensure homogeneous usability and user experience. In addition, this equipment should be supported by previous studies, and its manufacturers can offer this information to users through a website, Qr codes etc.
Safety	To ensure the safety and effectiveness of outdoor fitness equipment, testing, validation and maintenance service is very important. This includes testing and validating equipment to meet safety and quality standards, incorporating safety features such as non-slip surfaces, cushioned areas and clear instructions for use. Safety features can improve the overall user experience and make the equipment more attractive so that more users become engaged and adhere to training with it.
Accessibility	To promote inclusion and accessibility, outdoor fitness equipment can be adapted for people with disabilities, including those with mobility impairments. This includes the ability to perform seated or supported exercises and equipment with low initial resistance and that allows for progression. However, current outdoor fitness equipment in public parks is not accessible to people with mobility impairments, such as those who use wheelchairs or walkers. Therefore, it is critical that parks consider accessibility when installing outdoor fitness equipment to ensure that everyone has the opportunity to enjoy the benefits of physical activity.
Maintenance	The safety and longevity of outdoor fitness equipment in public parks depends on regular maintenance and cleaning. This ensures that the equipment is safe for use and can provide effective workouts for users. In addition, it is crucial to include instructions for proper use and furthermore, for users to promptly report any broken or malfunctioning equipment.
Education	To maximize the effectiveness of this equipment, it is crucial to educate and inform the public about its benefits and how they can train safely and effectively. Therefore, educational programs are important to inform the public about the benefits of training on outdoor fitness equipment. Companies that manufacture this equipment can install information boards with instructions for safe and effective use. Alternatively, QR codes can be placed on equipment that direct users to mobile apps or a website that provide workout information and allow for feedback, including notification of malfunctions or other problems. This can help improve the user experience and encourage safe and effective use of outdoor fitness equipment.

machines may differ between manufacturers and not activate the same musculature, as well as affect the person differently. A systematic review with meta-analysis was not possible due to the limited number of studies and their low methodological quality. Therefore, our review provides valuable information regarding the importance of outdoor fitness equipment and a series of recommendations for improvement in the manufacturing of this equipment. There is a need for public health experts, local municipal authorities, and public health agencies to invest in safe and effective outdoor fitness equipment in open spaces.

The study also highlights the need for further research to examine the effectiveness of training in populations with special needs and to compare current outdoor fitness equipment with new equipment that allows for increased load and is safer and more effective. Future research should also examine ways to increase the long-term use of outdoor fitness equipment, assess long-term efficacy, and include measures of how impacts the health status of participants.

In the older people it is not enough to just go for a walk, we need other physical exercise interventions to help prevent muscle wasting, sarcopenia, dinapenia and other diseases and this is where the outdoor spaces and outdoor fitness equipment can help.

Furthermore, as a strength, to highlight that this study proposes this series of recommendations, based on the review carried out and on the experience gained in the experimental studies that have been conducted within the projects led by the principal investigator (PJMP): reference CFE/CO/05-17 and reference RTC-2017-6145-1, 2017 and which are in the process of publication.

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Not applicable.

Consent for publication

Not applicable.

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CRediT authorship contribution statement

P.J.M.-P. conceived the design, obtained the grant, analyzed the literature, wrote, and critically edited the manuscript; A.E.-G; T.A.-L. and D.R.L.M. analyzed the literature and provided critical comments for the manuscript; P.J.M.-P; A.E.-G. and D.R.L.M. prepared the final manuscript.

All authors have read and agreed to the published version of the manuscript.

Declaration of competing interest

The authors declare that they have no competing interests. The funders had no role in the design of the study; in the analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Data availability

No data was used for the research described in the article.

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ANEXO 11. ESTUDIO 3

Open access Protocol

BMJ Open Sport & Exercise Medicine

Physical and psychological effects of outdoor fitness equipment training on middle-aged and older adults: study protocol of a randomised controlled trial

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ABSTRACT

This project will investigate the effectiveness of an 8-week outdoor fitness equipment (OFE) programme on health parameters in healthy community-dwelling middle and older adults, corresponding to the present paper to the study protocol, which follows a single-blind randomised controlled trial design. The training intervention will involve participation in an OFE programme implemented over 8 weeks, two sessions/week. Rating of perceived exertion, heart rate, training volume and adherence to the exercise programme will be registered each session. The control group will not receive any structured exercise programme. Blinded examiners will evaluate before and after the training programme muscle strength with both maximum knee extension and elbow flexion isometric tests, handgrip strength test and five time sit-to-stand test; cardiovascular fitness with 400-metre walking test; postural stability with the balance tests of the short physical performance battery (SPPB) battery; dynamic balance with Timed Up and Go (TUG) test; body composition with dual-energy X-ray absorptiometry; functional performance by gait speed, TUG and SPPB battery; blood pressure; and sagittal spine disposition and pelvic tilt. Information will also be collected about demographic characteristics, health-related quality of life, satisfaction with life and adherence to the Mediterranean diet questionnaires. After that, sarcopenia, osteoporosis and fracture risk will be calculated. The results derived from this research will increase the knowledge of the effectiveness of OFE training for improving the health of healthy community-dwelling middle and older adults.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Outdoor fitness programmes can have health benefits for middle-aged and older adults in relation to muscle strength, cardiovascular capacity, postural stability and body composition. However, few studies have examined the benefits of outdoor fitness equipment training for older adults.

WHAT THIS STUDY ADDS

⇒ This study provides evidence of the effectiveness of an outdoor fitness equipment training programme in improving specific health-related variables in a randomised controlled trial.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study proposes a detailed protocol to evaluate the effects of outdoor exercise equipment training in a specific population. The results could be substantial in the development of more effective and accessible interventions and the promotion of active and healthy lifestyles among older adults.

INTRODUCTION

Practicing consistent physical activity is crucial to uphold optimal health and stave off chronic conditions and the effects of ageing in the older population. According to the WHO, physical activity can reduce the likelihood of middle-aged and older people developing chronic diseases such as heart disease, stroke, diabetes, sarcopenia, certain types of cancer by approximately 30–40%, diseases whose incidence increases with increasing age.[1]

Among the different physical activity options for the prevention of the effects of ageing, resistance training has gained popularity in recent years. In this line, some researchers conclude that resistance and balance exercise, with or without nutritional intervention, are the most effective interventions for improving quality of life and physical function in older adults with sarcopenia.[2]

Public areas are ideal for encouraging physical activity and resistance training since they encompass green spaces and outdoor fitness equipment (OFE).[3] Furthermore, engaging in outdoor physical exercises can improve pulmonary, cardiovascular, cognitive, musculoskeletal and overall systemic health.[4] Despite this, few studies have examined the benefits of OFE training for older adults.[5] A recent review demonstrates that OFE training

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programmes have the potential to improve cardiovascular health, muscle strength, flexibility and balance and reduce falls while improving quality of life, alleviating depression and anxiety and increasing self-esteem.[6] However, the authors suggest that more rigorous research is needed to understand the psychophysiological and social effects on health comprehensively.

Therefore, OFE training may be a free, feasible and timely way to address various health-related aspects of the ageing process. However, to date, no studies have been found that have analysed the effects of planned OFE training on health in middle and older adults with a randomised controlled trial design. Thus, this project will investigate the effectiveness of an 8-week OFE programme on health parameters in middle and older adults, corresponding the present paper to the design of the study protocol in which it presents an ongoing randomised controlled trial to investigate the effects of a circuit resistance training intervention with OFE on relevant physical and psychosocial performance in healthy community-dwelling middle and older adults.

The hypothesis is that the OFE training for 8 weeks, twice per week, improves physical fitness, body composition, psychological state and prevention of the effects of ageing after the intervention period compared with the daily activities control group (CG).

MATERIALS AND METHODS

Study design and setting

This protocol describes an 8-week two-armed parallel single-blind randomised controlled trial with blinded examiners (NCT04958499). This study is designed considering the recommendations of Consolidated Standards of Reporting Trials [7] and Standard Protocol Items: Recommendations for Interventional Trials statements.[8]

Participants will be evenly and randomly divided between the training group (TG) and the CG. The overall study design is summarised in figure 1. The choice of this design is related to the main objective and facilitating the interpretation of the data with intragroup and intergroup.

Ethics approval and dissemination

All participants will be informed about the study procedures and will give their approval through informed consent before inclusion. All data collected during the study will be confidential. All participants receive a final report with their results to know their values at baseline and the end of the study. The trial will be conducted following the Declaration of Helsinki, and the study has been approved by the institutional ethics committee of the Catholic University of Murcia (CE111908).

Based on previous studies, groups larger than 30 were required for the result to reliably characterise precision error or change during clinical monitoring.[9] A dropout rate of 16% will be assumed based on previous studies,[10] so a minimum of 35 participants will be included per group. The RStudio V.3.15.0 software will be used to

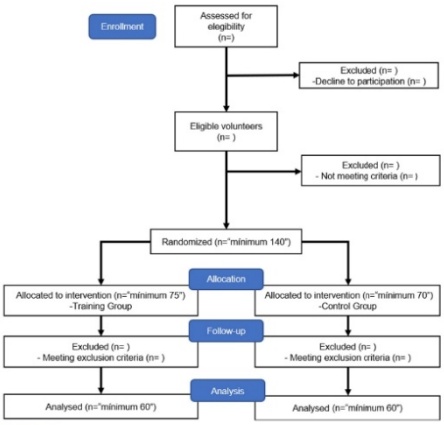


Figure 1 Consolidated Standards of Reporting Trials flow diagram showing the flow of participants through each stage of the study.

calculate the sample size. The sample size and statistical power were established considering the SD (4.2) in the maximum voluntary isometric contraction (MVIC).[11] A significance power of 95% (1-β=0.95) and a significance level of 0.05 will be considered. Ultimately, the sample consisted of a minimum of 60 participants per group. This resulted in an assumed error of 1.06.

Recruitment

Participants will be recruited through advertisements in health centres, older daycare centres, senior centres and women's centres in Murcia (Spain). In addition, publications with information about the trial will be made on social networks. All potential participants will be contacted personally by telephone before their inclusion in the study.

Inclusion and exclusion procedures

To be included in the study, participants will have to meet the following criteria: will be male or female, aged 50 years or older, being physically independent, not having any pathology incompatible with the study, not having participated in a structured exercise programme for at least 1 year and signing the informed consent form. The exclusion criteria will be self-reported substance abuse or dependence disorder (alcohol, non-prescribed medications, etc), being under medical prescription for taking medications that could influence physical performance, suffering from any pathology contraindicated for the exercise programme or requiring specialised medical attention (infectious, renal, pulmonary, coronary diseases, etc), having low adherence during the programme or performing physical exercise outside the study. During the pre-test phase, health personnel will

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Table 1 Progression in training during the study

Week	Workouts/week	Sets	Work/rest time (s)	Execution time (concentric-eccentric) (s)	Rest interval (s)
1	2	1	30/45	1–1	120
2	2	2	30/30	1–1	120
3	2	3	30/30	1–1	120
4	2	3	30/30	1–1	120
5	2	3	45/30	1–2	120
6	2	3	45/30	1–2	120
7	2	3	45/30	2–2	120
8	2	3	45/30	2–2	120

.s, seconds.

perform an ECG on each participant to corroborate their cardiac health just after signing the informed consent and before the assessment tests.

Randomisation and allocation

After baseline measurements, participants will be randomly assigned to the TG or CG. A research team member will create a randomisation sequence (1:1) before the trial begins. The investigators who will conduct the assessments are not aware of which group the participants belong to, and participants will be instructed not to disclose the group to which they had been assigned.

Training group

The TG will perform circuit strength training with OFE in groups of six to eight people. Two sports science graduates will supervise the training programme, which will be carried out for 8 weeks, with two training sessions per week on non-consecutive days (table 1). To increase adherence, a third weekly session will be available for participants who could not attend on their schedule.

Over the 8 weeks, both the volume and intensity of the training will be progressively increased. Training load control considers variables such as time under tension, execution time, training density, rest between sets and total volume.

The session structure will be based on timed circuit training. Each session will specify work time, rest time, execution time and sets to perform (table 1). Work and rest times will be monitored through Timebirds Original V.3.12 (Melbourne, Australia). A mobile application metronome (Metronome Beats, UK) programmed at 60 beats per minute will indicate execution time with a series of beeps. Participants will perform repetitions constantly, using the metronome information to control execution time during the concentric and eccentric phases.

The warm-up will consist of aerobic exercises designed to elevate the heart rate (HR), which include 150 m of walking, increasing the walking speed every 50 m without transitioning to a run, 10 body weight squats and 10 standing push-ups against the wall. Following the aerobic exercises, participants will perform upper and lower joint mobility movements to prepare them for the training. The cool-down phase will involve gentle stretches of the major muscles targeted during the session, with 10 s of stretching per position. The training circuit will comprise 11 exercises conducted on 8 OFE from Entorno Urbano S.L.U (Murcia, Spain), installed at the university facilities. These machines offer different usage modes by varying grips and limb positions. Accordingly, the training circuit will be composed of the following machines in sequence: Bonny rider (the handle will be pulled using both hands with a supine grip, with the elbow being flexed and the shoulder being extended), Gemini Low Grip (the handle will be pushed with grips held at a low height, with the elbow being extended and the shoulder being flexed), Air Walker (hip flexion-extensions will be performed on both platforms with the torso being kept upright. A brief isometric hold will be done at the end of the motion), Parallel Bars (the body's weight will be lifted by the elbow being extended from a flexed position. As an adaptation, triceps push-ups will be done sideways to the machine with a prone grip), Flyer Wheels circumductions (circumductions will be performed on the Flyers Wheels apparatus with elbows kept straight and grips being held, using shoulder mobility), Gemini Mid Grip (the handle will be pushed on the Gemini equipment with grips held at mid-level, by the elbow being extended and the shoulder being flexed), Flyer Wheels external rotation (internal and external rotations will be executed on the side of the Flyers Wheels machine, with the elbow being supported and the grip being held), Swing ankle extension (with the knee kept straight, the metatarsal will be rested on the platform's lower edge and the ankle will be alternately flexed and extended), Surfboard (a pendulum motion from the waist will be done in the frontal plane while the handle is being held on the platform. An isometric hold will be performed at the motion's furthest point), Swing leg press (resistance will be pushed against on the Swing apparatus with

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Figure 2 Images of the sequence and execution of the exercises on the different machines. (1) Bonny rider; (2) Gemini Low Grip; (3) Air Walker; (4) Parallel Bars; (5) Flyer Wheels circumduction; (6) Gemini Mid Grip; (7) Flyer Wheels External Rotation; (8) Swing Anke Extension; (9) Surfboard; (10) Swing Leg Extension; (11) Row.



Figure 3 Images of flashcards indicating the sequence of use for the outdoor fitness equipment during the training programme.

the knees being extended, while seated with feet on the platforms) and Row (on the seat, the movement will be performed by bending the elbow and shoulder, keeping the torso upright) (figure 2).

Each machine will be numbered with a sign to indicate the execution order to the participants (figure 3), allowing for alternating work on different muscle groups to prevent excessive localised fatigue. The starting exercise for each participant and session will be randomised to avoid potential influences on ratings of perceived exertion (RPE) and HR. The initial machine will be recorded for each participant in each session.

At the session's end, data on HR will be collected using a wrist-worn HR monitor, the Polar M430 (Polar Electro, Kempele, Finland), and participants' RPE after each exercise and at the end of the session will be recorded. Potential exercise adaptations will be based on participants' functional and physical capacity, assessed by an expert committee and considering the machines' everyday use.[12]

Control group

Individuals assigned to the CG (figure 1) will be instructed to continue their daily activities throughout the study. Participants' habits and physical activity levels will be monitored over the 8-week study period using specific inquiries incorporated within the socio-demographic questionnaire.

Data collection and measures

Measurements will be performed in the laboratory of the research group available at the university. Participants will be asked not to stretch or warm up before the tests. Measurers will be maintained from pre-test to post-test to avoid the influence of inter-rater error on the measurements made. Experts in the performance of the specified tests will evaluate all measurements. The tests will be performed in a random order. Variables collected and the assessment schedule during the study are shown in table 2.

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Table 2 Variables were collected, and assessments were scheduled during the study

	Training group			Control group		
	Baseline	Intervention	Post	Baseline	Intervention	Post
Consent	X			X		
Demographic survey: Age, sex, occupation, weekly physical activity, pathologies and medication	X			X		
Health-related quality of life: 36-Item Short Form Survey	X		X	X		X
Satisfaction with life: Satisfaction with Life Scale	X		X	X		X
Adherence to the Mediterranean diet: Prevention of Mediterranean Diet Score	X		X	X		X
Body composition: Height and weight Full body composition (DEXA) Bone mineral density (DEXA)	X		X	X		X
Blood pressure	X		X	X		X
Heart electrical activity: ECG	X			X		
Muscular strength: Isometric handgrip strength test Isometric knee extension strength test Isometric elbow flexion strength test	X		X	X		X
Cardiovascular fitness: 400 metres walking test	X		X	X		X
Postural stability: Centre of pressure (COP) in side-by-side test Centre of pressure (COP) in semi tandem test Centre of pressure (COP) in tandem test	X		X	X		X
Functional capacity: Short physical performance battery (SPPB) Time Up and Go Test	X		X	X		X
Risk of falls: Gait speed test	X		X	X		X
Risk of sarcopenia: European Working Group on Sarcopenia in Older People Consensus	X		X	X		X
Sagittal spine disposition and pelvic tilt: Spinal mouse relaxed standing position test Spinal mouse relaxed sitting position test	X		X	X		X
Rating of perceived exertion: 1–10 Borg rating of perceived exertion		X				
Effort and heart rate		X				
Training volume		X				
Adherence		X				

DEXA, dual-energy X-ray absorptiometry.

Primary outcomes

Maximum muscular strength

Both maximum knee extension and elbow flexion strengths will be evaluated under the same isometric conditions. For the knee extension test, participants will be seated in a chair specifically designed for the

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measurement of isometric knee extension strength (ES-1295254) equipped with a force transducer (Musclelab, Ergotest, Norway), maintaining both a hip and knee angle at 90 degrees. Participants will be directed to exert maximum strength against a pad above their ankle joint. For the elbow flexion test, participants will stand upright, holding a bar with both hands in a supine position, with the elbow at a 90-degree angle. Participants will be directed to exert maximal strength against the bar.

Following a previous protocol, participants will sustain exertion for 2–3s during both assessments.[13] The software (Musclelab, Ergotest, Norway) will quantify the maximum voluntary isometric contraction and the rate of force development. Each participant will complete three trials for each assessment, and the best one will be used.

Handgrip strength test

Handgrip strength (HG) test will be measured standing with the arms at the sides. The participants will perform one repetition in each hand to familiarise themselves with the device and the test. Each participant will be asked to squeeze the grip with maximal strength with both hands for 3s. The highest peak strength (kg) recorded between the three attempts will be considered for analysis. A digital grip strength dynamometer will be used for this (TKK 5401; Takei Scientific Instruments, Tokyo, Japan). This measure has been associated with frailty in older people.[13 14]

Cardiorespiratory fitness

The 400 m walking examination is deemed a suitable and reliable test for approximating cardiorespiratory fitness (CRF).[14] So CRF will be evaluated by measuring the time needed to complete 10 laps as rapidly as feasible on a 20 m long track. Participants will be directed to walk at their maximum pace, refraining from running.[14] The maximum and average HR during the test will be evaluated, and the HR with the test will be finished. Also, the HR 2 min after the test will be recorded as the CRF recovery variable. A single attempt at the test will be done.

Postural stability

A force platform will assess postural stability during quiet standing (Musclelab, Ergotest, Norway). The short physical performance battery (SPPB) balance protocol will be followed.[15] Participants will be maintaining a stationary stance for 30s with arms at their sides, repeated three times in each foot position, following this order: (1) feet together with eyes open; (2) semi-tandem stance (one foot's ankle behind the joint of the other foot) with eyes open; and (3) tandem stance (one foot's ankle directly behind and touching the other foot's ankle) with eyes open. Measurements such as the total centre of pressure displacement, anteroposterior and mediolateral amplitudes of the centre of pressure and the area of the centre of pressure displacement will be obtained from analyses conducted with Musclelab software (Musclelab, Ergotest, Norway).

Dynamic balance

The Timed Up and Go (TUG) test will assess the dynamic balance. During the TUG, participants will stand up from a chair, walk 3 m, turn around and sit back down in the chair while timed (38). Two attempts will be made, and the final value will be the best.

Body composition

An accredited anthropometrist will measure kinanthropometric parameters related to height and body mass according to the guidelines of the International Society for the Advancement of Kinanthropometry.[16] The portable Leicester HR 001 stadiometer (Tanita, Illinois, USA) will be used to measure the height (cm) with a precision of 1 mL, while body mass (kg) will be assessed in light clothing and barefoot using a Tanita BC-545N electronic scale (Tanita, Illinois, USA) with a precision of 0.1kg. Each measurement will be taken twice. If both measurements have a difference of less than 1%, their average will be calculated. Conversely, if the difference exceeds 1%, a third measurement will be taken, and the median will be considered.

Body composition will be evaluated using dual-energy X-ray absorptiometry (DEXA) through a Hologic QDR 4500A densitometer (Hologic, Massachusetts, USA). A whole-body scan will be conducted to assess lean and fat mass percentages.

Additionally, a second scan of the right proximal femur (femoral neck, trochanter region and ward area) will be performed to evaluate bone mineral density levels, osteoporosis risk and WHO-FRAX. The same certified technician will conduct all measurements and densitometry analyses following key guidelines.[17] Participants will be evaluated in a supine position with hips in internal rotation and feet in adduction to enhance femoral neck visibility. All participants will be instructed to use the restroom before the test and wear light clothing without metallic objects or shoes.[17] A single attempt at the test will be done.

Functional performance

Functional performance will be measured by 10 m of gait speed, the TUG and the SPPB.[18]

Gait speed will be assessed using a 10-metre test. Participants will be asked to walk at maximum speed without running, and the total time taken to cover the 10 m distance will be measured with two photocells (Witty, Microgate, Bolzano, Italy). The test will be performed twice, and the best one will be used.

The SPPB encompasses the postural stability assessment, five-time chair stand test and 4 m gait walk.[18] The five times sit-to-stand test will evaluate the gauges and the duration the subject takes to transition five times from a seated posture to a standing posture with utmost speed, refraining from using their arms. The test will be

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performed twice, and the best one will be used. In the 4 m gait walk, participants will be asked to walk at maximum speed without running and the total time taken to cover the 4 m distance.[18] To ensure a dependable measurement, it will be measured by two photocells (Witty, Microgate, Bolzano, Italy). The test was performed twice, and the best one was used.

Of the tests included in the SPPB, each test allowed for a potential accumulation of up to four points, yielding a score spectrum of 0– 12 points.[15]

Sarcopenia

The HG and chair stand tests will assess muscle strength (muscle quality). Muscle quantity will be measured through appendicular skeletal muscle mass with DEXA values, and functional performance will be measured by 4 m gait speed, TUG and the SPPB battery. The risk associated with each variable will be defined in connection with the EWGSOP2 (European Working Group on Sarcopenia in Older People) sarcopenia cut-off point.[18 19]

Secondary outcomes

Demographic survey

Participants will be asked about their basic sociodemographic data at the baseline. They will also be asked about their daily physical activity level, number of falls and weight loss in the last year and information regarding their health status, such as medication and pathologies.

Health-related quality of life

The 36-item Short-Form Health Survey (SF-36) will be employed to assess health-related quality of life. The SF-36 evaluates physical and mental health domains across eight concepts: physical functioning, physical role functioning, bodily pain, general health perceptions, vitality, social role functioning, mental health and emotional role functioning. The validated Spanish version[20] will be used in this study. A higher score indicates a better quality of life.[20]

Satisfaction with life

The Satisfaction with Life Scale questionnaire will be used to assess life satisfaction, specifically in its Spanish version.[21] This instrument consists of five items responded to using a 5-point Likert scale. These items are related to an individual's perception of achievements relative to their expectations. A higher value indicates greater life satisfaction.[21]

Adherence to the Mediterranean diet

Adherence to the Mediterranean diet will be assessed using the score obtained from the validated 14-item questionnaire of the Prevention of Mediterranean Diet (PREDIMED) study.[22] A higher score indicates greater adherence to the Mediterranean diet, with a score of ≥9 considered high adherence.[22]

Blood pressure

Blood pressure will be measured using an automatic blood pressure monitor (OMRON model HEM-7113, Osaka, Japan), following the general guidelines.[23] The participant will sit comfortably and quietly for 5 min before the first measurement, with the second measurement taken 2 min later. The final values of systolic blood pressure, diastolic blood pressure and pulse rate were the average of the two measurements. Subjects will be informed to abstain from vigorous exercise for 24 hours, avoid caffeine intake for 4 hours and refrain from tobacco use 30 min before the measurements.

Leg muscle strength

The chair stand test will be employed to quantify the leg muscle strength. This test will be carried out following the protocol of previous investigations.[18]

Risk of falls

Gait speed is a powerful predictor of fall risk.[24] Gait speed will be assessed using a 10-metre test.

Sagittal spine disposition and pelvic tilt

The sagittal spine disposition and pelvic tilt will be measured using the Spinal Mouse system (Idiag, Fehraltdorf, Switzerland). This device allows the angular measurement of the different spinal curvatures in a non-invasive way. An assessment of the sagittal spine disposition in relaxed standing and sitting will be performed, following the protocol from previous studies.[25] A positive value implies kyphosis for thoracic and lumbar curvatures and an anteversion for pelvic tilt. In contrast, a negative value implies lordosis for thoracic and lumbar curvatures and a retroversion for pelvic tilt. Each position will be evaluated three times, the final value being the mean of both values.[25]

Rating of perceived exertion

The Borg CR-10 RPE scale will be used to measure the perception of exertion among participants.[26] Participants will be instructed to evaluate their perceived exertion for the entire session and their general perception of exertion for each machine immediately after the session conclusion.

Effort and heart rate

The training intensity will be registered by monitoring the HR throughout the sessions. For this purpose, Polar M430 (Polar Electro, Kempele, Finland) wristband HR monitors will be employed. After each session, the average, peak and final HRs will be collected.

Training volume

The volume will be systematically registered for each training session. This includes the duration in seconds of the workout, the associated rest intervals and the number of repetitions and sets performed by each participant.

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Adherence to the exercise programme

In the TG, each participant's adherence to the exercise programme will be monitored. Adherence will be measured as the percentage of exercise sessions performed and/or the total number of scheduled sessions.

PATIENT AND PUBLIC INVOLVEMENT

Patients and/or the public will be involved in this research's design, performance, reporting or dissemination plans.

STATISTICAL ANALYSIS

The qualitative variables will be summarised in frequency. In contrast, the quantitative variables will be summarised using mean and SD for the TG and CG across the assessment time points. To ensure rigorous statistical evaluation, special attention has been given to controlling the type I (alpha) error and Bonferroni's correction will be used to achieve p=0.005 for statistical significance. To compare characteristics between and within groups, the principle of intention to treat will be applied, with adjustments made to adhere to the exercise programme. The following tests will be employed to assess baseline characteristic differences between the two groups: Student's t-test for parametric numerical variables, Mann-Whitney test for non-parametric variables and χ^2 test for categorical binary variables.

To compare changes within and between the TG and CG across baseline and follow-up assessments, the subsequent tests will be used: for variables exhibiting normal distribution, repeated measures analyses of variance. Given the multiple comparisons involved, post hoc analyses will be conducted using t-tests with Sidak corrections to control the type I error rate; for non-parametric variables, the Friedman test will be followed by the Wilcoxon test, and, to address the multiple comparisons, the Bonferroni correction will be applied.

SPSS V.25.0 statistical software will be used in all the analyses. A p value<0.05will be used to determine significant differences; however, this will be adjusted appropriately in the presence of multiple comparisons, as detailed above.

CONCLUSIONS

This protocol presents a randomised controlled trial to evaluate the efficacy and safety of an exercise programme with OFE designed to improve physical and psychological health variables.

Exercise and strength training are essential to prevent or reverse disease, maintain or improve health and prevent loss of function in adults, middle-aged and older people. This is where free and free training with OFE in outdoor spaces can be relevant to health. However, no specific indications are available on the appropriate training programme and which machinery can be safe and effective for their physical, psychological and social health. A design study is presented in this research, the results of which are as follows, which could provide evidence to physicians, exercise trainers and policymakers on the best strategy to ensure safe and effective outdoor exercise, establishing parameters for prescribing and monitoring a training programme with OFE, while respecting individual progress.

Patents

The results of this study were taken into account for the design of new machines that will more effectively and safely, with the following registered patent: Publication n° ES1296848 (U); (http://invenes.oepm.es/InvenesWeb/detalle?referencia=U202231979) and ES1296869 (U); (http://invenes.oepm.es/InvenesWeb/detalle?referencia=U202231980) (accessed on 2 August 2023) and others that are currently under patent review.

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Contributors Conceptualisation: PJM-P. Methodology: PJM-P, RV-C and NG-G. Validation: RV-C and TA-L. Formal analysis: PJM-P, RV-C and NG-G. Investigation: AE-G, TA-L and NG-G. Resources: FE-R. Data curation: AE-G and TA-L. Writing—original draft preparation: PJM-P and AE-G. Writing—review and editing: PJM-P and RV-C. Visualisation: AE-G and TA-L. Supervision: FE-R. Project administration: PJM-P and FE-R. Funding acquisition: PJM-P and FE-R. All authors have read and agreed to the published version of the manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of Universidad Católica San Antonio de Murcia (protocol code CE111908) and is part of the project ref: RTC-2017-6145-1. This study is part of a project registered at www.clinicaltrials.gov (ClinicalTrials.gov Identifier: NCT04958499).

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Data availability statement No data are available.

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ANEXO 12. ESTUDIO 4

healthcare

MDPI

Article

The Effect of Resistance Training with Outdoor Fitness Equipment on the Body Composition, Physical Fitness, and Physical Health of Middle-Aged and Older Adults: A Randomized Controlled Trial

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Abstract: This study examined the effect of outdoor-fitness-equipment-based resistance training on the health parameters of middle-aged and older adults, as well as analyzing the effect of age on the results found. A total of 149 volunteers were randomly assigned to the training (TG) and control (CG) groups. The TG performed two weekly sessions of resistance training for 8 weeks using outdoor fitness equipment, while the CG continued with their regular daily activities. Body composition was measured using DXA, and the maximal isometric voluntary contraction in knee extension, elbow flexion, and hand grip were assessed, along with the 4 m walk test, the Timed Up and Go Test, and the Short Form 36 Health Survey Questionnaire. The TG showed a significant increase in the lean mass index ($p = 0.002$) and maximal isometric voluntary contraction in both legs ($p < 0.001$) and arms ($p < 0.001$), as well as in physical functioning ($p < 0.001$) and the role physical dimension ($p = 0.006$) of the Short Form 36 Health Survey Questionnaire, compared to the CG, which showed a decrease in all these variables. In addition, the TG showed a greater decrease in fat mass ($p < 0.001$), fat mass index ($p = 0.003$), and the Timed Up and Go Test ($p < 0.001$) than the CG. Age conditioned the evolution of most of the variables analyzed ($p < 0.05$). In conclusion, resistance training with outdoor fitness equipment may be useful for improving the health of middle-aged and older adults, although age is a factor that could influence the adaptations found.

Keywords: aging; healthy aging; outdoor gym

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1. Introduction

In an era where the emphasis on health and wellness has gained paramount importance, understanding the profound impact of physical activity on middle-aged and older adults has become increasingly crucial [1]. As age advances, optimizing body composition and enhancing physical fitness are essential components of sustaining an active and fulfilling lifestyle [2].

According to the World Health Organization (WHO), moderate to vigorous physical activity can reduce the likelihood of middle-aged and older people developing chronic diseases such as heart disease, stroke, diabetes, sarcopenia, and certain types of cancer

by approximately 30–40% [1]. Also, physical activity allows older adults to reduce their risk of mobility limitations and decreased quality of life [3]. Moreover, physical activity can attenuate changes in body composition, such as increased body fat and decreased lean muscle mass, which can contribute to a range of health issues, including metabolic disorders and reduced functional capacity [4].

Within the different modalities of physical activity, researchers and fitness experts have turned to progressive resistance training as a potential solution. Maintaining a regular commitment to resistance training regimens stands as a notable element in the aging journey, potentially functioning as both a proactive strategy and a therapeutic choice for a range of musculoskeletal conditions [5]. This form of exercise involves gradually increasing the resistance during workouts, thereby stimulating muscle growth, promoting overall strength, and helping to improve the functional capacity, muscle mass, and quality of life of older adults [6].

The importance of strength training in promoting healthy aging and improving the quality of life of adults and older adults has been widely documented [2]. It has been shown that training at least two days a week at moderate to vigorous intensity can have significant effects on body composition, physical fitness, physical health, and overall physical well-being [7]. Traditionally, strength training in middle and older adults has focused on self-weight bearing or the use of equipment such as resistance bands and on activities guided by monitors and performed mainly in specialized centers or indoor environments [2,8]. However, although these methods have been shown to be effective in improving health and physical function, this approach may present barriers in terms of accessibility and cost, which may limit their widespread adoption [8].

In this sense, public areas are ideal for encouraging physical activity and resistance training, as they encompass both green spaces and structures that are purpose-built to foster physical activity [9]. More specifically, outdoor fitness equipment (OFE) refers to facilities or exercise equipment, adapted from traditional gym configurations, specially designed for outdoor use, which generally use the individual's own body weight for resistance [10,11]. OFE emerges as an innovative and accessible opportunity to integrate strength training into the daily lives of this population [9,12]. These free-to-use facilities, located in public spaces around the world, feature guided machines with clear instructions for use [13]. This allows anyone, regardless of their prior knowledge or experience, to engage in physical activity. In addition, the outdoor and accessible nature of these environments encourages interaction and mutual support among users, enhancing their exercise experience [14,15].

However, despite the growing amount of OFE in parks, studies on its specific effects on the health and well-being of adults and older adults are limited [16,17]. Indeed, a recent narrative review suggests that while OFE may have the potential to improve the health of users, there is a great lack of rigorous experimental studies demonstrating its actual effects in the medium to long term [14]. In line with this, most of the previous research has been based on a small number of machines or on a small sample size or has not focused on health-related variables [16,18]. Moreover, the design of OFE machines, mainly leveraging the user's body weight as unique external charge, raises considerations about their effectiveness in achieving the minimum intensity levels for significant health benefits and long-term training progression [11]. Furthermore, while the potential of OFE to deliver effective fitness solutions deserves exploration, its distinct nature from traditional fitness centers, and in particular its reliance on the user's body weight, warrants a tailored investigation to ascertain its true efficacy.

In view of the above, this current study addresses these gaps. More specifically, the aims were to assess the impact of a resistance training program conducted in OFE on health-related variables, including the body composition, physical fitness, and physical health of middle-aged and older adults, as well as analyzing the effect of age on the results found.

2. Materials and Methods

2.1. Experimental Approach to the Problem

The present study is an 8-week two-armed parallel single-blind randomized controlled trial with blinded examiners, which follows the methodology described in a protocol study already published in a previous research work [19]. The participants were divided equally and randomly between the training group (TG) and the control group (CG). The trial design was registered with ClinicalTrials.gov (identifier: NCT04958499) and followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines and Standard Protocol Items: Recommendations for Interventional Trials statements [20,21].

2.2. Subjects

Participants were recruited on a voluntary basis through informative conferences and advertising in senior centers located in the municipalities surrounding the university facilities in Murcia, Spain. The inclusion criteria were (a) being over 50 years of age; (b) being physically independent; (c) not performing resistance training or physical exercise systematically for at least 1 year before. The exclusion criteria were (a) self-reported substance abuse or dependence disorders; (b) suffering from any type of injury or pathology that prevented the performance of the measurements and/or training; (c) being medically prescribed to take medications that could have influenced physical performance; (d) having undergone surgery that would have prevented performing any of the tests and/or training or posed a risk. Moreover, further exclusion criteria were included for both groups: (a) absence in the post-test evaluations; (b) the initiation of other systematic physical exercise during the study period and for the TG participants specifically; (c) absence from more than 25% of the intervention program sessions. The final sample was composed of 128 middle aged and older adults, of which 28 were middle-aged men (age = 56.57 ± 3.91 years old, max = 64, min = 50; height = 169.17 ± 6.92 cm, max = 181.2, min = 158.1; body mass = 82.70 ± 9.82 kg, max = 106.60, min = 66.70; and BMI = 29.00 ± 3.91 kg/m^2, max = 37.90, min = 22.68); 18 were older adult men (age = 66.61 ± 2.17 years old, max = 72, min = 65; height = 166.28 ± 8.59 cm, max = 174.50, min = 154.70; body mass = 77.96 ± 15.21 kg, max = 127.70, min = 64.10; and BMI = 28.18 ± 5.00 kg/m^2, max = 44.76, min = 24.04); 62 were middle-aged women (age = 54.58 ± 4.82 years old, max = 63, min = 50; height = 157.38 ± 6.25 cm, max = 180.40, min = 148.00; body mass = 63.87 ± 8.90 kg, max = 96.00, min = 45.70; BMI = 25.79 ± 3.23 kg/m^2, max = 33.61, min = 19.17); and 20 were older adult women (age = 68.75 ± 3.61 years old, max = 77, min = 65); height = 153.97 ± 3.98 cm, max = 159.00, min = 146.50; body mass = 67.94 ± 8.63 kg, max = 89.10, min = 55.20; and BMI = 28.72 ± 4.06 kg/m^2, max = 37.83, min = 22.62). Subsequently, the participants were randomized assigned to the TG (n = 64; 29 males and 35 females; age = 60.02 ± 7.25 years old; height = 163.96 ± 9.30 cm; body mass = 75.42 ± 15.06 kg; and BMI = 27.97 ± 4.77 kg/m^2) and CG (n = 64; 17 males and 47 females; age = 57.83 ± 6.92 years old; height = 157.40 ± 6.37 cm; body mass = 65.79 ± 7.50 kg; and BMI = 26.60 ± 2.99 kg/m^2). The CONSORT flow diagram is shown in Figure 1.

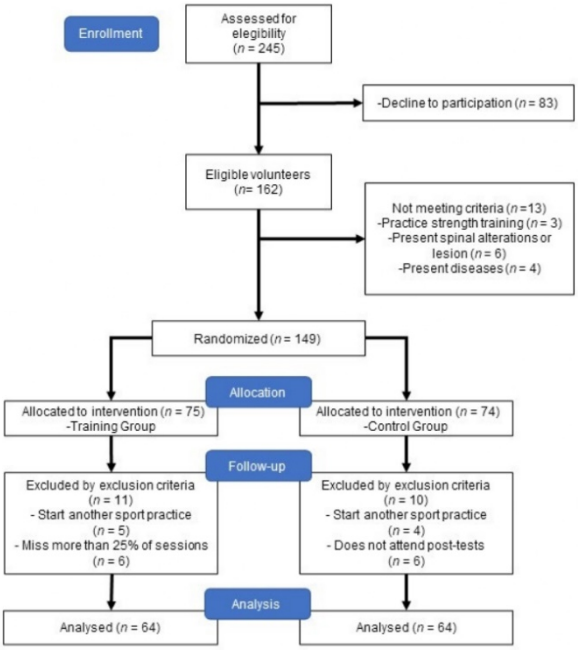


Figure 1. CONSORT flow diagram of participants through each stage of the study.

2.3. Randomization and Blinsding

Following recruitment and selection, the participants were randomized using a computer-generated random number table, ensuring that allocation was undertaken impartially. The chosen ratio for the randomized groups was 1:1. This process ensured that each participant had the same chance of being assigned to either of the two groups, removing any selection bias. Furthermore, a single-blind study design was adopted based on previous studies [22], where the evaluators were blinded and unaware of the group assignments, as well as the individuals' results for previous measurements, which helps to avoid possible biases and improve the objectivity of the study findings.

2.4. Procedures

The TG participants engaged in an 8-week training program utilizing OFE, with two weekly sessions lasting one hour per session on non-consecutive days. The CG participants did not perform any training and were asked to maintain their usual lifestyle [19]. Attendance at the training sessions was monitored daily, with an average rate of 92.75%. Given this high attendance rate, only 6 participants were excluded from the study due to a lack of adherence to the training program.

The intervention program was carried out in an OFE circuit, consisting of 11 exercises performed on eight body weight OFE (Bonny rider, Air Walker, Surfboard, Row, Parallel bars, Gemini, Flyer wheels, and Swing) provided by the company Equipamientos para Entorno Urbano S.L. (Murcia, Spain) (Table 1), located in a private area annexed to the laboratory within the facilities of the Catholic University of Murcia (UCAM) [19].

Table 1. Exercises to be performed in the outdoor fitness equipment circuit.

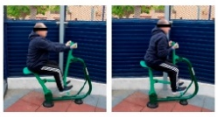
Exercise	Method of Use	Representation
Bonny rider	Using a supine grip, pull the handle with both hands by flexing your elbows and extending your shoulders.	
Shoulder press	On the Gemini machine, grasping the grips at a low height, push the handle by extending your elbows and flexing your shoulders.	
Air Walker	Holding onto the bar and standing on both platforms, perform hip flexion extensions, keeping the trunk perpendicular. Hold briefly and isometrically at the end of the range of motion.	
Tricep dips	On the parallel bars, holding with both hands and starting with your elbows flexed, extend them by overcoming the load of your own weight. Adaptation: triceps push-ups with a prone grip sideways to the machine.	
Shoulder wheel	On the Flyer wheels machine, with your elbows fully extended and grasping the grips, perform circumduction through shoulder mobility.	
Chest press	On the Gemini machine, holding the grips at a middle height, push the handle by extending your elbows and flexing your shoulders.	
Rotator cuff wheel	With the Flyer wheels machine to your side, support your elbow and hold your grip. Perform internal and external rotation.	
Calf raise	On the Swing machine, with your knees extended, rest your metatarsals on the lower edge of the platform. Flex and extend your ankles.	

Table 1. *Cont.*

Exercise	Method of Use	Representation
Surfboard	Standing on the platform and holding onto the handle, perform a pendulum movement from the waist in the frontal plane. Hold briefly and isometrically at the end of the range of motion.	
Leg press	On the Swing machine, while sitting with your feet on the platforms, push through knee extension to overcome the load.	
Row	Sitting on the seat and with your feet in position, pull on the grip by flexing your elbows and externally rotating your shoulders, keeping the trunk perpendicular to the ground.	

The training program was designed and concurrently supervised by two graduates in Sports Science with master's degrees in Strength and Conditioning Training, Healthy Aging, and Physical Activity and Health. Each resistance training session was preceded by a standardized warm-up routine, focused on joint mobility, cardiovascular, and body weight exercises, following a previous protocol [19]. The training protocol utilized is detailed in Table 2, which outlines the progression of the training over the 8 weeks of the intervention in terms of its volume and intensity. The circuit is based on the work time for each exercise and each set (T of work/exe), which indicates the exercise duration for each machine and each set, and the rest time between exercises (T of rest/exe), which denotes the rest interval between machines within the same set. The execution speed measured in seconds for the concentric and eccentric phases is also included (concentric/eccentric), as well as the total number of repetitions participants had time to carry out for each exercise in each set (Reps exe). In addition, the table includes information on the rest pause between sets or circuit rounds (T rest/set), the total duration of the session in minutes (T session), and the total volume of repetitions per session (Total Reps/session). The training load was regulated by the muscle time under tension using a digital metronome to set the execution rhythm of the concentric and eccentric phases for each piece of OFE [23]. This approach ensured that all the repetitions were performed at a controlled and constant speed, with no variations in the execution velocity. To achieve this, the two program supervisors provided individual and continuous feedback to each participant. After each session, a cool-down period was provided, consisting of a series of static active stretches of each of the muscle groups involved in the training [19].

The measurements were performed in a sports science laboratory under standardized conditions. Firstly, the participants completed a sociodemographic questionnaire that was created ad hoc for this study, which included questions about age, gender, physical activity level, illness, and injuries. Furthermore, the dimensions of physical functioning and role physical from the Spanish validated version of the Short Form 36 Health Survey Questionnaire (SF-36) were used to measure health status [24–26]. The participants completed the ad hoc and SF-36 questionnaires anonymously and individually as hard copies. The participants did not receive any additional explanation about the purpose of the questionnaires, other than that contained in the questionnaire itself.

Table 2. Training plan.

Week	Sets	T of Work/Exe (s)	Reps Exe	Concentric/Eccentric (Repetition/s)	T Rest/Exe (s)	T Rest/Set (min)	T Session (min)	Total Reps/Session
1	1	30	15	1/1	45	-	13.75	165
2	2	30	15	1/1	30	2	27	330
3	3	30	15	1/1	30	4	43	495
4	3	30	15	1/1	30	4	43	495
5	3	45	15	1/2	30	4	51.25	495
6	3	45	15	1/2	30	4	51.25	495
7	3	45	11	2/2	30	4	51.25	371
8	3	45	11	2/2	30	4	51.25	371

Exe: exercise; Reps: repetitions; T: time.

After completing the questionnaires, body mass and height were measured according to the protocol from the International Society for the Advancement of Anthropometry (ISAK) [27], performed by an ISAK Level 1 accredited anthropometrist and in accordance with previous studies [19]. Subsequently, body composition was determined using dual-energy X-ray absorptiometry (DXA) following the protocol used previously [19,28], which was used for the measurement of fat mass (kg), fat mass index (kg/m^2), lean mass (kg), and lean mass index (kg/m^2).

This was followed by a warm-up similar to that of the training sessions, as previously described [29]. After this, a maximum voluntary isometric contraction (MVIC) leg extension test, a MVIC elbow flexion test, a 4 m gait walk, and a Timed Up and Go test (TUG) were performed in a randomized order, following a previous protocol [19]. Before starting the MVIC tests, familiarization was performed, after which a 5 min rest period was allowed before two non-consecutive maximal attempts were performed, with 2 min of rest between tests. The maximum peak force in Newtons (N) between the two attempts of each test was recorded for the MVIC test, and the best time was registered for the 4 m and TUG tests.

2.5. Statistical Analyses

Based on previous studies, groups larger than 30 were required for the results to reliably characterize precision errors or changes during clinical monitoring [30]. A dropout rate of 16% was assumed based on previous studies [31], so a minimum of 35 participants had to be included per group. The RStudio 3.15.0 (Rstudio Inc., Boston, MA, USA) software was used for calculation of the sample size. The sample size and statistical power were established considering the standard deviation (167.46 N) in the maximum voluntary isometric contraction (MVIC) leg extension test [32]. A significance power of 95% ($1-\beta = 0.95$) and a significance level of 0.05 were considered. Ultimately, the sample consisted of 64 participants, resulting in an assumed error of 41.02 N. Due to the use of a convenience sampling method, a significantly larger sample than required was utilized since the recruitment of participants was conducted across several senior centers and many individuals enrolled together. This approach ensured a sufficient sample size in case of low adherence to the program, improving the generalizability and reliability of the results.

After analyzing the normality of the variables using the Kolmogorov–Smirnov test, as well as kurtosis, skewness, and variance, two-way ANOVAs with one-way repeated measures were carried out to analyze the inter- and intra-group differences. A two-way ANCOVA with one-way repeated measures was also performed to determine the influence of the covariate of age on the results obtained on the study variables. Partial eta squared (η^2) was used to calculate the effect size and was defined as small: ES $\geq$ 0.10; moderate: ES $\geq$ 0.30; large: $\geq$1.2; or very large: ES $\geq$ 2.0, with an error of $p < 0.05$ [33]. A value of $p < 0.05$ was set to determine the statistical significance. The statistical analysis was performed using the SPSS statistical package (v. 25.0; SPSS Inc., Chicago, IL, USA).

3. Results

Prior to the beginning of this study, all the participants were inactive and had not undergone systematic resistance training in the last year, thus fulfilling the established inclusion and exclusion criteria. The sample included 9 individuals with controlled high blood pressure, 11 with controlled cholesterol levels, 2 with controlled diabetes, 8 with lumbar discomfort, 3 with asthma, and 4 with osteoporosis. These conditions were thoroughly reviewed by healthcare professionals and were determined to meet the inclusion criteria, as they were controlled and did not interfere with the participants' ability to engage in the study's activities or measurements. This allowed us to proceed with the training and measurements in a normal manner.

Table 3 shows the pre- and post-intervention differences in body composition, physical fitness, and physical health of the groups. In terms of the body composition variables, the TG showed a significant decrease in fat mass ($p < 0.001$, ES = 0.257) and the fat mass index ($p < 0.001$, ES = 0.221) and a significant increase in the lean mass index ($p = 0.045$, ES = 0.044). In contrast, the CG showed a significant decrease in lean mass ($p = 0.024$, ES = 0.012) and the lean mass index ($p = 0.008$, ES = 0.037) with a small effect size on all these variables. In terms of the physical fitness variables, the TG showed a significant increase in MVIC in both legs ($p < 0.001$) with a moderate effect size (ES = 0.207 for the right, ES = 0.154 for the left) and MVIC in the arms ($p < 0.001$, ES = 0.521) with a large effect size; the TUG test ($p < 0.001$, ES = 0.393) indicated a large effect size; and the 4 m gait walk ($p = 0.006$, ES = 0.057) showed a small effect size, whereas the CG showed a significant decrease in MVIC of the left leg ($p = 0.019$, ES = 0.051) and MVIC of the arms ($p < 0.001$, ES = 0.073), both with a small effect size, and a significant increase in the TUG test ($p < 0.001$, ES = 0.102) with a moderate effect size. As for the physical health results according to the SF-36 scores, the CG showed a significant decrease in the physical functioning and role physical dimensions.

Table 3. Intra-group changes in body composition, physical fitness, and physical health variables.

					Unadjusted			Adjusted by Age		
Variable	**Group**	**Pre-Intervention (X ± SD)**	**Post-Intervention (X ± SD)**	**Mean Dif.**	**95% CI**	***p*-Value**	***ES***	**95% CI**	***p*-Value**	***ES***
Fat mass (kg)	TG	29.37 ± 8.35	28.47 ± 8.00	0.904 ± 1.297	0.577; 1.231	<0.001	0.257	0.645; 1.193	<0.001	0.263
	CG	26.51 ± 4.84	26.36 ± 4.83	0.144 ± 0.841	−0.066; 0.035	0.175	0.009	−0.141; 0.401	0.347	0.007
Fat mass index (kg/m^2)	TG	10.99 ± 3.32	10.71 ± 3.22	0.283 ± 0.408	0.181; 0.386	<0.001	0.221	0.195; 0.384	<0.001	0.230
	CG	10.80 ± 2.27	10.72 ± 2.24	0.080 ± 0.345	−0.006; 0.166	0.067	0.023	−0.020; 0.168	0.120	0.019
Lean mass (kg)	TG	44.15 ± 9.94	44.33 ± 9.58	−0.183 ± 1.859	−0.652; 0.285	0.437	0.008	−0.542; 0.170	0.304	0.009
	CG	37.61 ± 5.83	37.39 ± 6.23	0.219 ± 0.758	0.030; 0.408	0.024	0.012	−0.131; 0.575	0.217	0.012
Lean mass index (kg/m^2)	TG	15.42 ± 2.27	15.53 ± 2.20	−0.114 ± 0.443	−0.226; −0.003	0.045	0.044	−0.207; −0.017	0.022	0.042
	CG	14.36 ± 1.75	14.26 ± 1.88	0.103 ± 0.301	0.028; 0.178	0.008	0.037	0.006; 0.195	0.037	0.035
MVIC right leg (N)	TG	384.16 ± 127.56	419.15 ± 135.30	−34.993 ± 48.745	−47.169; −22.816	<0.001	0.207	−45.993; −21.876	<0.001	0.199
	CG	314.27 ± 128.63	311.01 ± 116.87	3.263 ± 48.742	−8.912; 15.439	0.594	0.002	−9.854; 14.264	0.718	0.001

Table 3. *Cont.*

					Unadjusted			Adjusted by Age		
Variable	**Group**	**Pre-Intervention (X ± SD)**	**Post-Intervention (X ± SD)**	**Mean Dif.**	**95% CI**	***p*-Value**	***ES***	**95% CI**	***p*-Value**	***ES***
MVIC left leg (N)	TG	381.98 ± 132.50	422.16 ± 139.64	−40.174 ± 61.150	−55.449; −24.899	<0.001	0.154	−55.807; −22.394	<0.001	0.146
	CG	328.74 ± 126.68	306.80 ± 118.25	21.937 ± 72.785	3.756; 40.118	0.019	0.051	4.157; 37.571	0.015	0.047
MVIC arms (N)	TG	252.69 ± 99.42	306.19 ± 109.47	−53.499 ± 44.576	7.848; 20.801	<0.001	0.521	−63.370; −45.254	<0.001	0.532
	CG	226.31 ± 72.41	211.98 ± 85.46	14.325 ± 25.929	−64.726; −42.273	<0.001	0.073	6.139; 24.111	0.001	0.082
TUG (s)	TG	5.33 ± 1.04	4.65 ± 0.89	0.683 ± 0.695	0.509; 0.857	<0.001	0.393	0.533; 0.835	<0.001	0.391
	CG	5.68 ± 1.06	5.39 ± 1.09	0.291 ± 0.497	0.166; 0.415	<0.001	0.105	0.139; 0.441	<0.001	0.104
4 m gait walk (s)	TG	1.97 ± 0.40	1.89 ± 0.36	0.086 ± 0.242	0.025; 0.146	0.006	0.057	0.015; 0.135	0.014	0.047
	CG	2.07 ± 0.42	2.06 ± 0.34	0.011 ± 0.256	−0.053; 0.075	0.723	0.001	−0.038; 0.082	0.472	0.004
PH physical functioning	TG	88.75 ± 12.05	90.47 ± 11.08	−1.719 ± 7.083	−3.488; 0.051	0.057	0.011	−4.787; 1.042	0.206	0.013
	CG	90.08 ± 12.23	84.53 ± 14.60	5.547 ± 14.963	1.809; 9.285	0.004	0.102	2.786; 8.615	<0.001	0.107
PH role physical	TG	88.28 ± 23.97	94.53 ± 19.14	−6.250 ± 30.861	−13.959; 1.459	0.110	0.016	−16.163; 0.534	0.066	0.027
	CG	88.28 ± 27.08	77.34 ± 34.13	10.938 ± 38.544	1.310; 20.565	0.027	0.047	4.154; 20.850	0.004	0.066

TG: training group; CG: control group; MVIC: maximum voluntary isometric contraction; TUG: Timed Up and Go test; PH: physical health.

The age-adjusted analysis revealed significant changes in the TG for fat mass ($p < 0.001$, ES = 0.263), the fat mass index ($p < 0.001$, ES = 0.230), and the lean mass index ($p = 0.022$, ES = 0.042), all showing a small effect size; for MVIC for both the right ($p < 0.001$, ES = 0.199) and left legs ($p < 0.001$, ES = 0.146), with a small effect size; for MVIC in the arms ($p < 0.001$, ES = 0.532), with a large effect size; for the TUG test ($p < 0.001$; ES = 0.391), with a moderate effect size; and for the 4 m gait walk ($p = 0.014$, ES = 0.047), with a small effect size. Age also influenced the within-group changes in the CG in the variables of the lean mass index ($p = 0.037$, ES = 0.035), MVIC left leg ($p = 0.015$, ES = 0.047), MVIC arms ($p = 0.001$, ES = 0.082), the TUG test ($p < 0.001$, ES = 0.104), PH physical functioning ($p < 0.001$, ES = 0.107), and PH role physical ($p = 0.004$, ES = 0.066), all with small effect sizes.

Table 4 compares the changes observed before and after the intervention between the TG and the CG. The pre-post change showed in the TG was significant compared to the pre-post change in the CG in the lean mass index, with a small effect size ($p = 0.002$, ES = 0.077); fat mass ($p < 0.001$, ES = 0.109) and the fat mass index ($p = 0.003$, ES = 0.069), both with small effect sizes; MVIC for both the legs and arms, with small effect sizes for the legs ($p < 0.001$, ES = 0.135 for the right leg and $p < 0.001$, ES = 0.178 for the left leg) and a moderate effect size for the arms ($p < 0.001$, ES = 0.469); the TUG test, with a small effect size ($p < 0.001$, ES = 0.097); as well as in the physical functioning ($p < 0.001$, ES = 0.089) and role physical dimensions ($p = 0.006$, ES = 0.058), both with small effect sizes. Age had a significant influence on the inter-group differences in the pre-post change for all the analyzed variables ($p < 0.001$–0.002; ES = 0.073–0.481), except for lean mass ($p = 0.115$, ES = 0.020) and the 4 m gait walk test ($p = 0.219$, ES = 0.012).

Table 4. Inter-group differences in the pre-post change in body composition, physical fitness, and physical health variables.

			Unadjusted			Adjusted by Age		
Variable	**Group**	**Mean Dif.**	***p*-Value**	***F*/*Z***	***ES***	***p*-Value**	***F*/*Z***	***ES***
Fat mass (kg)	TG CG	−0.759	<0.001	15.368	0.109	<0.001	16.055	0.115
Fat mass index (kg/m^2)	TG CG	−0.203	0.003	9.204	0.069	0.002	9.999	0.075
Lean mass (kg)	TG CG	0.402	0.112	2.561	0.020	0.115	2.514	0.020
Lean mass index (kg/m^2)	TG CG	0.217	0.002	10.481	0.077	0.002	9.662	0.073
MVIC right leg (N)	TG CG	38.256	<0.001	19.711	0.135	<0.001	17.341	0.124
MVIC left leg (N)	TG CG	62.111	<0.001	27.321	0.178	<0.001	24.454	0.166
MVIC arms (N)	TG CG	67.824	<0.001	110.269	0.469	<0.001	113.947	0.481
TUG (s)	TG CG	−0.392	<0.001	13.486	0.097	<0.001	14.288	0.104
4 m gait walk (s)	TG CG	−0.074	0.094	2.846	0.022	0.219	1.528	0.012
PH physical functioning	TG CG	7.266	0.001	12.327	0.089	<0.001	12.570	0.093
PH role physical	TG CG	17.188	0.006	7.755	0.058	0.002	10.423	0.078

TG: training group; CG: control group; MVIC: maximum voluntary isometric contraction; TUG: Timed Up and Go test; PH: physical health.

4. Discussion

The main aim of the present study was to analyze the effect of resistance training with OFE on health-related variables in middle-aged and older adults. The present investigation showed a significant increase in lean mass and a decrease in fat mass in the group that received resistance training with OFE, while the CG showed a decrease in lean mass and no change in fat mass. Only two studies have applied intervention programs with OFE, both in older adults. One of them applied an intervention program that included seven types of OFE (two cardiovascular training, two strength, two mobility, and two balance machines), three sets, 8–12 repetitions, and 12 weeks of training [16], while the other study applied a 6-week program that included five types of OFE (three strength and two cardiovascular training machines), three sets, and 12–15 repetitions [18]. The study by Chow [16] showed no changes in the body composition variables, but as the study did not include a control group, no comparisons could be made with it. The results found in the present study may be due to the fact that it included middle-aged adults and not only older adults. Some research has shown different effects according to age, with significant changes observed in the body composition of middle-aged adults, while older adults did not show significant changes in body composition [34], or a larger effect size in middle-aged adults than in older adults [35], suggesting that OFE training may improve body composition in middle-aged adults and slow age-associated changes in body composition in older adults.

In addition, the difference between the results could also be due to the different prescribed volumes of the programs. Both Chow's [16] study and Kim's [18] study included a much lower number of strength exercises (2–3, respectively, vs. 11 exercises in the present

study). Research studies on resistance training usually utilize at least six exercises [36], and a minimum dose has been identified as necessary to produce adaptations, ranging from low-volume and high-intensity to high-volume and low-intensity. However, resistance training with OFE is considered to be low- to moderate-intensity resistance training [11], and it is therefore considered necessary to utilize a sufficient volume in order to achieve body adaptations [14]. More research is needed to determine what the minimum volume of OFE training should be to produce adaptations.

Most of the research examining the effect of resistance training programs on body composition has been focused on middle-aged adults [36], older adults [37], overweight and obese people [35], people with sarcopenia [6], people with sarcopenia and obesity [38], or postmenopausal women [34]. Although all of them have shown improvements in most of the variables related to body composition, some of them do not show improvements in lean mass [6]. This could be due to the dose applied in resistance training.

Another objective of the present study was to analyze the effect of resistance training with OFE on the physical fitness of middle-aged and older adults. Improvements were observed in upper and lower limb strength, as well as in the Timed Up and Go test and gait speed. Resistance training programs have shown improvements in muscle strength and muscle function [6] or show a trend towards improvement, as well as improvements in strength and muscle performance [6]. In this sense, this shows that neural mechanisms and muscle innervation, such as adaptations in activation, timing, and rhythm coding, and not muscle hypertrophy, are the most likely reasons for the increase in muscle strength, mainly in beginners during the first 8 weeks [39]. It has been reported that improvements in muscle performance are mainly associated with an increase in muscle strength rather than muscle mass after resistance training. In this sense, resistance training with OFE could be of added benefit to resistance training using other machines or other equipment given the reports of an improvement not only in muscle strength and function but also an increase in muscle mass in the first 8 weeks [40].

Resistance training has been shown to change skeletal muscle properties, leading to an increase in lean body mass and a reduction in exercise-induced oxidative stress [41]. The main reason for the increase in lean mass is the increase in muscle mass, which may be due to intramuscular anabolic signaling, the maximization of the response of muscle fiber recruitment, the time under tension, or the metabolic stress [42]. Some research indicates that there seems to be evidence that moderate–high loads (>60% 1RM) and lower–moderate volumes (<12 repetitions) produce a better response in muscle mass, although in both cases (moderate–high vs. low loads), adaptations have been observed [6]. A repetition continuum or strength–endurance continuum proposes that the adaptations produced will depend on the number of repetitions and the intensity of the load [43]. However, it appears that muscle mass improvements can be achieved with loads greater than 30% 1RM, indicating that there is no ideal zone from a practical point of view [44]. In contrast, in relation to the effect on fat mass, there seems to be more evidence about the need for low to moderate intensity and high volumes [35]. A possible explanation could be the relationship between lipolysis with low intensity training and some volume because the optimal intensity for fat oxidation has been described as around 60% [45]. In this sense, it has been described how resistance training programs of low–moderate intensity and moderate–high volume are the most suitable when the objective is both to reduce fat mass and increase muscle mass without changes in body mass [36]. The present program utilizes between 12 and 15 repetitions, and it is therefore considered moderate-intensity, as well as optimal training for both a muscle mass increase and fat mass reduction.

In relation to the concept "strength–endurance continuum", it is considered that the adaptations produced by light load protocols are specific to endurance muscle adaptations and that the ability to improve maximal strength is minimal [43]. This may be because studies that have used 1RM testing do support the repetition continuum with respect to muscle strength in dynamic constant resistance exercise, and studies that used a device to

assess isometric strength showed no difference, which may be due to the specificity of the test with respect to training [44].

Both previous studies discussed and the present research have shown improvements in strength using moderate loads [6,37,38]. Early adaptations to strength training in strength improvement occur through motor learning and neural enhancement, and it is possible for any load to influence strength. However, maximizing the strength-related results requires heavier loads for experienced individuals [46]. In this sense, the effect of OFE should also be investigated in experienced individuals.

OFE resistance training involves moderate intensities and a number of repetitions. These intensities are interesting for the sedentary population, because, as described, they produce improvements in body composition, strength, and muscle function. Furthermore, it seems reasonable to prescribe moderate loads given that training with light loads involves performing many repetitions, increases the training time, and produces high levels of metabolic acidosis, which tends to cause discomfort, affecting adherence. On the other hand, the minimum dose approach to resistance training minimizes the barriers to physical activity practice, favoring adherence and reducing negative affective responses, such as increased discomfort and reduced satisfaction [17].

Another aim of the present study was to analyze the effect of resistance training with OFE on the physical health and quality of life of middle-aged and older adults. Previous meta-analyses have reported improvements in quality of life, specifically in the physical domains, after resistance training [47]. These quality of life domains have been influenced by aspects such as disability, diseases, and socioeconomic status; thus, these domains decrease with age [48]. In this sense, the present research showed no changes in physical functioning, although improvements were observed in the role physical dimension. At the same time, a decline was observed in the group that did not train (CG). This could be due to the fact that in our study, the volunteers were relatively healthy and had high values in these domains. Previous research has indicated that quality of life improved with training in older adults with various chronic conditions as compared to healthy controls [3] and those with low quality of life values prior to the intervention [40].

Likewise, improvements or decreases in deterioration could be related to improvements in muscle mass, strength, and muscle function, as well as an improvement in energy and the ability to perform the activities of daily living [49]. Therefore, the present research suggests that training with OFE could prevent a decline in these domains of quality of life in healthy middle-aged and older age adults.

Another important objective of the present study was to analyze the influence of age on the findings of the present research. It was found that age had a significant influence on the intergroup changes for almost all the variables analyzed, as well as on the differences found when comparing the changes in the TG and CG for most of the variables analyzed. Previous research has suggested that age may influence body composition, showing an increase in fat mass and a decrease in muscle mass with increasing age [50,51], which may be related to the appearance of numerous chronic diseases [52]. Other research has found that strength, resistance, and power decrease during the aging period [53], which could result in reduced functionality, autonomy, and quality of life [54,55]. Moreover, investigations reveal that as individuals age, there is a decline in both speed and agility [56,57], factors also associated with functionality and autonomy [58,59]. Indeed, the combination of losses of muscle mass, strength, and physical fitness that occur during the aging period has been referred to as sarcopenia [60], being a pathology that affects between 10 and 16% of older people [61]. Therefore, it is not surprising that the covariate of age showed a significant influence on the evolution of these variables of body composition and physical condition, including other more subjective variables, such as the participant's perception of their physical functioning and role physical dimensions. In fact, previous research has shown that the effects of a circuit strength training program on body composition and fitness may be different depending on whether it is performed by middle-aged adults [62] or older people [63]. Therefore, although it can be indicated that this type of program is effective

in both age groups, future research is needed to analyze the specific adaptations of the training to each age group.

The strength of the present study is its pioneering nature in demonstrating that an outdoor training circuit with OFE, consisting of 11 exercises performed on eight types of OFE, can induce adaptations in health-related variables (body composition, physical fitness, and physical health) in middle-aged and older adults, despite relying on the principle of body weight resistance. This finding is significant given that it enhances and expands the range of tools available for improving health and physical function in middle-aged and older adults, offering an accessible alternative that overcomes the traditional barriers associated with strength training, such as the need for expensive equipment or indoor facilities. Leveraging OFE placed in public spaces, this study not only highlights the possibility of effectively incorporating strength training into the lifestyle of this population group but also emphasizes the importance of inclusive and easily accessible training facilities that encourage the adoption of an active and healthy lifestyle.

While this study provides valuable insights, there are areas for further exploration that could enhance our understanding. One such area is the short duration of the intervention. Although improvements in some parameters were observed, it is conceivable that longer intervention durations could have had a greater impact on the results. Future studies must carry out interventions of longer durations to be able to provide long-term results. Another limitation could be the contaminating variable of nutrition. Nutrition was not monitored, and the volunteers were only given guidelines to maintain their nutritional habits. A further limitation concerns the quantification of the training load, which was performed using time under tension instead of traditional sets and repetitions since OFE does not allow for load adjustments. In addition, the lack of inclusion of a third group using traditional resistance training in the gym could be considered a limitation, as it would have been interesting to directly compare the effects of OFE training with conventional strength training methods. This approach could make it difficult to compare the results obtained with other studies that use different methods to quantify the training load. Another limitation was that the low number of participants prevented the separation of the TG and CG data between middle-aged and older adults. Given that the present research has found that age may influence the evolution of health-related variables in both TG and CG, this is an issue to be addressed in future studies. Furthermore, some of the participants had chronic illnesses or injuries, but the number of participants was not sufficient to analyze the influence of this issue on the evolution of the intervention. Future studies should aim to include a larger cohort of individuals with these medical backgrounds to facilitate a more comprehensive examination of the effects of training in these specific populations. Finally, attention must be paid to the limitation of the study regarding the replication of the equipment setup. It is important to note that if training is not conducted with the machines or training program used in this study, the results may not be extrapolatable. Finally, a possible limitation of the study is the small number of participants with pathologies or injuries, which precluded a detailed analysis of the effects of these conditions on the study variables due to their low incidence.

5. Conclusions

The present study found that resistance training with OFE twice a week for 8 weeks, despite only allowing self-loading, led to significant improvements in body composition, physical fitness, health, and quality of life among middle-aged and older adults compared to a control group that continued with their usual daily activities. The age of the participants influenced the evolution of the variables analyzed. The significant improvements observed through the use of OFE, based on the principle of body weight resistance, highlight an opportunity in the areas of clinical practice, public health, and physical fitness. This approach removes traditional barriers to resistance training, such as the costs of equipment and the need for indoor spaces, thereby democratizing health and fitness benefits. The detailed training program provided within this article ensures direct practical applicability

and marks a fundamental breakthrough, promising a more inclusive future in health promotion and disease prevention strategies, making health improvements accessible to a wider population.

6. Patents

The results of this study were taken into consideration for the design of new OFE that will be more effective and safer, with the following registered patents: Publication n° ES1296848 (U) (http://invenes.oepm.es/InvenesWeb/detalle?referencia=U202231979) and ES1296869 (U) (http://invenes.oepm.es/InvenesWeb/detalle?referencia=U202231980) (accessed on 2 August 2023), as well as others that are currently under patent review.

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Institutional Review Board Statement: The research was conducted in accordance with the Declaration of Helsinki. Approval was obtained from the Ethics Committee of the Universidad Católica San Antonio de Murcia (Ethical Application Ref: CE111908) before the start of the project. All the participants were informed about the evidence for the study and voluntarily signed an informed consent form prior to the measurements and intervention.

Informed Consent Statement: Informed consent was obtained from all the subjects involved in the study.

Data Availability Statement: The data presented in this study is available on request from the corresponding author. The data are not publicly available due to is personal health information.

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