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Análise de marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosos submetidos ao Taekwondo

Rio de Janeiro
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Dissertação apresentada, como requisito parcial para obtenção do título de Mestre, ao Programa de Pós- Graduação em Ciências do Exercício e do Esporte, da Universidade do Estado do Rio de Janeiro. Área de concentração: Aspectos Biopsicossociais do Esporte

Orientador: Prof. Dr. Rodrigo Gomes de Souza Vale

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DEDICATÓRIA

Dedico ao meu orientador Rodrigo Vale, ao grupo Labees- Uerj, em especial aos amigos Luciano Lima dos Santos, Juliana Brandão Pinto de Castro, Andressa Oliveira Barros dos Santos e Lilliany de Souza Cordeiro.

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À Universidade do Estado do Rio de Janeiro, especialmente ao Programa de Pós-Graduação em Ciências do Exercício e do Esporte.

RESUMO

LINHARES, Diego Gama. *Análise de marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosos submetidos ao Taekwondo*. 2023. 76 f. Dissertação (Mestrado em Ciências do Exercício e do Esporte) – Instituto de Educação Física e Desportos, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2023.

A população mundial aumenta significativamente, processos degenerativos da função física, cognitiva e problemas de saúde tendem a aumentar concomitantemente com o envelhecimento e cuidados com essa população são necessários. É importante ressaltar que os maiores níveis de atividade física estão associados a diminuição de morbidade cardiovascular e mortalidade e impactam sobre um envelhecimento senescente. Dentre as diferentes variações de atividades físicas, o taekwondo e muitos outros esportes de lutas vêm se popularizando nas últimas décadas com um crescente número de participantes. **Objetivo:** Este documento refere-se a pesquisa por meio da aplicação de ações metodológicas distintas. A primeira se refere a realização de uma revisão sistemática para analisar os efeitos do taekwondo na saúde física e mental em idosos. A segunda se refere a uma revisão sistemática e metanálise com a finalidade de analisar os efeitos do treinamento físico multicomponente na saúde de mulheres idosas com osteoporose. Na terceira ação foi desenvolvida uma revisão sistemática para verificar os efeitos das artes marciais em variáveis físicas em idosos. Na quarta ação foi realizada uma revisão sistemática e metanálise para analisar os efeitos dos esportes de combate na aptidão física para atividades da vida diária de idosos submetidos a esportes de combate: revisão sistemática e metanálise de ensaios clínicos randomizados. E por último, a quinta ação, foi realizado um ensaio clínico randomizado para investigar os efeitos do taekwondo sobre marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosos submetidos a 12 semanas de treinamento. **Métodos:** Trata-se de uma pesquisa experimental com desenho para dois grupos que foram avaliados pré e pós período de intervenção. A amostra foi composta por mulheres idosas inexperientes com a prática do taekwondo, moradores da cidade de Campos dos Goytacazes -RJ. Foram aplicados os instrumentos de avaliação da autoestima, da autoimagem, avaliações antropométricas, testes de força muscular, autonomia funcional, coletas sanguíneas dos grupos experimental e controle para análise dos marcardores fisiológicos: fosfatase alcalina, vitamina B12, fósforo sérico, Vitamina D e PTH e o exame de densidade mineral óssea. Em seguida os participantes realizaram 12 semanas de intervenção específica para cada grupo e por último uma nova coleta de dados de todas as variáveis do estudo. **Resultados:** Houve melhora ($p<0,05$) da autoestima na comparação intergrupo e intragrupo. Para avaliar a força muscular, os testes de flexão de cotovelo e, sentar e levantar foram utilizados e apresentaram aumentos ($p<0,05$) da força muscular no no GE e na comparação intergrupos (pós-teste) em ambos os testes. Na avaliação da autoestima foram encontradas melhoras ($p<0,05$) nos GE e GC na comparação intragrupo e intergrupo indicando aumentos da autoestima. Na autonomia funcional, foi utilizado o protocolo GDLAM, houve aumento ($p<0,05$) no GE na avaliação intragrupo. Na avaliação dos biomarcadores ósseos foram encontradas diferenças ($p<0,05$) em todas as variáveis analisadas na comparação intragrupo (pré *vs.* pós) no GE. **Conclusão:** Os resultados encontrados neste estudo experimental apoiam a eficácia do taekwondo nos marcadores fisiologicos de remodelagem óssea, na força muscular, na autonomia funcional e na autoimagem de idosos.

Palavras-chave**:** Idosos. Taekwondo. Remodelagem óssea. Atividades da vida diária.

ABSTRACT

LINHARES, Diego Gama. *Analysis of physiological markers of bone remodeling, muscle strength, functional autonomy, self-esteem and self-image in elderly people undergoing Taekwondo*. 2023. 76 f. Dissertação (Mestrado em Ciências do Exercício e do Esporte) – Instituto de Educação Física e Desportos, Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 2023.

The world population increases significantly, degenerative processes of physical and cognitive function and health problems tend to increase concomitantly with aging and care for this population is necessary. It is important to emphasize that higher levels of physical activity are associated with a decrease in cardiovascular morbidity and mortality and have an impact on senescent aging. Among the different variations of physical activities, taekwondo and many other fighting sports have become popular in recent decades with a growing number of participants. Objective: This document refers to research through the application of different methodological actions. The first refers to carrying out a systematic review to analyze the effects of taekwondo on physical and mental health in the elderly. The second refers to a systematic review and meta-analysis with the aim of analyzing the effects of multicomponent physical training on the health of elderly women with osteoporosis. In the third action, a systematic review was developed to verify the effects of martial arts on physical variables in the elderly. In the fourth action, a systematic review and meta-analysis was carried out to analyze the effects of combat sports on physical fitness for activities of daily living of elderly people undergoing combat sports: systematic review and meta-analysis of randomized clinical trials. And finally, the fifth action, a randomized clinical trial was carried out to investigate the effects of taekwondo on physiological markers of bone remodeling, muscle strength, functional autonomy, self-esteem and self-image in elderly people submitted to 12 weeks of training. **Methods:** This is an experimental study designed for two groups that were evaluated pre and post intervention period. The sample consisted of elderly women inexperienced with the practice of taekwondo, residents of the city of Campos dos Goytacazes -RJ. Instruments for assessing self-esteem, self-image, anthropometric assessments, muscle strength tests, functional autonomy, blood samples from the experimental and control groups were applied for the analysis of physiological markers: alkaline phosphatase, vitamin B12, serum phosphorus, Vitamin D and PTH and the bone mineral density test. Then, the participants performed 12 weeks of specific intervention for each group and, finally, a new data collection of all study variables. **Results:** There was an improvement ($p<0.05$) in self-esteem in the intergroup and intragroup comparison. To assess muscle strength, the elbow flexion and sit and stand tests were used and showed increases ($p<0.05$) in muscle strength in the EG and in the intergroup comparison (post-test) in both tests. In the assessment of self-esteem, improvements ($p<0.05$) were found in the EG and CG in the intragroup and intergroup comparison, indicating increases in self-esteem. In functional autonomy, the GDLAM protocol was used, there was an increase ($p<0.05$) in EG in the intragroup evaluation. In the evaluation of bone biomarkers, differences ($p<0.05$) were found in all variables analyzed in the intragroup comparison (pre vs. post) in the EG. **Conclusion:** The results found in this experimental study support the effectiveness of taekwondo on physiological markers of bone remodeling, muscle strength, functional autonomy and self-image of the elderly.

Keywords: Older. Taekwondo. Bone remodeling. Activities of daily living.

SUMÁRIO

INTRODUÇÃO

A Organização Mundial de Saúde (OMS) alerta que, em 2020, a população de pessoas com mais de 65 anos represente 20% da população mundial, sendo a maior parte em paises desenvolvidos. O envelhecimento populacional é multifatorial e inclui saúde, vida social, aposentadoria, prestação de cuidados e primcipalmente associado a carga de doenças crônicas não transmissíveis. Em torno de 20-30 anos de idade os individuos atingem o ápice de desenvolvimento. A partir daí inicia-se o processo de envelhecimento de maneira heterogênea. Esse processo levará até seis ou sete décadas terminando em morte (IZQUIERDO et al., 2021).

Com o envelhecimento, efeitos deletérios podem surgir, dentre eles, as doenças cardiovasculares (doenças arteriais coronarianas), esqueléticas (artrite e osteoporose) e mentais (ansiedade e depressão) (KAZEMINIA et al., 2020). Além disso, a diminuição na capacidade funcional e de recuperação dos sistemas do corpo são caraterísticas do envelhecimento biológico levando ao processo de homeostenose, processo degenerativo continuo do sistema imunológico (EL-KADER et al., 2018; KHAN et al., 2017).

Adicionalmente, o processo de envelhecimento leva a mudanças significativas na composição corporal, aumento da gordura abdominal e redução da massa corporal magra, processo conhecido como sarcopenia. Esta associa-se ao alto risco de quedas e fraturas, diminuição da mobilidade e maior números de internações (COSTA RIELA et al., 2021).

Dessa forma, no envelhecimento, a perda da massa óssea (osteoporose) e muscular dificulta a manutenção da autonomia funcional voltada para o desempenho das atividades da vida diária (AVD). A osteoporose é uma patologia que preocupa a saúde pública devido os riscos de quedas e, consequentemente, fraturas. Alterações nas ações osteoblásticas e osteoclásticas são constantes e biomarcadores ósseos podem identificar essas possíveis alterações (CURTIS et al., 2015; RADUT et al., 2019).

Outros biomarcadores ósseos podem mapear a condição óssea. A deficiência da vitamina B12 aumenta o estresse oxidativo e consequentemente processos inflamatórios. O fósforo sérico, o hormônio da paratireóide e a vitamina D indicam possíveis patologias nos rins, ossos e sistema digestivo. Já a fosfatase alcalina pode mostrar possíveis danos ao metabolismo ósseo (ANTONIAK; GREIG, 2017; HUEMER; BAUMGARTNER, 2019; SUKI; MOORE, 2016; MILIONI et al., 2014).

Outro fator que afeta a qualidade de vida do idoso é o sedentarismo, que foi

classificado na Europa Ocidental como a quinta principal causa de carga de doença e um dos principais fatores de risco para doenças não transmissíveis. Entretanto, a frequência, a intensidade, o tipo e tempo de atividade física são fatores bem variados, porém, é importante relatar que o exercício físico pode reduzir os efeitos fisiológicos da senescência (LÓPEZ-TORRES et al., 2019).

A falta de atividade fisica interfere negativamente na autoestima, na autoimagem, na coordenação e na vivência motora. A autoestima baixa tem relação com saúde mental prejudicada e respostas mal-adaptativas em situações de dificuldades e estresse. A idade e capacidade física são autoavaliadas, determinando a capacidade de realização de movimentos corporais do próprio indivíduo. Nesse sentido, o treinamento físico aumenta a força muscular e melhora a autoimagem e autoestima em idosos (TYLKA; WOOD-BARCALOW,2015; WEBB; WOOD-BARCALOW;TYLKA, 2015; WAGAN et al., 2021).

A atividade física regular reduz o declinio e mantém ou aumenta a autonomia funcional e qualidade de vida em idosos. Estes indivíduos podem se beneficiar com um programa de exercícios adaptados. Os exercícios reduzem os riscos de lesões osteomioarticulares, incluindo as quedas, a osteopenia e osteoporose (MITTAZ HAGER et al., 2019).

O programa de exercícios físicos deve ser adequado a população idosa, levando em consideração possíveis restrições comuns nesse grupo. A atividade física aparece como uma estratégia eficaz no tratamento da osteopenia e osteoporose em função da melhor resposta as cargas mecânicas sofridas pelo osso, melhorando a força muscular e a constituição óssea (ZHANG et al., 2019; WATSON et al., 2017). O exercício físico regular reduz a morbidade e mortalidade e levam ao envelhecimento saudável. Por sua vez, estimula a remodelagem óssea associada ou não a terapias hormonais reduzindo os riscos de fraturas e quedas (JAKOVLJEVIC, 2018; HONISETT et al., 2016).

O exercício físico, em específico aquele voltado para o trabalho de equilíbrio, é importante na prevenção do risco de queda que é um dos problemas mais graves de saúde pública e pela redução do estado de saúde do idoso. Em média, 33% de pessoas acima de 65 anos caem pelo menos uma vez por ano e com aumento da idade, esse percentual tende a aumentar. Com as quedas o risco de fraturas, principalmente quadril e fêmur, aumentam a chance de hospitalização e mortalidade (GSCHWIND et al., 2013).

Com o avanço da idade, de forma concomitante, as funções físicas reduzem a força muscular, resistência muscular, mobilidade articular, equilibrio e agilidade. Há indicação para

a prática regular de exercícios físicos, pois estes podem reduzir os efeitos deletérios do envelhecimento, melhorar a qualidade de vida e o desempenho nas atividades da vida diária. Exercícios de diferentes tipos são indicados para a pessoa idosa, incluindo aqueles voltados para aptidão cardiorespiratória, força, flexibilidade e equilibrio (LAO et al., 2021).

A perda de força e massa muscular com o envelhecimento são classificadas como dinapenia e sarcopenia, respectivamente. Essas reduções levam a limitações de mobilidade e aumento da mortalidade em idosos, aumentando a possibilidade de incapacidade física. O exercício físico tem efeitos positivos nos ganhos de força e massa muscular na população idosa (GRGIC et al., 2020). Dentre as diferentes metodologias de exercícios, a combinação de desafios cognitivos e motores utilizando exercícios aeróbicos mostrou ser eficaz tanto na marcha quanto no desempenho cognitivo em individuos idosos (RAICHLEN et al., 2020).

As atividades físicas aparecem em diversas modalidades e dentre elas o taekwondo, esporte que se originou na Coréia e se popularizou pelo mundo com milhões de praticantes de todas as idades. É um esporte considerado como arte marcial que envolve movimentos de chutes e socos, principalmente. A prática do Taekwondo pode melhorar a aptidão física, coordenação e equilibrio de pessoas idosas (CHO et al., 2018; WAZIR et al., 2020).

O taekwondo é uma arte marcial tradicional sistemática e científica e as qualidades físicas intervenientes são potências aeróbica, anaeróbica e muscular, a flexibilidade, a velocidade e a agilidade (TAYECH et al., 2020). Essas qualidades físicas estão relacionadas com um melhor desempenho das atividades da vida diária em pessoas idosas. Dessa forma, espera-se que a prática do taekwondo para indivíduos idosos possa gerar melhoras na autonomia funcional, força muscular, autoimagem, autoestima e remodelagem óssea.

Sendo assim, esta dissertação está organizada em 5 estudos intitulados na forma que segue: 1- Efeito dos esportes de combate na aptidão física e atividades da vida diária de idosos: uma revisão sistemática e meta-análise de ensaios clínicos randomizados, que foi realizada de acordo com a metodologia PRISMA para analisar estudos que tratam dos efeitos do taekwondo na aptidão física de idosos. 2 - Effects of Multicomponent Exercise Training on the Health of Older Women with Osteoporosis: A Systematic Review and Meta-Analysis, estudo de revisão sistemática e metanálise de acordo com a metodologia PRISMA sobre os efeitos dos exercícios multicomponentes na saúde de mulheres idosas com osteoporose. 3 - Efeitos das artes marciais em variáveis físicas em idosos: um estudo de revisão sistemática, que foi realizada de acordo com a metodologia PRISMA para analisar estudos que utilizaram as artes marciais como intervenção e as possíveis alterações em diferentes variáveis

de sono e qualidade de vida em idosos. 4- Efectos del taekwondo sobre la salud en adultos mayores: una revisión sistemática, que foi realizada de acordo com a metodologia PRISMA para analisar estudos que tratam dos efeitos do taekwondo na saúde física e mental de idosos. 5 - Impacto do taekwondo sobre os marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosas: um ensaio clinico randomizado: um ensaio clínico randomizado, com o objetivo de investigar os efeitos do treinamento do taekwondo sobre as variáveis de análise do presente estudo para melhorar as condições de vida durante o envelhecimento.

1 APTIDÃO FÍSICA EM IDOSOS PRATICANTES DE ESPORTES DE COMBATE: UMA REVISÃO SISTEMÁTICA E METANÁLISE

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Clinical Geriatric - Reviews

Effect of combat sports on physical fitness and activities of daily living of older adults: a systematic review and meta-analysis of randomized controlled trials

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Objective. To analyze the effects of combat sports (CS) on the physical fitness of older individuals.
Methods. A systematic review and meta-analysis were conducted following the PRISMA criteria and registered in PROSPERO (CRD42022378159). MEDLINE (via PubMed), Scopus, SPORTDiscus, and Web of Science databases were searched for randomized controlled trials (RCTs) that observed older adults submitted to CS programs that reported physical fitness outcomes. The methodological quality and the risk of bias were evaluated using the TESTEX scale and Cochrane Collaboration tool, respectively.
Results. Seventeen RCTs were included in the systematic review and 6 provided data for the meta-analysis. The CS analyzed in the studies were Tai Chi Chuan, Taekwondo, and Jiu-Jitsu, with a duration of interventions ranging from 8 to 48 weeks (≅ 57 min/session, 3 ×/week). There was evidence of increases in muscle strength, flexibility, agility, and balance in the participants who practiced CS ($p < 0.05$). There was a reduction in the absolute values of execution time in the Timed Up and Go (TUG) test after the intervention, indicating improvement in balance (standardized mean difference [SMD]: -0.38; 95% confidence interval (CI): -0.60 to 0.16; $p < 0.01$; $I^2 = 0\%$). Balance assessed by the Berg balance scale (BBS) showed significant differences (SMD: 0.44; 95% CI: 0.27 to 0.61; $p < 0.01$; $I^2 = 0\%$) in favor of participants in the experimental group.
Conclusions. The current results pointed out that the different CS is effective in physical fitness, improving the performance of activities of daily living in older adults.

Key words: combat sports, martial arts, aged, physical fitness, postural balance, functional status

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INTRODUCTION

Physical fitness can be considered as the individual's ability to participate in activities of daily living (ADLs) and leisure with enthusiasm and attention, without excessive fatigue. Cardiorespiratory capacity, endurance, muscle strength, morphological characteristics, and flexibility are part of the components of physical fitness and are related to the level of physical activity. In this sense, physical fitness is an important health-related parameter that can indicate the risk of developing non-communicable diseases [1,2].

The practice of physical exercises can contribute to increasing the quality of life and preventing cardiovascular and mental diseases in older adults. Thus, different types of exercises involving cardiorespiratory capacity, balance, immunity, strength, and muscle mass are prescribed for older adults to maintain functional capacity and improve the performance of ADLs [3,4].

Combat sports (CS) are considered physical exercises and represent different sports modalities. CS includes attack and defense simulations involving upper and lower limb movements, takedowns, and a combination of these techniques [5]. A large part of the world's population practices some type of CS recreationally or in high performance. CS can be smooth, characterized by light and relaxed movements performed slowly, aiming at posture regulation, with fast, vigorous, and dynamic movements, which impose maximum force on the impact surface [6]. At CS modalities most found in the literature are Aikido, Boxing, Capoeira, Fencing, French Boxing, Full Contact, Hapkido, Jet Kune Do, Judo, Jiu-Jitsu, Karate, Kempo, Kendo, Kickboxing, Kung Fu, Mixed Martial Arts, Muay Thai, Qigong, Sumo, Sambo, Soo Bahk Do, Taekwondo, Tai Chi Chuan, and Wrestling [5,7,8].

The regular practice of CS can improve physical fitness, cognitive, and psychological functions, considering the possible stimulation of factors related to physical, mental, and spiritual well-being, and the improvement of physical abilities [5,9,10]. However, the effects of CS on physical fitness and their relationship with performance in ADLs in the older population are still not fully understood. Therefore, the present study aimed to analyze the effects of CS on the physical fitness of older individuals.

METHODS

This systematic review with meta-analysis was conducted in accordance with established guidelines from Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [11] and was approved by the International Prospective Register of Systematic Reviews (PROSPERO) as number CRD42022360904.

Search strategies

EndNote online 20.0.1 literature management software was used to manage literature search records. Two independent and experienced authors conducted an electronic search, without language or time filters, from the 1st to the 20th of December 2022, in the MEDLINE (via PubMed), Scopus, SPORTDiscus, and Web of Science databases. Any conflict was resolved by a third author. Descriptors related to the theme were selected based on a literature review and verified by the Medical Subject Headings (MeSH) and Health Sciences Descriptors (DeCS) metadata systems. Then, the descriptors were grouped into a single Boolean phrase (Appendix A).

Eligibility criteria

The inclusion criteria were designed according to the population, intervention, comparison, outcome, and study design (PICOS) strategy [12], as follows: (a) Population: older adults (aged ≥ 60 years) of both sexes. Participants with neurological (e.g., Parkinson's disease), musculoskeletal, metabolic, and cardiovascular diseases were excluded; (b) Intervention: CS not associated with another type of training; (c) Comparison: other interventions and/or control group; (d) Outcome: physical fitness variables (e.g., balance, functional autonomy, muscle strength, flexibility, agility); (e) Study design: RCTs that analyzed the effects of CS on physical fitness in apparently healthy older adults. Articles published in conferences, systematic reviews, and meta-analyses were excluded.

Appendix A.

Database	Search phrase
PubMed	Search: ((“martial arts”[MeSH Terms] OR (“martial”[All Fields] AND “arts”[All Fields]) OR “martial arts”[All Fields]) AND (“aged”[MeSH Terms] OR “aged”[All Fields] OR “elderly”[All Fields] OR “elderlies”[All Fields] OR “elderlys”[All Fields] OR “elderlys”[All Fields])) AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter])
Scopus	((TITLE-ABS-KEY (martial AND arts) OR TITLE-ABS-KEY (combat AND sport) AND TITLE-ABS-KEY (elderly) OR TITLE-ABS-KEY (older))
SPORTDiscus	AB martial arts OR AB Fighting OR AB combat sports AND AB aged OR alder adults OR elderly OR seniors OR geriatrics
Web of Science	(((AB = (martial arts)) AND AB = (aged)

Risk of bias assessment

Two experienced authors independently assessed the elected RCTs for risk of bias using the Cochrane Collaboration's tool, available at https://training.cochrane.org/handbook/. Any discrepancies and doubts were resolved by a third author. Bias from the following sources was assessed: 1) random sequence generation; 2) allocation concealment; 3) blinding of participants and personnel; 4) blinding of outcome assessments; 5) incomplete outcome data; 6) selective reporting; 7) other bias. Each domain has the risk of bias established as low, uncertain, or high risk of bias. The final score is assigned with the highest classification among the domains evaluated in each RCT [13].

Assessment of methodological quality

For the evaluation of methodological quality, we used the Tool for the assEssment of Study qualiTy and reporting in EXercise (TESTEX), which analyzes the quality of the study, as it is a report evaluation tool, specifically designed for use in exercise training studies. TESTEX is a 15-point scale used in experimental studies, including internal validity assessment criteria and presentation of the statistical analysis used. One point is attributed to each criterion defined in the scale and zero point is attributed to the absence of these indicators. The scale comprises the following criteria: 1) specification of inclusion criteria; 2) random allocation; 3) allocation confidentiality; 4) similarity of groups in the initial or baseline phase; 5) evaluator blinding (for at least one key outcome); 6) measurement of at least one primary outcome in 85% of the allocated subjects (up to three points); 7) intention-to-treat analysis; 8) comparison between groups of at least one primary outcome (up to two points); 9) report measures of variability for all reported outcome measures; 10) monitoring of activities in control groups; 11) constancy in relative exercise intensity; 12) characteristics of exercise volume and energy expenditure [14].

Data extraction

To extract data from the included articles, an electronic spreadsheet was used, according to the eligibility criteria, in duplicate and independently. Then, the data extracted from the articles were evaluated by two evaluators. A third evaluator was responsible for possible divergences and decisions for a consensus. The extracted variables were: authors, year of publication, country, characteristics of the study population (age, sex, and sample size), intervention data, including general and specific exercises, intervention duration (weeks), training volume (duration of the training session, in minutes, and training frequency, in times per week), evaluation and results for the CS applied to older adults in the physical fitness variables.

Meta-analysis

The Review Manager 5.4.1 program (RevMan version 5.4.1; The Cochrane Collaboration, Oxford, UK, available at http://tech.cochrane.org/revman was used to analyze physical fitness in older practitioners of CS. The statistical technique of meta-analysis is used when two or more independent studies can be grouped [15]. As the variables were continuous, we chose to use the statistical method of inverse variance and the analysis model with fixed effect. Effect measure was the difference between the means with a confidence interval (CI) of 95% of the studies. The meta-analysis and the distribution of the studies were analyzed by the weight of each variable in the statistical procedure. The risk of bias in the selected studies was classified as low, uncertain, or high based on the criteria established by the Cochrane Collaboration's tool [13]. Each standardized mean difference (SMD) was weighted according to the inverse variance method. The SMD values in each RCT were pooled with a random (if heterogeneity was significant) or fixed-effects model (if heterogeneity was by chance). SMD values were interpreted as: < 0.2: weak; 0.2-0.79: moderate; ≥ 0.8: strong [16]. A statistically significant effect was indicated by $p < 0.05$.

Evidence-level assessment

Two authors independently assessed the certainty of evidence using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach with the GRADE PRO website, available at https://gradepro.org. GRADE specifies four categories: "high", "moderate", "low", and "very low", applied to a body of evidence. RCTs begin with high-quality evidence. Five aspects can decrease the quality of evidence: methodological limitations, inconsistency, indirect evidence, inaccuracy, and publication bias. On the other hand, three aspects can increase the quality of the evidence: effect size, dose-response gradient, and confounding factor [17]. Heterogeneity between studies was analyzed using I^2 statistics. I^2 values are interpreted as low heterogeneity (0-50%), moderate heterogeneity (50-74%), and high heterogeneity ($\geq$ 75%) [13,18].

RESULTS

A total of 1415 publications were found from the database search following the proposed search methodology (MEDLINE via PubMed = 445; Scopus = 211; SPORTDiscus = 47; Web of Science = 712). After using the selection criteria, a total of 17 randomized controlled trials (RCTs) were included in this systematic review. From these studies, 6 studies provided data to be included in the meta-analysis (Fig. 1).

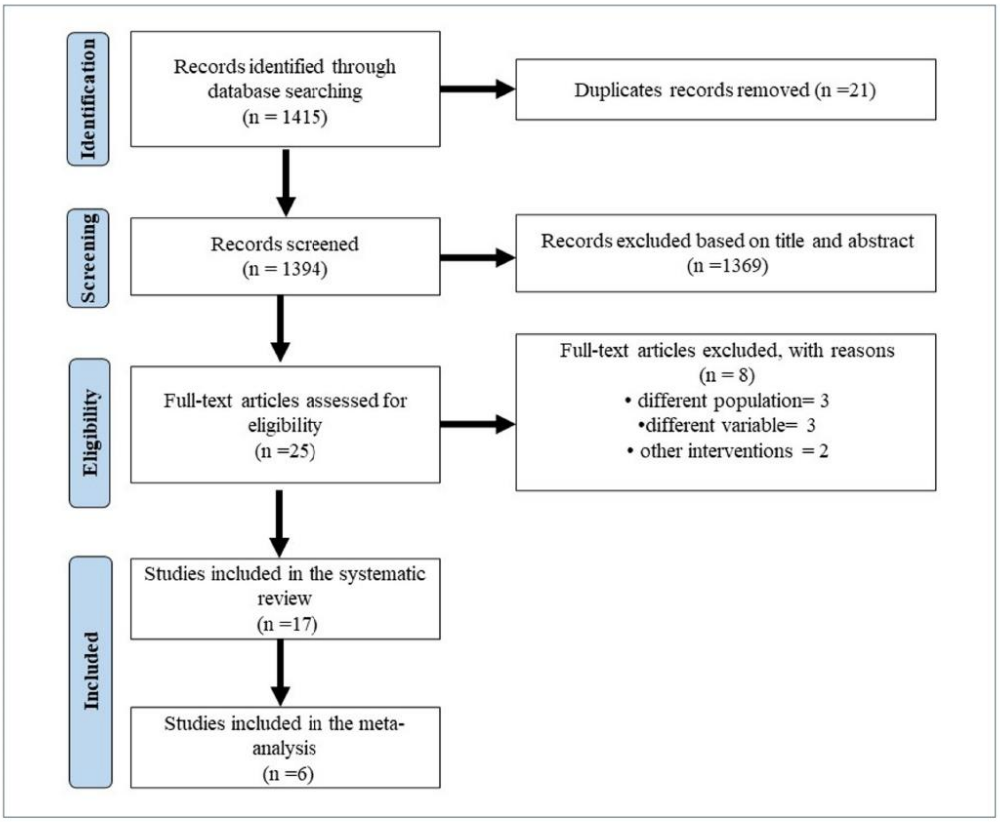

Figure 1. PRISMA flow diagram of study selection.

Figure 2 summarizes the risk of bias analysis of the RCTs. In all the assessed studies, it was neither practical nor possible to blind the participants and/or evaluators. It was judged that this presented a high risk of bias. All other domains were judged to have a low to unclear risk of bias.

Table I presents the methodological quality of studies using the TESTEX tool. According to the TESTEX scale (0 to 15 points), all included studies scored above 10 points. The most sensitive points in the studies were: blinding of the evaluator to assess the outcome (100% of the studies) and blinding of the participants (94% of the studies).

Table II shows the characteristics of the studies by author/year, country of origin, study design, age (mean ± standard deviation), sex and number of participants per group, and total sample. The year of publication of the studies varied between 2004 and 2021. Regarding the country of origin, most of the studies were carried out in the United States of America (USA) (n = 5; 31%). The mean age of the experimental group (EG) and control group (CG) was 71 years. The average number of participants in the EG and CG was 40 participants. The total number of participants was 1384 (681 in the EG and 703 in the CG).

The type of intervention, the CS, the duration, and the training volume were reported in Table III. Among the CS evidenced in the present systematic review, Tai Chi Chuan appears in 12 studies (75%), Taekwondo in 4 studies (25%), and Jiu-Jitsu in 1 study (6%). The duration of the intervention varied between 8 and 48 weeks with an average of 19 weeks and the training volume had an average of 57 minutes per session with a frequency of 3 times a week.

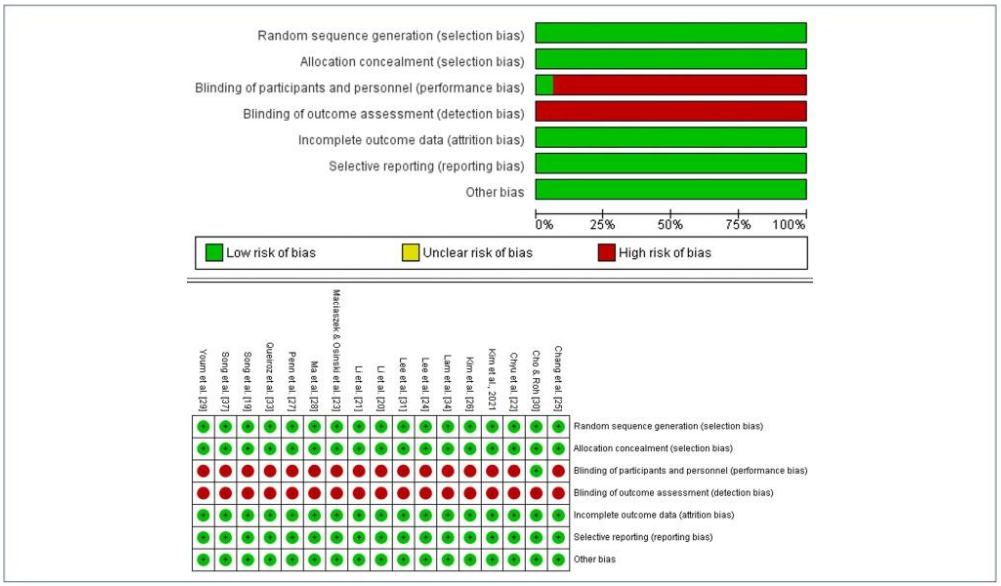

Figure 2. Analysis of risk of bias summary and graph in included RCTs (Cochrane Collaboration tool).

Table I. TESTEX study quality assessment.

Study	Study quality					Sub-total (0 to 5)	Study reporting									Sub-total (0 to 10)	Total (0 to 15)
	1	2	3	4	5		6a	6b	6c	7	8	8b	9	10	11	12	
Song et al. [19]	1	0	0	1	1	3	1	0*	1	1	1	1	1	1	1	1	9	12
Li et al. [20]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	1	1	10	13
Li et al. [21]	1	1	0	1	1	5	1	1	1	1	1	1	1	1	1	1	10	14
Chyu et al. [22]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Song et al. [37]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Youm et al. [29]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	0	1	9	12
Maciaszek and Osinski [23]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	1	1	10	13
Lam et al. [34]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Lee et al. [24]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Queiroz et al. [33]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	1	1	10	13
Chang et al. [25]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	1	1	10	13
Cho and Roh [30]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	1	1	10	13
Kim et al. [26]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Lee et al. [31]	1	1	0	1	0	3	1	1	1	1	1	1	1	1	1	1	10	13
Ma et al. [28]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Penn et al. [27]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14
Kim et al. [32]	1	1	0	1	1	4	1	1	1	1	1	1	1	1	1	1	10	14

*Study that did not report the number of dropouts, but ended with the same number of participants who started the intervention; Study quality: 1: specific eligibility criteria; 2: type of randomization specified; 3: hidden allocation; 4: similar groups at *baseline*; 5: raters were blinded (at least one main outcome); 6: outcomes assessed in 85% of participants (6a: 1 point if more than 85% completed; 6b: 1 point if adverse events were reported; 6c: if exercise attendance was reported); 7: intention-to-treat statistical analysis; 8: statistical comparison between groups was reported (8a: 1 point if between-group comparisons are reported for the primary outcome variable of interest; 8b: 1 point if statistical comparisons between groups are reported for at least one secondary measure); 9: point measures and measures of variability for all outcome measures that were reported; 10: activity monitoring in the control group; 11: relative exercise intensity remained constant; 12: exercise volume and energy expenditure were reported.

Table II. Characteristics of the studies included in the systematic review.

Author	Year	Country	Age: mean ± SD (years)	Sex	Groups (n)	Total (n)
Song et al. [19]	2003	Korea	EG: 64.80 ± 6.0 CG: 62.5 ± 5.6	♀	EG: 22 CG: 21	43
Li et al. [20]	2004	USA	EG: 75.30 ± 7.8 CG: 75.45 ± 7.8	♀	EG: 62 CG: 56	118
Li et al. [21]	2005	USA	EG: 76.94 ± 4.7 CG: 77.99 ± 5.2	♀/♂	EG: 125 CG: 131	256
Chyu et al. [22]	2010	USA	EG: 72.4 ± 6.2 CG: 71.3 ± 6.0	♀	EG: 30 CG: 31	61
Song et al. [37]	2010	Australia	EG: 63.03 ± 7.3 CG: 61.20 ± 8.0	♀	EG: 30 CG: 35	65
Youm et al. [29]	2011	Korea	EG1: 69.4 ± 5.8 EG2: 71.4 ± 7.6 CG: 70.6 ± 4.8	♀	EG: 20 CG: 10	30
Maciaszek and Osinski [23]	2012	Poland	EG: 70.30 ± 5.9 CG: 69.10 ± 5.9	♂	EG: 20 CG: 20	40
Lam et al. [34]	2014	China	EG: 77.20 ± 6.3 CG: 78.30 ± 6.6	♀/♂	EG: 171 CG: 218	389
Lee et al. [24]	2015	USA	EG: 83.50 ± 8.9 CG: 84.80 ± 8.1	♀/♂	EG: 10 CG: 10	20
Queiroz et al. [33]	2016	Brazil	EG: 69.5 ± 6.1 CG: 70.7 ± 6.4	♂	EG: 31 CG: 31	62
Chang et al. [25]	2016	China	EG: 60.13 ± 2.7 CG: 60.30 ± 2.9	♀	EG: 22 CG: 21	43
Cho and Roh [30]	2019	Korea	EG: 68.89 ± 4.16 CG: 69.00 ± 4.41	♀	EG: 19 GC: 18	37
Kim et al. [26]	2019	Korea	EG1: 71.40 ± 3.3 EG2: 70.90 ± 4.3	♀	EG1: 28 EG2: 30	58
Lee et al. [31]	2019	USA	EG: 70.00 ± 4.0 CG: 70.00 ± 4.0	♀	EG: 29 CG: 30	59
Ma et al. [28]	2019	China	EG: 67.5 ± 6.3 CG: 72.80 ± 6.7	♀/♂	EG: 17 CG: 16	33
Penn et al. [27]	2019	Taiwan	EG1: 76.45 ± 8.6 EG2: 75.27 ± 5.2 CG: 73.40 ± 8.2	♀/♂	EG1: 20 EG2: 15 CG: 15	50
Kim et al. [32]	2021	Korea	EG: 72.90 ± 5.8 CG: 71.90 ± 3.1	♀	EG: 10 CG: 10	20

SD: standard deviation; USA: United States of America; EG: experimental group; CG: control group: M: male; F: female.

Table III. Types of CS and characteristics of interventions.

Study	Intervention	Combat sport	Duration (weeks)	Volume of training	
				DT (min)	FT (×/week)
Song et al. [19]	EG1: warm-up, Tai Chi Chuan, cool down (20 min)	Tai Chi Chuan	12	20	3
	CG: no exercise				
Li et al. [20]	EG: warm-up (10 min), Tai Chi Chuan (40 min), cooldown (10 min)	Tai Chi Chuan	24	60	3
	CG: low-impact exercise: controlled breathing, stretching, and relaxation				
Li et al. [21]	EG: warm-up (5-10 min), Tai Chi practice (40 min), cooldown (5-10 min)	Tai Chi Chuan	26	60	3
	CG: warm-up (5-10 min), stretching, breathing, and relaxation (40 min), cooldown (5-10 min)				
Chyu et al. [22]	EG: warm-up (10 min), Tai Chi Chuan (25 min), cooldown (10 min)	Tai Chi Chuan	24	60	3
	CG: no exercise				
Song et al. [37]	EG: warm-up (10 min), Tai Chi Chuan (40-45 min), cool-down (5-10 min)	Tai Chi Chuan	24	60	3
	CG: no exercise				
Youm et al. [29]	EG1: warm-up, taekwondo training, cooldown	Taekwondo	12	60	3
	EG2: warm-up, stretching, walking, cooldown				
	Intensity (EG1 and EG2):				
	weeks 1 to 4: 40-50% HR_{max} and 9-11 RPE				
	weeks 5 to 12: 50-60% of HR_{max} and 9-13 RPE				
	CG: no exercise				
Maciaszek and Osinski [23]	EG: warm-up (10 min), Tai Chi Chuan (30 min), cool-down (5 min)	Tai Chi Chuan	18	45	2
	CG: no exercise				
Lam et al. [34]	EG: Tai Chi Chuan	Tai Chi Chuan	48	30	3
	CG: stretching and relaxation exercises				
Lee et al. [24]	EG: mobility (5 min), warm-up (10 min), Tai Chi Chuan (40 min), cooldown (5 min)	Tai Chi Chuan	12	60	3
	CG: limbs mobilization exercise				
Queiroz et al. [33]	EG: warm-up and stretching (30 min), Jiu-Jitsu (50 min), cool down (10 min)	Jiu Jitsu	12	90	2
	CG: no exercise				
Chang et al. [25]	EG: Tai Chi Chuan	Tai Chi Chuan	24	60	4
	CG: no exercise				
Cho e Roh [30]	EG: warm-up, walking, stretching, taekwondo training, cooldown	Taekwondo	16	60	5
	Intensity: 50-80% HR_{max}				
	CG: no exercise				
Kim et al. [26]	EG: warm-up (15 min), Tai Chi Chuan (35 min), cooldown (10 min)	Tai Chi Chuan	12	60	2
Lee at al. [31]	EG: warm-up, taekwondo training, cooldown	Taekwondo	12	60	3
	Intensity: week 1 to 4: 30-40% of HRR;				
	last 4 weeks: increased up to 50-60% of HRR				
	CG: no exercise				
Ma et al. [28]	EG: warm-up (10 min), Tai Chi Chuan (40 min), and cool-down (10 min)	Tai Chi Chuan	24	60	3
	CG: no exercise				
Penn et al. [27]	EG1: individualized tai-chi exercise (30 min)	Tai Chi Chuan	8	30	3
	EG2: traditional Tai-Chi exercise (30 min)				
	CG: no exercise				
Kim et al. [32]	EG: warm-up, taekwondo training, and cooldown.	Taekwondo	12	90	3
	Intensity: weeks 1 to 4: 40-59% of HRR				
	weeks 5 to 12: 60-75% of HRR				
	CG: no exercise				

EG: experimental group; CG: control group; DT: duration of training; FT: frequency of training; RPE: rating of perceived exertion; HRR: heart rate reserve; HR_{max}: maximum heart rate; min: minutes; ×/week: times per week.

Table IV. Analyzed variables and outcomes.

Study	Evaluation	Results
Song et al. [19]	Muscle strength	↑ Abdominal muscle strength (30 seconds)
	Balance	↑ Balance
Li et al. [20]	Muscle strength	↑ Chair rise
	Balance	↑ Right leg-stand; ↑ Left leg stand
	Walking speed	↓ 50-foot walk
Li et al. [21]	Balance	↑ BBS; ↑ Functional reach, ↑ TUG
	Walking speed	↑ 50-Foot walk; ↑ Dynamic gait index
Chyu et al. [22]	Balance	↑ Stride width; ↑ Sensory Organization Test
Song et al. [37]	Muscle strength	↑ Knee endurance extensor
Youm et al. [29]	Balance	↓ COP trajectories
Maciaszek and Osinski [23]	Balance	↓ 8 foot up to go; ↑ Forward; ↑ Back; ↑ Maximum sway area
Lam et al. [34]	Balance	↑ BBS
Lee at al. [24]	Balance	↓ Sequential weight shifting test; ↑ FRD; ↑ Accuracy
Queiroa et al. [33]	Muscle strength	↑ Lower body strength; ↑ Upper body strength
	Flexibility	↑ Lower body flexibility; ↑ Upper body flexibility
	Cardiorespiratory fitness	↑ Aerobic endurance
Chang et al. [25]	Balance	↑ Knee joint kinesthesia; ↑Ankle joint kinesthesia
Cho e Roh [30]	Muscle strength	↑ 30 s chair stand; ↑ Chair sit-and-reach; ↔ 30s arm curl
	Balance	↔ 2.44 m TUG
	Cardiorespiratory fitness	↑ 2 min step
Kim et al. [26]	Muscle strength	↓ 5 × STS; ↑ 30s STS
	Balance	↑ TUG; ↑ FR; ↑ OLS
Lee et al. [31]	Muscle strength	↑ Hand grip strength; ↑ Leg strength
	Cardiorespiratory fitness	↓ Heart rate
Ma et al. [28]	Muscle strength	↑ Gastrocnemius muscle activation onset latency; ↑ Time to peak force of knee; ↑ Time to peak force of knee flexors extensors
Penn et al. [27]	Muscle strength	EG1: ↑ Lower-limb muscle strength EG2: ↑ Lower-limb muscle strength
	Balance	EG1: ↑ BBS; ↓ TUG; ↑ FRD EG2: ↑ BBS
Kim et al. [32]	Muscle strength	↑ Handgrip strength; ↑ Step count; ↑ Trunk flexion in a sitting position
	Cardiorespiratory fitness	↑ 2 min walk

EG: experimental group; BBS: Berg balance scale; HR: heart rate; COP: center of pressure; STS: sit-to-stand;TUG: timed up and go; FR: functional reach; OLS: one-leg standing; 5×STS: five times sit-to-stand test; 30 s STS: 30-second sit-to-stand test; FRD: forward reach distance; BBS: Berg balance scale; ↑: increase; ↓: decrease; ↔: maintenance.

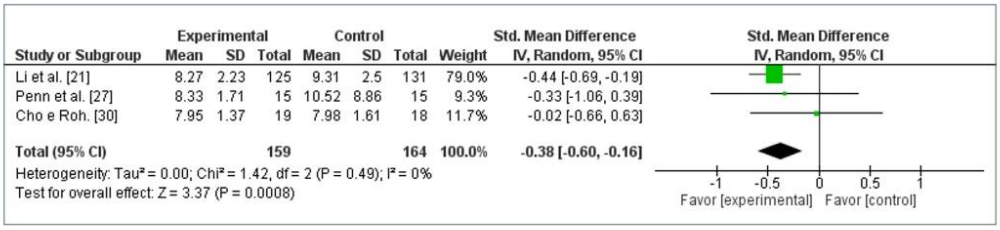

Figure 3. Time Up Go test (TUG) analysis.

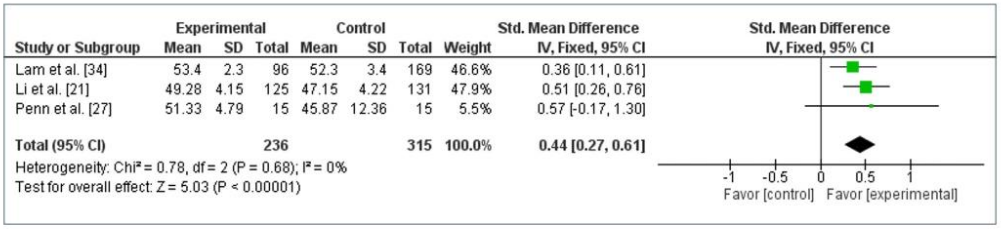

Figure 4. Analysis of the Berg Balance Scale (BBS).

Table IV presents the data of the evaluation variables and outcomes of the included studies. The variables walking speed, cardiorespiratory fitness, muscle strength, flexibility, and balance were investigated by different tests.

Figure 3 shows the results of the meta-analysis of the studies that investigated balance using the Time Up Go (TUG) test. The effect size was calculated by SMD with 95% CI. When calculating the effect size, the negative sign means greater effects for EG when compared to CG. Participants who received the CS intervention achieved improvements in balance ($p < 0.05$) when compared to the CG. The average effect size of all RCTs is represented by the diamond and should be interpreted equally. There was a reduction in the absolute values of the execution time in seconds in the TUG test after the intervention, indicating improvement in balance (95% CI: -0.60 to -0.16) with inconsistency $I^2 = 0\%$ and $p < 0.01$.

Figure 4 presents the results of the meta-analyses of studies that used the Berg Balance Scale (BBS) for balance assessment. There was a significant difference in balance (95% CI: 0.27 to 0.61) in favor of CS participants with inconsistency $I^2 = 0\%$ and $p < 0.01$.

Table V presents the level of evidence of the meta-analyzed studies on the balance variable using the (GRADE) tool.

DISCUSSION

This study investigated the effects of CS on variables related to physical fitness in older adults. The most researched CS was Tai Chi Chuan [19-28], followed by Taekwondo [29-32], and Jiu-Jitsu [33].

Among the physical fitness variables, balance was the most analyzed variable in the included studies (n = 11; 69%) [19-27,29,30,34], which showed improvements after the intervention period ($p < 0.05$). Balance can be checked dynamically and/or statically and by different testing protocols. In this systematic review, the tests used were the single-leg (right and left) stance time, one-leg balance, sensory organization vestibular test, BBS, TUG, functional reach test, and 2.44 m up-and-go test.

Cho e Roh [30], Lee et al. [31], Kim et al. [32], and Queiroz et al. [33] evaluated the cardiorespiratory capacity. These studies prioritized rapid tests to assess this variable. The tests used were aerobic endurance, heart rate, 2 min step, and 2 min walk. There were increases ($p < 0.05$) in the EG when compared to the CG in the post-test.

Muscle strength was another variable evaluated in some of the included studies [19,20,26-28,30-33] and had increases ($p < 0.05$) with CS interventions. This variable was assessed by the hand grip strength, leg strength, 30s tests chair stand, 30s arm curl, chair rise, sit-to-stand, and trunk flexion. Kujach et al. [35] conducted an RCT to evaluate muscle strength in older men and women, with a mean age of 68 years, divided into EG and CG. EG participants performed Judo training (12 weeks, 3 ×/week, 45 min/session) and showed increases ($p < 0.05$) in isometric knee muscle strength assessed by a dynamometer [5] used interventions with Judo and Karate (13 months, 3 ×/week, 60 min/session) and found improvements ($p < 0.05$) in EG in lower limb muscle strength, functional autonomy, quality of life, and bone remodeling. These variables were assessed using the 10-repetition maximum (RM) test, the Latin American Development Group for Maturity (GDLAM) protocol, the Osteoporosis Assessment Questionnaire (OPAQ), and dual-energy X-ray densitometry (DXA), respectively. These studies show that improvements in these physical fitness variables can be a potential factor in improving ADLs in older adults.

Walking speed, flexibility, and agility variables were investigated in a few studies compared to other variables in this systematic review. The walking speed variable was investigated by Li et al. [20] and Li et al. [21] and showed improvements ($p < 0.05$) through the 50-foot walk and dynamic gait index tests. The flexibility variable was assessed by Queiroz et al. [33], who found increases ($p < 0.05$) in flexibility through the lower body flexibility and upper body flexibility tests. It is noteworthy that a sedentary lifestyle and aging accelerate

Table V. Level of evidence (GRADE).

Certainty assessment							No. of participants		Effect		Certainty	Importance
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	EG	CG	Relative (95% CI)	Absolute (95% CI)		
Balance (analyzed with TUG)												
3	RCTs	Not serious	Not serious	Not serious	Not serious	None	159	164	—	Mean – 0.38 highest (– 0.60 lower to – 0.16 higher)	⊕⊕⊕⊕ HIGH	Important
Balance (analyzed with BBS)												
3	RCTs	Not serious	Not serious	Not serious	Not serious	None	236	315	—	Mean 0.44 highest (0.27 lower to 0.61 higher)	⊕⊕⊕⊕ HIGH	Important

RCTs: randomized controlled trials; EG: experimental group; CG: control group; CI: confidence interval; TUG: Time Up Go; BBS: Berg Balance Scale.

important motor losses in performing ADLs, such as reduced physical fitness. The regular practice of physical exercises reduces these losses and can improve the responses of walking speed, flexibility, and agility variables [36].

Studies conducted by Song et al. [19], Li et al. [20], Li et al. [21], Chyu et al. [22], Maciaszek and Osinski [23], Lee et al. [24], Chang et al. [25], Kim et al. [26], Penn et al. [27], Ma et al. [28], Youm et al. [29], Cho e Roh et al. [30], Lee et al. [31], Kim et al. [32], Queiroz et al. [33], Lam et al. [34] and Song et al. [37], analyzed different physical fitness variables (muscle strength, balance, flexibility, agility, walking speed, and cardiorespiratory capacity) in older adults. Corroborating these studies, Arkkugangas et al. [38] conducted an RCT and used Judo training on 142 participants aged between 18 and 68 years. After 10 weeks of training, increases ($p < 0.05$) were found in the variables muscle strength, balance, and walking speed. The tests used were mini-BESTest, tandem heel raise, tandem with heel raise with closed eyes to assess balance, backward for gait speed, and the chair stand on one leg-left/right test to assess muscle strength. It is worth remembering that these improvements in physical fitness are essential for maintaining ADL in older adults.

Regarding the risk of bias, all included studies showed a high risk in terms of blinding participants and/or evaluators.

One of the limitations of this systematic review and meta-analysis was the variety of tests to assess the same study variables. This makes it difficult to diagnose results in the intervening physical qualities used. Another important limiting factor is the small number of RCTs addressing other CS, which are distinguished both by the wide variety of modalities and by the way the training is carried out.

CONCLUSIONS

The CS described in this study are effective in improving the physical fitness of older adults, with positive effects on physical performance and functional autonomy to carry out ADLs. Favorable results were found in different physical variables, such as muscle strength, flexibility, balance, walking speed, agility, and cardiorespiratory capacity, associating CS with improved physical fitness of older individuals submitted to Tai Chi Chuan, Taekwondo, or Jiu-Jitsu. Nevertheless, it is worth emphasizing that the included studies showed great heterogeneity in the application of testing protocols in assessing the physical fitness variables, even when it was the same physical quality. On the other hand, the studies showed positive results in the CS relation and the physical fitness of older individuals. It is suggested that future studies investigate, with randomized methods, other CS (e.g., Judo, Krav Maga, Karate) and the possible effects on physical health (e.g., muscle power) and mental health (e.g., self-image, self-esteem, and depression) in older adults.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions
DGL: creation of the study, construction of methods and results; JBPdC: translation, development of methods and final adjustments; CJB-P: preparation of methods and discussion; BGL: elaboration of results, assessment of risk of bias and methodological quality; LLdS: elaboration of the conclusion and assessment of the risk of bias and methodological quality; PJM-P: elaboration of the discussion; RGdSV: configuration of risk of bias and methodological quality tools and discussion.

Ethical consideration
Not applicable.

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2 EFFECTS OF MULTICOMPONENT EXERCISE TRAINING ON THE HEALTH OF OLDER WOMEN WITH OSTEOPOROSIS: A SYSTEMATIC REVIEW AND META-ANALYSIS

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MDPI

Systematic Review

Effects of Multicomponent Exercise Training on the Health of Older Women with Osteoporosis: A Systematic Review and Meta-Analysis

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Abstract: This study aimed to analyze the effects of multicomponent exercise training in older women with osteoporosis. We conducted a systematic review following the PRISMA guidelines and registered on PROSPERO (number CRD42022331137). We searched MEDLINE (via PubMed), Web of Science, Scopus, and CINHAL databases for randomized experimental trials that analyzed the effects of physical exercise on health-related variables in older women with osteoporosis. The risk of bias in the studies was verified using the Cochrane Collaboration tool and the Jadad scale was used to assess the methodological quality of the studies. Fourteen randomized controlled trials were included, with a total of 544 participants in the experimental group and 495 in the control group. The mean age of all participants was 68.4 years. The studies combined two to four different exercise types, including strength, aerobic, balance, flexibility, and/or functional fitness training. The practice of multicomponent training with an average of 27.2 weeks, 2.6 sessions per week, and 45 min per session showed improvements in strength, flexibility, quality of life, bone mineral density, balance, and functional fitness and reduced the risk of falls in older women with osteoporosis. Multicomponent training was shown to be effective in improving health-related variables in older women with osteoporosis.

Keywords: elderly; exercise; osteoporosis; bone density; quality of life; health; physical functional performance; postural balance; muscle strength; resistance training

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1. Introduction

The world population has shown an abrupt increase in older people in relation to the total population since the mid-twentieth century. Aging tends to be accompanied by a loss of bone and muscle mass and an increase in the percentage of fat due to the reduction of sex hormones, especially anabolic steroids [1,2].

In this sense, changes in bone mineral density (BMD) levels can generate classifications of osteoporosis, such as mild, moderate, and severe. About 200 million people have osteoporosis. In the next three decades, the number of people with this disease is expected to increase by up to three times. Women have a lower BMD and a higher risk of fractures from falls due to the reduction in estrogen and the occurrence of menopause. Other functional losses can occur, such as reduced strength and muscle mass, balance, and visual capacity, which can increase the risk of falls [3].

The risk of fractures increases with osteoporosis followed by morbidity due to the reduction of the bone mineral component. Mortality is directly related to increased hip

fracture rates of around 20%. Other factors are related to osteoporosis, such as hypothyroidism and reduced calcitonin secretion, which can lead to reduced BMD. Adult women diagnosed with BMD below the mean of 2.5 (T-score), estimated by dual-energy X-ray absorptiometry (DXA), are more likely to fracture [4].

Fractures resulting from falls due to osteoporosis leave important sequelae, such as regular pain, musculoskeletal, respiratory, and postural dysfunctions, leading to low functional autonomy and quality of life (QoL). Effective treatments that include exercise are needed to reduce these physical risk factors, pain, and physical dysfunction [5].

Physical exercise can maintain bone mass, increase muscle strength, and improve balance. Thus, aerobic and/or resistance exercises alone, even when not associated with drug therapies, are effective in reducing the loss of BMD in women with osteoporosis [6,7]. Additionally, a training modality that involves different physical capacities in the same exercise session is defined as multicomponent training. The combination of different physical capacities in the same exercise session is used in this training to address older people's functional needs and health. This favors adherence through the proposal of socialization and participation in group activities [8].

Hence, multicomponent training can improve perceptual-cognitive functioning and reduce the frailty state of older people, as the combination of strength, aerobic, balance, and/or flexibility exercises can increase muscle strength, power, balance, and flexibility. These factors are important, as they improve performance in activities of daily living (ADL) [9–12].

Senescence, lifestyle habits, and chronic pathologies can lead to sarcopenia, osteopenia, and osteoporosis. On the other hand, healthy aging with an active lifestyle can provide the older person with a better perception of QoL, ADL, and health [13,14]. Despite those benefits, the effects of multicomponent exercise training on the health of older women with osteoporosis are not clear. As osteoporosis is common in this population and multicomponent training shows high adhesion and adherence rates [8], it is important to know the effects of this modality in older women with osteoporosis.

In this sense, the present study is justified by the need to investigate the control of variables related to the prescription of exercises in older women with osteoporosis and the possible physiological effects that can be optimized with multicomponent training in obtaining important results on bone health. Therefore, the present study aimed to analyze the effects of multicomponent training on the health of older women with osteoporosis. We hypothesized that this training modality would be effective in improving health-related variables of older women with osteoporosis.

2. Materials and Methods

This study is characterized as a systematic literature review. The procedure for conducting this research followed the criteria of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) [15]. This study was registered in the international prospective register of systematic reviews (PROSPERO), as number CRD42022331137.

2.1. Search Strategy

Two independent and experienced researchers conducted an electronic search without language or time filters, in April 2022, in the MEDLINE (via PubMed), Web of Science, Scopus, and CINHAL databases. Any disagreements between the two researchers were solved by consulting a third researcher. The terms related to the topic were osteoporosis, elderly, treatment, and physical exercise. Those terms and their synonyms were appropriately combined using the Boolean operators [OR], between synonyms, and [AND], between descriptors. Reproducible search strategies can be found in Appendix A.

2.2. Eligibility Criteria

Randomized controlled trials (RCTs) that analyzed the effects of multicomponent training that combines a minimum of two different exercise types (strength, aerobic, balance,

flexibility, and/or functional fitness) on health-related variables in older women with osteoporosis were included. Studies that did not use physical exercise as the main intervention or osteoporosis as the main pathology, articles published in congress, systematic reviews, and meta-analyses were excluded.

2.3. Research Question

We based the research question and strategy of our study on the population, intervention, comparison, and outcome (PICO) model, often used in evidence-based practice and recommended for systematic reviews [16]. Therefore, the population was older women with osteoporosis, the intervention was multicomponent exercise training, the control was the group of participants that did not practice multicomponent exercise training, and the outcome was health-related variables. Therefore, the final PICO question was "What are the effects of multicomponent exercise training on health-related variables in older women with osteoporosis?".

2.4. Risk of Bias Analysis

The risk of bias of each included RCT was assessed by the Cochrane Collaboration tool, available at: https://training.cochrane.org/handbook/, accessed on 10 April 2022. This tool consists of 7 domains: (1) generation of the random sequence; (2) allocation concealment; (3) blinding of evaluators and participants; (4) blinding of outcome evaluators; (5) incomplete outcomes; (6) reports of selective outcomes; (7) report on other sources of bias. Each domain has the risk of bias classified as "high", "uncertain", or "low". The final score is assigned with the highest rating among the domains evaluated in each study [17]. Two authors independently performed the risk of bias assessment of each included study and a third researcher was consulted in case of divergences.

2.5. Methodological Quality Analysis

The Jadad scale was used for the analysis of the methodological quality of the RCTs. This instrument has 3 items with a total of 5 points: (1a) the study was described as randomized; (1b) the randomization was accurately performed; (2a) the study was a double-blind trial; (2b) the blinding was properly performed; (3) the study described the sample loss. The score can vary from 0 to 5. Studies with a score ≤ 3 are considered at high risk of bias. Two researchers conducted the methodological quality analysis. Any divergences in the analysis were sent to a third researcher for consensus [18].

2.6. Data Collection Process

Data from the included publications were independently extracted by two researchers. Disagreements were resolved in a consensus meeting with a third researcher. The following variables were extracted: authors, year of publication, country, characteristics of the study population (age, sample size, and BMD), and intervention data, including general and specific exercises, intervention duration (weeks), intensity and volume of training (duration of the training session, in minutes, and frequency, in times per week), evaluation, and outcomes for variables related to physical and mental health.

2.7. Meta-Analysis

We used the Review Manager 5.4.1 program, available at http://tech.cochrane.org/revman, accessed on 25 October 2022, to analyze the effects of multicomponent exercise training on the health of older women with osteoporosis. Meta-analyses were performed when two or more studies could be pooled. As variables were continuous, we used the inverse variance statistical method and the analysis model with the random effect. The effect measure was the difference between the means with a 95% confidence interval from the studies. The meta-analysis and distribution of the studies were analyzed by the weight of each variable in the meta-analysis.

2.8. Evidence Level Assessment

Two independent researchers used the grading of recommendations assessment, development and evaluation (GRADE) approach to evaluate the evidence level for each investigated outcome. The quality of evidence can be assessed by four classification levels: high, moderate, low, and very low. RCTs start with high quality of evidence, and observational studies begin with low quality of evidence. Five aspects can decrease the quality of the evidence: methodological limitations, inconsistency, indirect evidence, inaccuracy, and publication bias. Contrariwise, three aspects can increase the quality of the evidence: effect size, dose-response gradient, and confounding factor [19].

3. Results

In total, 919 studies were found following the proposed research methodology (MEDLINE via PubMed = 416; Scopus = 226; Web of Science = 108, CINAHL = 169). After using the selection criteria, 14 articles were included in the qualitative analysis and four studies provided data to be included in the pooled analysis (Figure 1).

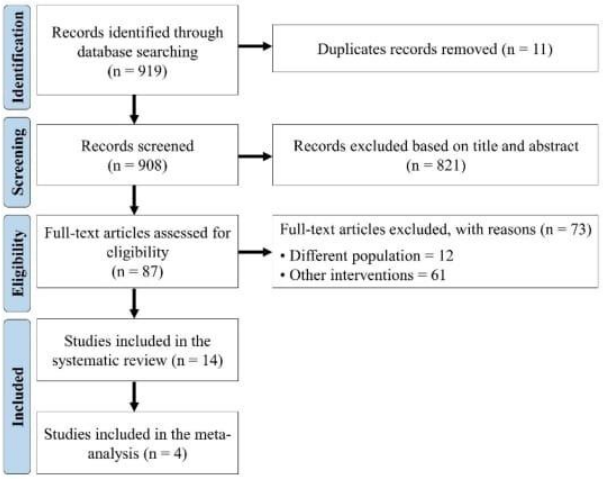

Figure 1. PRISMA flow diagram of study selection.

Table 1 shows the risk of bias of the included RCTs assessed using the Cochrane Collaboration tool. Of the 14 studies included in the present systematic review, 13 (92.85%) presented a low risk of bias and 1 study (7.15%) presented an uncertain risk of bias because it did not present how the participants were randomized [20].

Table 2 presents the analysis of the methodological quality of the RCTs by the Jadad scale. The studies showed a high risk of bias (score ≤ 3). In the studies, randomization occurred in a simple way, despite having a satisfactory score in the description of sample loss and randomization. Double-blinding could improve the methodological quality of the studies.

Table 1. Risk of bias analysis for randomized controlled trials (Cochrane Collaboration tool).

Studies	1	2	3	4	5	6	7	Total
Burke et al. [20]	Uncertain	Low	Low	Low	Low	Low	Low	Uncertain
Carter et al. [7]	Low	Low	Low	Low	Low	Low	Low	Low
Dizdar et al. [21]	Low	Low	Low	Low	Low	Low	Low	Low
Evstigneeva et al. [22]	Low	Low	Low	Low	Low	Low	Low	Low
FilipoviĆ et al. [23]	Low	Low	Low	Low	Low	Low	Low	Low
Garcıa-Gomariz et al. [24]	Low	Low	Low	Low	Low	Low	Low	Low
Halvarsson et al. [25]	Low	Low	Low	Low	Low	Low	Low	Low
Lord et al. [26]	Low	Low	Low	Low	Low	Low	Low	Low
Murtezani et al. [23]	Low	Low	Low	Low	Low	Low	Low	Low
Olsen and Bergland [27]	Low	Low	Low	Low	Low	Low	Low	Low
Paolucci et al. [28]	Low	Low	Low	Low	Low	Low	Low	Low
Preisinger et al. [29]	Low	Low	Low	Low	Low	Low	Low	Low
Stanghelle et al. [30]	Low	Low	Low	Low	Low	Low	Low	Low
Nawrat-Szołtysik et al. [31]	Low	Low	Low	Low	Low	Low	Low	Low

1: randomization; 2: allocation of randomization; 3: blinding of participants; 4: blinding of the evaluators; 5: incomplete outcomes; 6: report on selective outcome; 7: other sources of bias.

Table 2. Methodological quality assessment (Jadad scale).

Studies	1a	1b	2a	2b	3	Total Score
Burke et al. [20]	1	−1	0	0	1	1
Carter et al. [7]	1	1	0	0	1	3
Dizdar et al. [21]	1	1	0	0	1	3
Evstigneeva et al. [22]	1	1	0	0	1	3
FilipoviĆ et al. [23]	1	1	0	0	1	3
Garcıa-Gomariz et al. [24]	1	1	0	0	1	3
Halvarsson et al. [25]	1	1	0	0	1	3
Lord et al. [26]	1	1	0	0	1	3
Murtezani et al. [32]	1	1	0	0	1	3
Olsen and Bergland [27]	1	1	0	0	1	3
Paolucci et al. [28]	1	1	0	0	1	3
Preisinger et al. [29]	1	1	0	0	1	3
Stanghelle et al. [30]	1	1	0	0	1	3
Nawrat-Szołtysik et al. [31]	1	1	0	0	1	3

1a: randomized study; 1b: adequate randomization; 2a: double-blind study; 2b: proper blinding; 3: description of the sample loss.

Table 3 presents the years, countries, mean values and standard deviation of age, sample size, and BMD of participants of the studies included in the present systematic review. Interventions from the included studies consisted of a total of 1186 participants, with 691 participants in the experimental group (EG) and 495 in the control group (CG). It was found that the mean age of participants in the EG and CG of all studies was 68.4 years. The studies included in this review were developed in different countries, located on different continents. All participants were over 50 years of age. Publication years ranged from 1996 to 2021.

Table 3. Characteristics of the participants of the included studies.

Author	Year	Country	Age (Years)	EG (*n*)	CG (*n*)	Total (*n*)	BMD	
							(T-Score)	(g/cm^3)
Lord et al. [26]	1996	Australia	EG: 71.7 ± 5.4 CG: 71.5 ± 5.5	90	89	179	NI	Lumbar spine: EG: 1.014 ± 0.2 CG: 0.965 ± 0.2 Femoral Neck: EG: 0.770 ± 0.1 CG: 0.742 ± 0.1 Trochanter EG: 0.689 ± 0.1 CG: 0.652 ± 0.1
Preisinger et al. [29]	1996	Austria	EG1: 62.6 ± 5.9 EG2: 60.9 ± 7.8 CG: 59.0 ± 8.0	EG1: 27 EG2: 34	31	92	NI	Distal forearm: EG1: 0.266 EG2: 0.269 CG: 0.305 Mid-forearm: EG1: 0.382 EG2: 0.383 CG: 0.424
Carter et al. [7]	2002	Colombia	EG: 69 ± 3.5 CG: 69.6 ± 3.0	40	40	80	NI	Total hip or lumbar spine ≤−2.5 SD
Burke et al. [20]	2010	Brazil	EG: 72.8 ± 3.6 CG: 74.4 ± 3.7	17	16	33	Lumbar spine: EG: −3.69 ± 0.83 CG: −3.53 ± 0.96	NI
Murtezani et al. [32]	2014	Switzerland	EG1: 60.68 ± 7.62 EG2: 59.78 ± 5.99	31	30	61	Lumbar spine: EG1: −3.04 ± 0.4 EG2: −3.10 ± 0.5	NI
Olsen and Bergland [27]	2014	Norway	EG: 70.4 ± 5.9 CG: 72 ± 5.6	47	42	89	NI	NI
Paolucci et al. [28]	2014	Switzerland	EG: 65.6 ± 5.8 CG: 65.6 ± 5.3	40	20	60	NI	Lumbar spine ≤−2.5 SD
Halvarsson et al. [25]	2014	Sweden	EG1: 76 ± 10 EG2: 77 ± 9 CG: 76 ± 10	EG1: 25 EG2: 18	26	69	NI	NI
Evstigneeva et al. [22]	2016	Russia	EG: 70.7 ± 8.1 CG: 67.6 ± 7.0	40	38	78	NI	NI
García−Gomáriz et al. [24]	2017	Spain	EG: 60.3 ± 5.4 CG: 56.5 ± 6.7	17	17	34	Femoral neck: −0.76 Lumbar spine: 1.93	NI
Dizdar et al. [21]	2017	Turkey	EG1: 57.87 ± 4.5 EG2: 59.86 ± 5.5 EG3: 60.91 ± 6.5	EG1: 25 EG2: 25 EG3: 25	–	75	Lumbar total: EG1: −2.44 ± 0.8 EG2: −2.62 ± 0.8 EG3: −2.54 ± 0.6 Femur neck: EG1: −1.67 ± 0.8 EG2: −1.85 ± 0.8 EG3: −1.97 ± 0.4 Femur total: EG1: −0.63 ± 1.2 EG2: −0.95 ± 0.9 EG3: −0.91 ± 1.1	NI
Nawrat−Szołtysik et al. [31]	2019	Poland	EG: 81.5 ± 10 CG: 81.5 ± 10	EG1: 23 EG2: 21 EG3: 23	24	91	≤1	NI
Stanghelle et al. [30]	2020	Norway	EG: 74.2 ± 5.8 CG: 74.7 ± 6.1	76	73	149	NI	Lumbar spine and femoral neck ≤ −2.5 SD
FilipoviĆ et al. [23]	2021	Serbia	EG: 64.40 ± 5.45 CG: 64.20 ± 5.08	47	49	96	Neck: −2.62 ± 0.72	Lumbar spine and femoral neck ≤ −2.5 SD

EG: experimental group; CG: control group; BMD: bone mineral density; NI: not informed; SD: standard deviation.

Table 4 shows the intervention and training volume of the studies. It was found that 12 studies had EG and CG, while 2 studies used only EG. The CG participants did not perform physical exercises, except for the studies of Dizdar et al. [21], García-Gomáriz et al. [24], and Paolucci et al. [28]. The EG participants performed strength, aerobic, balance, flexibility, and/or functional fitness exercises. The duration of the interventions ranged from 4 to 96 weeks, 20 to 60 min per training session, and a frequency of 2 to 5 sessions per week.

Table 4. Study intervention data.

Study	Intervention	Duration (Weeks)	VT	
			DT (min)	FT (×/week)
Lord et al. [26]	EG: RT for upper limbs and balance CG: no physical exercises	5	60	4
Preisinger et al. [29]	EG1: regular RT, balance, motor, and postural coordination EG2: irregular RT, balance, motor, and postural coordination CG: no physical exercises	48	20	2
Carter et al. [7]	EG: RT, balance, postural exercises, and coordination CG: no physical exercises	20	40	2
Burke et al. [20]	EG: RT for lower limbs and balance CG: no physical exercises	8	30	2
Murtezani et al. [32]	EG1: RT, balance, and aerobic exercise (land) EG2: aerobic exercise and RT (water)	40	35	3
Olsen and Bergland [27]	EG: aerobic circuit training, balance, and flexibility CG: no physical exercises	12	60	3
Paolucci et al. [28]	EG: low-impact aerobics training, balance, and flexibility CG: aerobic training	24	60	3
Halvarsson et al. [25]	EG1: balance EG2: balance and aerobic training CG: no physical exercises	12	30–45	2
Evstigneeva et al. [22]	EG: RT for lower limbs and balance CG: no physical exercises	48	40	2
Dizdar et al. [21]	EG1: RT, balance, and coordination EG2: RT EG3: aerobic training	12–24	60	3
García-Gomáriz et al. [24]	EG: RT and high-impact training + calcium + vitamin D CG: high-intensity walk	96	60	2
Nawrat-Szołtysik et al. [31]	EG1: modified Sinaki exercises EG2: Nordic walking EG3: modified Sinaki exercises + Nordic walking CG: did not perform physical exercises	12	40	2
Stanghelle et al. [30]	EG: RT and balance CG: no physical exercises	24	60	2
FilipoviĆ et al. [23]	EG: RT, aerobic training, and balance CG: no physical exercises	4–24	50–60	5

EG: experimental group; CG: control group; VT: volume of training; DT: duration of training (each session); FT: frequency of training; RT: resistance training; min: minutes; ×/week: times per week.

Table 5 presents the data on the evaluation and results of the included studies. The evaluation was divided between two and four moments according to each study. Functional fitness, BMD, and balance appeared more frequently in the included studies. Variables such as muscle strength, agility, quality of life, flexibility, pain assessment, and cardiorespiratory fitness were also analyzed and showed significant post-intervention increases ($p < 0.05$). The effect size (d) in the last column should be interpreted as follows: weak (<0.2), moderate (0.2 to 0.79), or strong (>0.8) [33].

Table 5. Data from the variables analyzed and the results of the included studies.

Study	Evaluation	Results in the EG ($p < 0.05$)
Lord et al. [26]	Balance	EG: ↔ Sway ($d = -0.30$)
	BMD	EG: ↔ lumbar spine ($d = 0.06$); ↔ femoral neck ($d = 0.08$); ↔ trochanter ($d = 0.04$)
	Muscle strength	EG: ↑ quadriceps strength ($d = 0.88$)
Preisinger et al. [29]	BMD	EG1: ↑ distal forearm; ↔ mid-forearm EG2: ↓ distal forearm; ↓ mid-forearm
Carter et al. [7]	Balance	EG: ↔ composite balance score ($d = 0.13$)
	Functional fitness	EG: ↔ eight−figure ($d = 0.33$)
	Muscle strength	EG: ↔ knee extension strength ($d = 0.09$)
	QoL	EG: QUALEFFO−41: ↔ total score; ↔ social; ↔ general health perception; ↔ physical function; ↔ pain; ↔ mental state
Burke et al. [20]	Isometric muscle strength	EG: ↑ ankle flexion; ↑ knee extension; ↑ knee flexion
	Balance	EG: ↑ COP velocity; ↑ endpoint excursion; ↓ maximum excursion; ↓ directional control; ↑ stable surface/open eyes; ↓ stable surface/closed eyes; ↓ unstable surface/open eyes; ↓ unstable surface/closed eyes
Murtezani et al. [32]	Balance	EG1: ↔ BBS ($d = 0.21$) EG2: ↔ BBS ($d = 0.02$)
	Functional fitness	EG1: ↑ six-minute walking test ($d = 0.96$) EG2: ↑ six-minute walking test ($d = 0.71$)
	Muscle strength	EG1: ↑ quadriceps strength ($d = 0.34$); ↑grip strength ($d = 0.76$) EG2: ↑ quadriceps strength ($d = 0.11$); ↑grip strength ($d = 0.02$)
	BMD	EG1: ↑ BMD ($d = 0.51$) EG2: ↔ BMD ($d = 0.07$)
Olsen and Bergland [27]	Fall	EG: ↓ falls efficacy scale ($d = -0.70$)
	Functional fitness	EG: ↓ maximum walking speed ($d = -0.40$)
	Flexibility	EG: ↔ functional reach ($d = 0.10$)
Paolucci et al. [28]	Pain	EG1: ↓ VAS of pain ($d = -1.58$); ↓ McGill Pain Questionnaire ($d = -0.60$) EG2: ↑ VAS of pain ($d = -2.31$); ↑ McGill Pain Questionnaire ($d = -2.31$)
	QoL	EG1: ↑ Shortened Osteoporosis Quality of Life Questionnaire ($d = 0.63$) EG2: ↑ Shortened Osteoporosis Quality of Life Questionnaire ($d = 0.88$)
	Disability	EG1: ↓ Oswestry Disability Questionnaire ($d = -0.63$) EG2: ↓ Oswestry Disability Questionnaire ($d = -0.88$)
Halvarsson et al. [25]	Balance	EG: ↑ preferred speed single−task ($d = 0.60$); ↑ preferred speed dual-task ($d = 1.00$); ↔ error in the performance of the dual-task in percentage ($d = 0.20$); ↑ fast speed ($d = 0.50$); ↔ LLFDI: functional total ($d = 0.40$); ↔ upper extremity ($d = 0.00$); ↔ basic lower extremity ($d = 0.20$); ↑ advanced lower extremity ($d = 0.60$)
	Fall	EG: ↓ FES−I: ↑ one leg stance; ↑ modified figure−of−eight test time; ↑ physical activity; ↔ fear of falling; ↑ no percent; ↓ a little percent; ↓ quite a bit; ↓ very much; ↓ gait speed
Evstigneeva et al. [22]	QoL	EG: QUALEFFO−41: ↓ pain ($d = -1.20$); ↔ADL (0.10); ↓ mobility ($d = -1.27$), ↓ social function ($d = -0.65$); ↓ general health perception ($d = -1.10$); ↓ mental function ($d = -0.48$)
	Functional fitness	EG: ↔ Test weight−bearing/squat ($d = 0.17$); ↑ sit-to-stand weight transfer ($d = -0.24$); ↔ sit-to-stand left/right weight symmetry ($d = -0.12$); ↑ Tandem Walk and Sway test ($d = -0.48$); ↔ TUG ($d = 0.03$)
	Flexibility	EG: ↔ occiput−wall distance ($d = 0.24$)

Table 5. *Cont.*

Study	Evaluation	Results in the EG ($p < 0.05$)
Dizdar et al. [21]	Balance	EG: ↓ TUG (12th) ($d = -0.33$); ↑ BBS (12th) ($d = 0.33$)
	Pain	EG: ↓ VAS (12th) ($d = -1.21$)
	QoL	EG: QUALEFFO−41: ↓ total score ($d = -0.43$); ↓ pain (24th) ($d = -0.43$); ↔ physical function ($d = -0.15$); ↓ social function ($d = -0.56$); ↓ general health ($d = -0.46$); ↔ mental function ($d = 0.06$)
García−Gomáriz et al. [24]	BMD	EG: ↑ femoral neck ($d = 0.37$); ↔ lumbar spine ($d = 0.41$)
Nawrat−Szołtysik et al. [31]	Functional fitness	EG1 vs. EG2: ↑ number of steps and distance per day ($d = 3.18$); ↔ TUG; ↔ FRT EG2 vs. EG3: no differences ($p > 0.05$)
	QoL	EG1/EG2/EG3: QUALEFFO−41: ↔ pain, ↔ ADL; ↔ mobility; ↔ jobs around the house; ↔ mobility; ↔ leisure social activities; ↓ general health perception; ↓ mental function
Stanghelle et al. [30]	Functional fitness	EG: ↔ FRT ($d = 0.39$); ↓ four square step test ($d = -0.32$); ↔ grip strength right ($d = -0.11$); ↑ arm curl ($d = -0.69$); 30−s sit to stand ($d = 0.44$); ↔ TUG ($d = -0.05$); ↔ 6−min walking distance ($d = 0.25$)
	QoL	EG: HRQoL (QUALEFFO−41): ↓ FES−I ($d = -0.13$)
FilipoviĆ et al. [23]	Balance	EG: ↓ TUG ($d = -0.63$); ↑OLST ($d = 0.76$)
	Muscle strength	EG: ↓ STS ($d = -0.80$)
	Osteoporosis	EG: ↑ OKAT−S ($d = 2.92$)
	Fall	EG: ↓ FES−I ($d = -1.15$)

ADL: activities of daily living; BBS: Berg balance scale; BMD: body mass density; COP: center of pressure; *d*: effect size; FES-I: falls efficacy scale international; FRT: functional reach test; HRQoL: health-related quality of life; OKAT-S: osteoporosis knowledge assessment tool—short version; OLST: one leg stance test; OPAQ: osteoporosis assessment questionnaire; OQoLQ: Osteoporosis Quality of Life Questionnaire; QoL: quality of life; QUALEFFO-41: 41-item Quality of Life Questionnaire of the European Foundation for Osteoporosis; SF-36: 36-item short form health survey; STS: sit-to-stand test; TUG: timed up and go; VAS: visual analogue scale; LLFDI: late life disability and function instrument; ↑ increase; ↔ maintenance; ↓ reduction.

Figure 2 shows the results of the meta-analyses of the studies that used the QUALEFFO-41 to evaluate the quality of life. The effect size was calculated by the standardized mean difference (SMD) with a confidence interval (CI) of 95%. When calculating the effect size, the negative sign means greater effects to the EG compared to the CG. In the forest plot, lines on the left side of the graph denote participants who received the multicomponent training intervention and presented significant positive changes compared to control participants. The average effect size of all RCTs is represented by the diamond and should be interpreted equally. There was a no significant difference in QUALEFFO-41 (95% CI: −2.06 to −0.69) with inconsistency $I^2 = 95\%$ and p-value = 0.33.

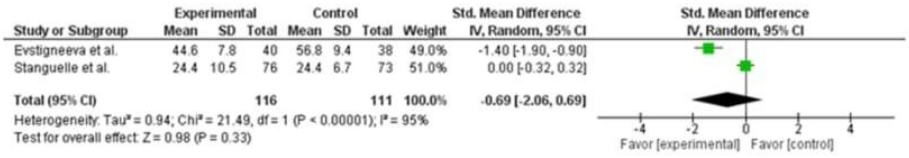

Figure 2. Forest plot (QUALEFFO-41) [22,30].

Figure 3 presents the results of the meta-analyses of studies that used TUG for balance assessment. There was no significant difference in balance (95% CI: −1.41 to −0.50) with inconsistency $I^2 = 90\%$ and p-value = 0.35.

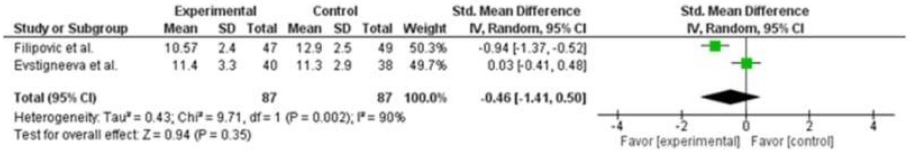

Figure 3. Forest plot (timed up and go) [22,23].

Table 6 shows the level of evidence of the included studies, which was considered high, according to the GRADE tool. This means that there is moderate confidence in the estimated effect.

Table 6. Level of evidence (GRADE).

Certainty Assessment							No. of Participants		Effect		Certainty	Importance
No. of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	EG	CG	Relative (95% CI)	Absolute (95% CI)		
QoL (analyzed with QUALEFFO-41)												
2	RCTs	not serious	not serious	not serious	not serious	none	116	111	—	mean −1.09 highest (−2.06 lower to 0.69 higher)	⊕⊕⊕⊕ HIGH	Important
Balance (analyzed with TUG)												
2	RCTs	not serious	not serious	not serious	not serious	none	87	87	—	mean −0.46 highest (−1.41 lower to −0.50 higher)	⊕⊕⊕⊕ HIGH	Important

RCTs: randomized controlled trials; EG: experimental group; CG: control group; QoL: quality of life; QUALEFFO-41: 41-item Quality of Life Questionnaire of the European Foundation for Osteoporosis; TUG: timed up and go; CI: confidence interval; ⊕⊕⊕⊕: represents high confidence in the estimated effect.

4. Discussion

The present study aimed to analyze the effects of multicomponent training on health-related variables of older women with osteoporosis. Increases in muscle strength, balance, cardiorespiratory fitness, and functional fitness were reported in the studies included in the present systematic review.

The included studies (n = 14) combined a minimum of two and a maximum of four different exercise types, involving strength, aerobic, balance, flexibility, and/or functional fitness training. The analysis of the 14 studies showed that older women with osteoporosis that practiced multicomponent training, with an average of 27.2 weeks, 2.6 sessions per week, and 45 min per session, improved strength, flexibility, QoL, BMD, balance, functional fitness, and reduced the risk of falls.

Different variables were analyzed in this systematic review. Balance was the most investigated variable, covering half (n = 7) of the included studies [7,20,21,23,25,26,31]. Muscle strength was evidenced in five studies [7,20,23,26,32]. Moreover, QoL was evaluated in six studies [7,21,22,28,30,31] and functional fitness was verified in six studies [7,27,29,30,32,34]. The frequency of falls was evaluated in three studies [23,25,27] and BMD was analyzed in four studies [24,26,29,32]. Flexibility was the least analyzed physical capacity among the included studies, being verified in two studies [22,23].

Burke et al. [20], Lord et al. [26], and Murtezani et al. [32] verified increases ($p < 0.05$) in isometric muscle strength of lower limbs in the knee, hip, and ankle flexion and extension movements with the application of the tests: knee extension, leg press, and back extensor strength. Murtezani et al. [32] reported increases ($p < 0.05$) in handgrip strength and lower limb strength. Filipović et al. [23] found an increase ($p < 0.05$) in lower limb muscle strength with the sit-to-stand test used to assess physical quality. Cardoso et al. [12] also reported increased muscle strength in upper and lower limb resistance exercises in a

12-week multicomponent program. However, Carter et al. [9] found no changes in lower limb muscle strength in the knee extension strength test.

Balance was the most analyzed variable in the studies included in this systematic review. Carter et al. [7] reported increases ($p < 0.05$) in balance using the Berg balance, while Murtezani et al. [32] found no changes in this variable using the same test. Burke et al. [20] and Halvarson et al. [25] reported improvements ($p < 0.05$) in balance through the COP velocity, directional control, balance performance, walking speed with a dual-task, fast walking speed, advanced lower extremity physical function, timed up and go (TUG), and Bretz stabilometer measurements. Lord et al. [26] and Carter et al. [7] found no differences ($p > 0.05$) in balance with the sway test and the composite balance score. Similarly, Dizdar et al. [21] and Filipović et al. [23] used the TUG test to assess balance and found no significant differences. Evstigneeva et al. [22] investigated flexibility and found no significant differences ($p > 0.05$). Nevertheless, increases in flexibility ($p < 0.05$) were reported by Olsen and Bergland [27] in the functional reach test.

Increases in QoL ($p < 0.05$) were observed in five studies, one [28] of them analyzed this variable with the Shortened Osteoporosis Quality of Life Questionnaire and four [21,22,30,31] used the 41-item Quality of Life Questionnaire of the European Foundation for Osteoporosis (QUALEFFO-41): pain, activities of daily mobility, jobs around the house, mobility, leisure social activities, general health perception, and mental function. On the other hand, Carter et al. [7] found no differences in the assessment of QoL in EG with the same instrument.

In the variable functional fitness, significant increases ($p < 0.05$) were reported in five studies [22,27,30–32], while the study by Carter et al. [7] did not present significant changes in this variable ($p > 0.05$). Different tests were used to assess functional fitness (eight-figure, test sit-to-stand weight transfer, six-minute walking test, maximum walking test, and functional reach test). However, the TUG test appeared more frequently in the evaluation of the functional fitness variable. Multicomponent training has been shown to be effective ($p < 0.05$) to improve the functional autonomy of older women [10], as well as resistance training with a frequency of two times and three times a week [6].

Few studies have investigated falls. The reduction in the frequency of falls ($p < 0.05$) was reported by Olsen and Bergland [27], Halvarsson et al. [25], and Filipović et al. [23] using the falls efficacy scale tests.

Lord et al. [26] used resistance training for 5 weeks and found no differences in BMD ($p > 0.05$) between the CG, but three studies [24,29,32] reported increases ($p < 0.05$) in BMD in the lumbar spine, forearm, and total BMD. A possible explanation may be the longer intervention time used in these studies, both with more than 40 weeks. The study of Borba-Pinheiro et al. [6] evaluated BMD, functional autonomy, muscle strength, and QoL in 52 postmenopausal women using different types of resistance training (RT), one performed twice a week (RT2) and the other performed three times a week (RT3). Both training programs (RT2 and RT3) showed positive results in 13 months of intervention when compared to the CG, using the Osteoporosis Assessment Questionnaire (OPAQ). Olsen and Bergland [27], with postmenopausal women using different types of exercises (water aerobics and judo) with 12 months of intervention, demonstrated that RT presented the best results ($p < 0.05$) for lumbar BMD, balance, and QoL (OPAQ) compared to other exercises and GC.

Of the 14 studies included in this systematic review, 4 studies were part of the meta-analysis. Evstigneeva et al. [22] and Stanghelle et al. [30] analyzed the quality of life using the QUALEFFO-41. These studies [22,30] showed favorable results ($p < 0.05$) with the multicomponent training intervention when compared to the CG (Figure 2). Additionally, two studies [22,23] evaluated the balance with the TUG test. Both of them showed improvements ($p < 0.05$) with the multicomponent training intervention when compared to the CG (Figure 3).

A limitation of the present systematic review to be highlighted was that some studies did not use the double-blind randomization methodological process. Furthermore, some

studies investigated patients with and without fractures, which may interfere with the time and optimization of results. Other limitations to be considered are the different intervention protocols presented and the lack of data from some studies [22,25,27] regarding the confirmation of osteoporosis. The lack of patterns for the outcomes among the elected studies is another limitation. Moreover, there were a small number of studies included in the meta-analysis. Thus, these findings should be analyzed with caution when prescribing physical exercises for women with osteoporosis.

5. Conclusions

Physical exercise involving multicomponent training in women with osteoporosis can improve BMD, strength, flexibility, balance, functional fitness, and QoL, and reduce the risk of falls. Other types of physical exercise (aerobic, resistance, and flexibility) were presented in this review for this population. The results showed the importance of applying different forms of physical exercise as a treatment for osteoporosis in older women. Therefore, a physical exercise program that aims to stimulate different physical qualities in training sessions can promote musculoskeletal health and QoL in this population. Future studies are recommended to investigate body weight excess, due to low mobility, and rheumatic diseases, as they may be related to bone remodeling and the association of physical exercise in the health of older women with osteoporosis. Moreover, it is suggested to design and apply an intervention program of multicomponent exercise training for women with osteoporosis to determine if there are some positive effects on BMD.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Database	Search Phrase
MEDLINE (PubMed)	(("osteoporosis"[MeSH Terms] OR "osteoporosis"[All Fields] OR "osteoporoses"[All Fields] OR "osteoporosis, postmenopausal"[MeSH Terms] OR ("osteoporosis"[All Fields] AND "postmenopausal"[All Fields]) OR "postmenopausal osteoporosis"[All Fields]) AND ("aged"[MeSH Terms] OR "aged"[All Fields] OR "elderly"[All Fields] OR "elderlies"[All Fields] OR "elderly s"[All Fields] OR "elderlys"[All Fields]) AND ("therapeutics"[MeSH Terms] OR "therapeutics"[All Fields] OR "treatments"[All Fields] OR "therapy"[MeSH Subheading] OR "therapy"[All Fields] OR "treatment"[All Fields] OR "treatment s"[All Fields]) AND ("exercise"[MeSH Terms] OR "exercise"[All Fields] OR "exercises"[All Fields] OR "exercise therapy"[MeSH Terms] OR ("exercise"[All Fields] AND "therapy"[All Fields]) OR "exercise therapy"[All Fields] OR "exercise s"[All Fields] OR "exercised"[All Fields] OR "exerciser"[All Fields] OR "exercisers"[All Fields] OR "exercising"[All Fields])) AND (clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter])
Web of Science	(((TS = (osteoporosis)) AND TS = (elderly)) AND TS = (exercise)) AND TS = (treatment)
Scopus	(TITLE-ABS-KEY (osteoporosis) OR TITLE-ABS-KEY (bone loss) OR TITLE-ABS-KEY (osteoporosis) AND TITLE-ABS-KEY (therapeutic) OR TITLE-ABS-KEY (therapy) OR TITLE-ABS-KEY (treatment) AND TITLE-ABS-KEY (elderly) OR TITLE-ABS-KEY (aged) AND TITLE-ABS-KEY(exercise) OR TITLE-ABS-KEY(physical activity) OR TITLE-ABS-KEY(physical exercise))
CINHAL	AB (osteoporosis OR bone density OR bone loss) AND AB (elderly OR aged OR older OR elder or geriatric) AND AB (treatment OR intervention OR therapy) AND AB (exercise OR physical activity)

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3 EFEITOS DAS ARTES MARCIAIS EM VARIÁVEIS FÍSICAS EM IDOSOS- UM ESTUDO DE REVISÃO SISTEMÁTICA

Efeitos das artes marciais em variáveis físicas em idosos- um estudo de revisão sistemática

Trabalho completo apresentado no V Congresso Internacional de Educação Física (CIEFD) publicado na Revista de Educação Física do Exército

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Resumo: Objetivo: Analisar as variáveis físicas relacionadas a qualidade de vida e sono em idosos com a prática das artes marciais. **Métodos:** As bases de dados foram MEDLINE (via PubMed), Scopus, SportDiscus e Web of Science. As palavras-chave relacionadas ao tema foram selecionadas com base em uma revisão da literatura e nos descritores em ciências da saúde (Decs/ Mesh). Foram excluídos artigos publicados em congresso, artigos de revisão sistemática e metanálise. **Resultados:** Dentre as artes marciais, apenas o Tai Chi Chuan aparece evidenciando as variáveis propostas nesta revisão sistemática. A duração da intervenção variou entre 12 e 48 semanas e o volume de treinamento teve uma média de 45 minutos por sessão e 3 vezes por semana. Nos 5 estudos incluídos nessa revisão sistemática as variáveis de qualidade de vida e sono foram analisadas. **Discussão:** Na qualidade de vida houve redução ($p<0,05$) da perturbação total do humor e seus 6 estados (tensão-ansiedade, depressão-rejeição, raiva-hostilidade, vigor-atividade, fadiga-inércia e confusão-perplexidade) e aumentos ($p<0,05$) da saúde física e mental. Em relação ao sono houve melhora ($p<0,05$). Os testes utilizados foram o de latência do sono, duração do sono, eficiência habitual do sono, distúrbios do sono, sonolência, tempo de vigília após o início do sono, número de despertares e tempo médio de despertar. **Conclusão:** De acordo com os 5 estudos incluídos nessa revisão sistemática, as artes marciais são eficazes na saúde física e mental da pessoa idosa. Resultados favoráveis foram encontrados nas variáveis físicas de qualidade de vida e sono de idosos.

Introdução: As artes marciais são definidas por diferentes movimentos específicos, chutes, socos, bloqueios, grappling e a combinação desses movimentos. Podem ser praticados em diferentes categorias competitivas, de forma recreativa e em diferentes faixas de idade. Aumentos da força muscular, flexibilidade são os principais benefícios em relação a aptidão física e em relação aos aspectos psicológicos estão a função cognitiva, autoestima, autoimagem e autorrespeito. [1]

Problemas relacionados ao sono são problemas importantes e chegam a atingir 50% da população idosa. Dentre os problemas mais comuns estão a dificuldade de adormecer e manter o sono, despertar no período da manhã e sonolência excessiva durante o dia. Esses problemas em relação ao sono quando se tornam crônicos podem impactar na saúde física da pessoa idosa, levando a inatividade física, redução das atividades de vida diária, depressão, problemas cardiometabólicos e maior incidência de mortalidade. [2,3]

A qualidade de vida pode ser entendida como a percepção do indivíduo sobre si mesmo em relação a própria vida, está relacionado a saúde física, a condição psicológica, vida financeira, socialização e capacidade de lhe dar com situações adversas. O termo “qualidade de vida relacionada à saúde (QVRS) é o termo normalmente utilizado. Há uma relação importante da sensação de prazer, prosperidade, conquistas e felicidade com a qualidade de vida. [4]

O Tai Chi Chuan, uma arte marcial chinesa milenar, se apresenta como arte cultural, ritual religioso, exercício físico e defesa pessoal envolve técnicas com movimentos suaves e contínuos podendo ser praticados por indivíduos de diferentes idades incluindo a pessoa idosa, com ou sem limitações físicas e mentais. Ganhos de força muscular, equilíbrio, melhora da função cognitiva e melhora da coordenação tem sido reconhecidos com a prática regular do Tai chi Chuan. [5,6]

O objetivo deste estudo é analisar as variáveis físicas relacionadas a qualidade de vida e sono em idosos com a prática das artes marciais.

Métodos: Este estudo caracteriza-se como revisão sistemática da literatura. Foram seguidos os critérios do Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [7]. O estudo foi registrado no registro porspectivo internacional de revisões sistemáticas sob o registro nº CRD42022360904. As estratégias de buscam ocorreram com dois autores independentes e experientes conduziram uma busca eletrônica sem filtros de idioma ou tempo de 01 a 04 de agosto de 2022 nas bases de dados MEDLINE (via PubMed), Scopus, SportDiscus e Web of Science. As palavras-chave relacionadas ao tema foram selecionadas com base em uma revisão da literatura e nos descritores em ciências da saúde (Decs/ Mesh). Em seguida, as palavras-chave foram agrupadas em uma única frase booleana da seguinte forma: pubmed: Search: (((martial arts) OR (fighting)) OR (combat sport)) AND (aged) Filters: Clinical Trial, Randomized Controlled Trial, English, Female, Male, Aged: 65+ years, 80 and over: 80+ Years (("martial arts"[MeSH Terms] OR ("martial"[All Fields] AND "arts"[All Fields]) OR "martial arts"[All Fields] OR ("fight"[All Fields] OR "fighting"[All Fields] OR "fights"[All Fields]) OR (("combat"[All Fields] OR "combatant"[All Fields] OR "combatants"[All Fields] OR "combated"[All Fields] OR "combating"[All Fields] OR "combats"[All Fields] OR "combatted"[All Fields] OR "combatting"[All Fields]) AND ("sport s"[All Fields] OR "sports"[MeSH Terms] OR "sports"[All Fields] OR "sport"[All Fields] OR "sporting"[All Fields]))) AND ("aged"[MeSH Terms] OR "aged"[All Fields])) AND ((clinicaltrial[Filter] OR

randomizedcontrolledtrial[Filter]) AND (female[Filter] OR male[Filter]) AND (english[Filter]) AND (aged[Filter] OR 80andover[Filter])); scopus: (TITLE-ABS-KEY (martial AND arts) OR TITLE-ABS-KEY (fighting) OR TITLE-ABS-KEY (combat AND sports) AND TITLE-ABS-KEY (aged)) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SRCTYPE , "j")); sportDiscus: AB martial arts OR AB fighting OR AB combat sports AND AB aged; Web of Science: (((AB=(martial arts)) OR AB=(fighting)) OR AB=(combat sport)) AND AB=(aged).

Nos critérios de elegibilidade foram incluídos estudos experimentais e quase experimentais que analisaram os efeitos do esporte de combate em idosos. Foram excluídos artigos publicados em congresso, artigos de revisão sistemática e metanálise.

O Risco de viés foi verificado através da ferramenta Risk of Bias In non-randomized Studies – of Interventions (ROBINS-I), que contém sete elementos para classificação e é realizada em 3 etapas, a seguir, no pré-intervenção, intervenção e pós-intervenção [8]. O único estudo [5] não randomizado apresentou risco baixo de viés pelos critérios da ferramenta. O risco de viés dos estudos experimentais foi realizado pela ferramenta Cochrane Collaboration, disponível em: <https://training.cochrane.org/handbook/>. Os estudos [3,9,10,11] apresentaram classificação “baixo” na avaliação de enviesamento.

Na qualidade metodológica todos os estudos apresentaram a classificação “incerto” no item de cegamento dos avaliadores, com exceção do estudo de Chen et al. [5] recebeu a classificação “alto” por não utilizar o processo de randomização na intervenção. [14]

Resultados: Os estudos variaram o ano de publicação entre 2002 e 2021. Em relação ao país de origem, 3 estudos são dos EUA [5,3,9] e 2 estudos da China [10,12]. Os ensaios clínicos randomizados aparecem em todos os estudos com exceção do estudo de intervenção quase experimental de Chen et al. [5]. A idade média do GE foi de 70 e do CG 72 anos. A média de 72 participantes no GE e 63 no GC. O sexo feminino foi evidenciado nos 5 estudos incluídos nessa revisão sistemática enquanto o masculino em 3 estudos. O número total de participantes foi de 764.

Dentre as artes marciais, apenas o Tai Chi Chuan (5 estudos) aparece evidenciando as variáveis propostas nesta revisão sistemática. A duração da intervenção variou entre 12 e 48 semanas e o volume de treinamento teve uma média de 45 minutos por sessão e 3 vezes por semana.

Nos 5 estudos incluídos nessa revisão sistemática as variáveis de qualidade de vida e

sono foram analisadas.

Discussão: Chen at al. [5], Chyu et al. [9], Chan et al. [10] analisaram a variável qualidade de vida. Houve redução ($p<0,05$) da perturbação total do humor e seus 6 estados (tensão-ansiedade, depressão-rejeição, raiva-hostilidade, vigor-atividade, fadiga-inércia e confusão-perplexidade) e aumentos ($p<0,05$) da saúde física e mental. Os testes percepção do estresse, SF12, alto eficácia, SF-36; O POMS-SF foram utilizados. Corroborando com Chen at al. [5], Chyu et al. [9], Chan et al. [10], Chittrakul et al. [12] conduziram um estudo com exercícios multicomponentes (força, flexibilidade, equilíbrio, tempo de reação e propriocepção), exercícios estes que envolvem qualidades físicas utilizadas nas artes marciais. Participaram do estudo 72 idosos divididos em 2 grupos (GE= 36 e GC= 36), de ambos os sexos e com idade média de 69 anos. Foi utilizado o questionário de qualidade de vida relacionada com saúde (HRQOL) e ambos os grupos apresentaram melhoras ($p<0,05$) na variável qualidade de vida.

O sono foi avaliado por Li et al. [3], Siu et al. [12], os estudos verificaram melhora ($p<0,05$) nesta variável. Os testes utilizados foram o de latência do sono, duração do sono, eficiência habitual do sono, distúrbios do sono, sonolência, tempo de vigília após o início do sono, número de despertares e tempo médio de despertar. Corroborando com Li et al. [3], Siu et al. [12], um estudo controlado randomizado conduzido por Irwin et al. [15] investigou 112 mulheres com idade média de 69 anos e o grupo experimental foi submetido ao Tai Chi Chuan minutos por dia, 3 x semana durante 16 semanas, houve melhora ($p<0,05$) no sono, os testes utilizados foram o escore global do questionário de pittsburgh sobre a qualidade do sono (PSQI), eficiência habitual do sono, qualidade do sono, duração do sono e distúrbio do sono.

Conclusão: De acordo com os 5 estudos incluídos nessa revisão sistemática as diferentes artes marciais são eficazes na saúde física e mental da pessoa idosa. Resultados favoráveis foram encontrados nas variáveis físicas da qualidade de vida e sono de idosos. Os estudos ao avaliarem o sono de idosos utilizaram em maior parte os meus protocolos de testagem facilitando a confirmação dos resultados encontrados, enquanto a avaliação da qualidade de vida diferentes protocolos foram utilizados. Vale ressaltar que é preciso investigar estudos envolvendo outras artes marciais (Capoeira, Kung-Fu, Krav-Magá, Aikido, Muay Thai, Sanda, Taekwondo, Sumô) e os possíveis efeitos na qualidade de vida e sono de idosos. Foi observado que há poucos estudos experimentais com artes marciais comparados a outras modalidades de esporte envolvendo idosos e possíveis benefícios em diferentes

variáveis físicas (força, flexibilidade e capacidade cardiorrespiratória) e mentais (autoestima e autoimagem) devem ser investigados.

Palavras-chave: Arte marcial; Idosos; Qualidade de vida, Sono.

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4 EFECTOS DEL TAEKWONDO SOBRE LA SALUD EN ADULTOS MAYORES: UNA REVISIÓN SISTEMÁTICA

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Effects of taekwondo on health in older people: a systematic review
Efectos del taekwondo sobre la salud en adultos mayores: una revisión sistemática

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Abstract. Objective: This study aimed to identify the effects of taekwondo on health in elderly individuals. Methods: A systematic literature review was conducted following the PRISMA recommendations and registered on PROSPERO, as number CRD42021279561. The electronic databases MEDLINE (via PubMed), Scopus, SPORTDiscus, and Web of Science were searched, with the Medical Subject Headings (MeSH) terms "martial arts" and "aged" and the alternative terms "taekwondo", "elderly", and "older". We included studies that analysed the effects of taekwondo on health-related variables in older adults of both sexes. The risk of bias of the included experimental and quasi-experimental studies were analysed using the Cochrane Collaboration tool and the Risk Of Bias In Non-randomised Studies – of Interventions (ROBINS-I) tool, respectively. Results: Seven studies met the eligibility criteria. The interventions of the included studies ranged from 6 to 17 weeks, with 45 to 90 minutes per training session, and frequency from 3 to 5 times a week. The total sample number was 160 participants, with a predominance of females in the samples. After the taekwondo intervention, the protocols demonstrated improvement in muscle strength, flexibility, balance, and body composition. Conclusion: The investigated studies showed that taekwondo can effectively maintain health and develop physical qualities in the older population. Nevertheless, these findings should be considered preliminary due to the relatively small sample and heterogeneity of the interventions of the identified studies.
Keywords: Sports, Exercise, Aged, Martial arts, Health.

Resumen. Objetivo: Este estudio tuvo como objetivo identificar los efectos del taekwondo en la salud de adultos mayores. Métodos: Se realizó una revisión sistemática de la literatura siguiendo las recomendaciones PRISMA y registrada en PROSPERO, con el número CRD42021279561. Se realizaron búsquedas en las bases de datos MEDLINE (a través de PubMed), Scopus, SPORTDiscus y Web of Science, con los términos del Medical SubjectHeadings (MeSH) "martialarts" y "aged" y los términos alternativos "taekwondo", "elderly", y "older". Se incluyeron estudios que analizaron los efectos del taekwondo sobre variables relacionadas con la salud en adultos mayores de ambos sexos. El riesgo de sesgo de los estudios experimentales y cuasiexperimentales incluidos se analizó mediante la herramienta de la Colaboración Cochrane y la herramienta Riesgo de sesgo en estudios no aleatorios de intervenciones (ROBINS-I), respectivamente. Resultados: Siete estudios cumplieron los criterios de elegibilidad. Las intervenciones de los estudios incluidos variaron de seis a 17 semanas, con 45 a 90 minutos por sesión de entrenamiento y una frecuencia de tres a cinco veces por semana. El número total de la muestra fue de 160 participantes, con predominio del sexo femenino. Los protocolos demostraron una mejora en la fuerza muscular, la flexibilidad, el equilibrio y la composición corporal después de la intervención de taekwondo. Conclusión: Los estudios investigados demostraron que el taekwondo puede ser efectivo en el mantenimiento de la salud y el desarrollo de las cualidades físicas en la población de adultos mayores. No obstante, estos hallazgos deben considerarse preliminares debido a la muestra relativamente pequeña y la heterogeneidad de las intervenciones de los estudios identificados.
Palabras clave: Deportes, Ejercicio, Envejecimiento, Artes marciales, Salud.

Introduction

Biological ageing is associated with a reduction in repair capacity and regenerative potential in human tissues and organs. The decrease in physiological reserve in response to stress (homeostenosis) is characterised by immunosenescence, a progressive degenerative process of the immune system (Khan et al., 2017).

Other factors related to ageing are osteopenia (loss of bone mass) and sarcopenia (loss of muscle mass). The search for functional autonomy is crucial and the loss of bone and muscle mass appears as a negative aspect in obtaining results related to the health of elderly people. Thus, osteoporosis presents itself as a public health problem and is correlated with the risk of fractures due to frailty (Cruz-Jentoft & Sayer, 2019; Curtis et al., 2015).

Likewise, structural and functional brain reductions occur with the ageing process, impairing reaction speed, perception, and memory. This entails difficulty in making decisions and performing daily life activities. Physical exercise plays an essential role in reducing these degenerative processes caused by senescence (Cho & Roh, 2019; Romero Ramos et al., 2021).

The number of deaths in older people is related to physical inactivity and can be caused by cerebrovascular, cardiovascular, metabolic diseases, age, gender, and lifestyle habits

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(Kim et al., 2021). According to Ramalho et al. (2021), a sedentary lifestyle is common in older people. This excessive daily sedentary behavior can be reduced to achieve healthy aging. There is a correlation between higher physical activity levels and a decrease in cardiovascular morbidity and mortality in the aging process. Older individuals who practice regular physical exercise show positive physiological responses (Honisett et al., 2016; Jakovljevic, 2018).

The regular practice of physical exercise has a prophylactic and therapeutic effect on older individuals, leading to better functional autonomy, improved quality of life, and performance of activities of daily living (Won et al., 2019; Ramalho et al., 2021). Hence, physical exercise works as a non-pharmacological strategy to maintain health during ageing. Additionally, it prevents diseases, preserves muscle mass and strength, improves body composition, and positively impacts the quality of life of older people (Galloza et al., 2017; Marcos-Pardo et al., 2019).

However, physical exercise, in its different forms such as resistance training, aerobic training, and aquatic exercises, is vital in maintaining and developing health. Martial arts are an option that can bring benefits to older people, such as improvements in motor coordination, static and dynamic balance, muscle strength, and endurance (Csapo & Alegre, 2016; Sungkaratet al., 2017; Silva et al., 2019; Seals et al., 2019). Among the various martial arts, there is taekwondo, which originated in Korea and entered the Olympic context in the Sydney 2000 Olympic Games (Apollaro & Ruscello, 2021).

Taekwondo is a combat sport practised in most countries worldwide with approximately 120 million children and adults around the world. The word taekwondo means "path of the feet and hands", which characterises this modality as a full-contact free-sparring sport that uses punching and kicking movements (Wazir et al., 2019; Castro-Garrido et al., 2020).

The practice of taekwondo can be an effective strategy for the older population. The diversity of frequency, intensity, duration, and type of application of this modality can optimise the results in the intervening physical qualities of the taekwondo martial art (Lee et al., 2019).

However, it is not clear in the scientific literature the contribution of this type of physical exercise to variables related to health in older people. This increases the need to expand scientific knowledge about the practice of taekwondo in aging. Therefore, the present study aimed to identify the effects of taekwondo on health in older individuals.

Methods

This study is characterised as a systematic literature review. The procedures for conducting this research followed the criteria of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021). The protocol of this study was registered in the International Prospective Register of Systematic Reviews (PROSPERO), with registration ID CRD42021279561.

Search strategy

Two experienced and independent researchers conducted an electronic search without language or time filters, in November 2021, in the MEDLINE (via PubMed), Scopus, SPORTDiscus, and Web of Science databases. Any divergences between the two researchers were solved through discussion or arbitration of a third researcher. The terms related to the theme were searched in the Health Sciences Descriptors (DeCS) and the Medical Subject Headings (MeSH) and the descriptors found were "martial arts" and "aged", and the alternative terms were "taekwondo", "elderly" and "older". Then, these terms were grouped in a single Boolean sentence as follows: "taekwondo AND elderly" OR "taekwondo AND older" OR "taekwondo AND aged" OR "martial arts AND elderly" OR "martial arts AND older" OR "martial arts AND aged".

Inclusion criteria

Experimental and quasi-experimental studies that analysed the effects of taekwondo on health-related variables in older adults of both sexes were included. Studies that did not use taekwondo as the primary intervention and articles published in congresses, systematic review articles, and meta-analyses were excluded.

Risk of bias assessment

Two authors independently assessed the risk of bias for each included study. If the score was inconsistent, a third author was consulted to decide the final score. We used the Risk of Bias In Non-randomized Studies – of Interventions (ROBINS-I) tool to verify the risk of bias in the quasi-experimental studies. This instrument contains seven elements for classification and is carried out in three stages, pre-intervention, intervention, and post-intervention. The risk of bias score is assigned to each domain according to the classification "high risk of bias", "severe risk of bias", "moderate risk of bias", "low risk of bias", and "no information" (Sterne et al., 2016).

To verify the risk of bias in the experimental studies, we used the Cochrane Collaboration tool, available at <https://training.cochrane.org/handbook/>. This instrument has seven domains that analyse the risk of bias from the randomised controlled trials (RCT): 1) generation of the random sequence; 2) allocation concealment; 3) blinding of evaluators and participants; 4) blinding of

outcome evaluators; 5) incomplete outcomes; 6) reports of selective outcomes; 7) report on other sources of bias. Each domain has the risk of bias classified as "high", "uncertain", or "low" (Carvalho et al., 2013).

Data extraction

Data from the included publications were extracted independently by two authors, and any discrepancies were settled in a consensus meeting with a third author. The variables extracted were: authors, publication year, country, characteristics of the study population (age, sex, and sample size), and intervention data, including general and specific exercises, duration of the intervention(weeks), training volume (duration of the training session, in minutes, and frequency, in times per week), evaluation, and outcome findings for physical and mental health.

Results

In total, 155 publications were found from the database search following the proposed research methodology (MEDLINE via PubMed = 19; Scopus = 63; SPORTDiscus = 8; Web of Science = 65). After using the selection criteria, a total of 7 studies were included: 4 RCT and 3 non-randomised studies (Figure 1).

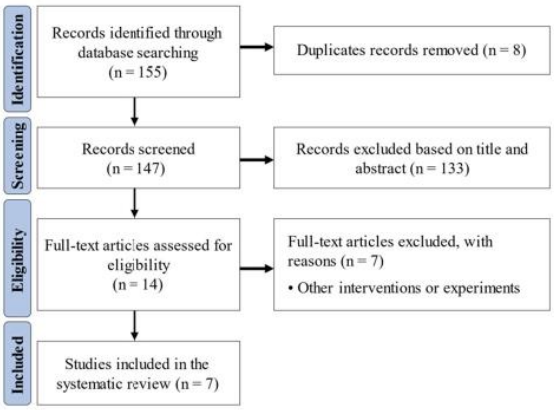

Figure 1. Flow diagram of study selection.

Table 1 shows the mean and standard deviation values of the experimental (EG) and control (CG) groups, sex, and sample size of the studies included in this systematic review. The mean age of the participants in the EG and CG of all included studies was 71.47 and 70.78 years old, respectively, and the average number of participants was 15.1. The sample of the included studies consisted of 160 participants, with 100 individuals from the EG and 60from the CG. Regarding the origin of the interventions, 5 studies (Baek et al., 2021; Cho & Roh, 2019; Kim et al., 2021; Kim & Park, 2012; Youm et al., 2011) were held in the home country of taekwondo, Korea. The years of publication ranged from 2002 to 2021. Females had greater participation in the number of volunteers in the included studies. Baek et al. (2021), Kim et al. (2021), and Lee et al. (2019) used a specific program for sample calculation.

Table 1
Sample characterisation.

Author, year	Country	Study design	Age: Mean ± SD (years)	Sex	Groups (n)
Baek et al., 2021	Korea	Intervention study	EG: 72.55 ± 5.45 CG: 72.40 ± 3.81	F	EG: 12 CG: 12
Brudnak et al., 2002	USA	Intervention study	EG: 71	F/M	EG: 12
Cho & Roh, 2019	Korea	RCT	EG: 68.89 ± 4.16 CG: 69.00 ± 4.41	F	EG: 19 CG: 18
Kim & Park, 2012	Korea	Intervention study	EG: 75.58 ± 0.58	F/M	EG: 17
Kim et al., 2021	Korea	RCT	EG: 72.90 ± 5.84 CG: 71.90 ± 3.11	F	EG: 10 CG: 10
Lee et al., 2019	Netherlands	RCT	EG: 70 ± 4 CG: 70 ± 4	F	EG: 10 CG: 10
Youm et al., 2011	Korea	RCT	EG1: 69.4 ± 5.8 EG2: 71.4 ±7.6 CG: 70.6 ± 4.8	F	EG: 20 CG: 10

SD: standard deviation; RCT: randomised controlled trial; EG: experimental group; CG: control group; F: female; M: male; USA: United States of America.

Table 2 presents the risk of bias in the non-randomised included studies by the ROBINS-I tool. Two studies (Baek et al., 2021; Kim & Park, 2012) had a moderate risk of bias, and one study (Brudnak et al., 2002) had a high risk of bias.

Table 2
Risk of bias of the non-randomised studies (ROBINS-I tool).

Studies	Bias due to confounding	Bias in the selection of participants into the study	Bias in the classification of interventions	Bias due to deviations from intended interventions	Bias due to missing data	Bias in measurement of outcomes	Bias in the selection of the reported result	Overall bias
Baek et al., 2021	NI	NI	Moderate	NI	NI	NI	NI	Moderate
Brudnak et al., 2002	High	Moderate	NI	High	High	High	High	High
Kim & Park, 2012	Moderate	Moderate	NI	NI	NI	NI	NI	Moderate

NI: No information.

Table 3 shows the risk of bias of the included RCT assessed through the Cochrane Collaboration tool. The four studies (Cho & Roh, 2019; Kim et al., 2021; Lee et al., 2019; Youm et al., 2011) were classified as having no risk of bias.

Table 3
Risk of bias analysis for randomised studies (Cochrane Collaboration tool).

Studies	1	2	3	4	5	6	7	Total
Cho & Roh, 2019	Low	Low	Low	Low	Low	Low	Low	Low
Kim et al., 2021	Low	Low	Low	Low	Low	Low	Low	Low
Lee et al., 2019	Low	Low	Low	Low	Low	Low	Low	Low
Youm et al., 2011	Low	Low	Low	Low	Low	Low	Low	Low

1: Randomisation; 2: Allocation of randomisation; 3: Blinding of participants; 4: Blinding of the evaluators; 5: Incomplete outcomes; 6: Report on the selective outcome; 7: Other sources of bias.

Table 4 shows the intervention characteristics and training volume of the studies. Most studies (Baek et al., 2021; Brudnak et al., 2002; Cho & Roh, 2019; Kim & Park, 2012; Kim et al., 2021; Lee et al., 2019; Youm et al., 2011) used 2 groups: 1 EG and 1 CG. Of these studies, EG participants performed specific taekwondo exercises and CG participants did not perform exercises. Warm-up, walking, stretching, and cool-down were also part of the intervention in the EG. The training intensity ranged from 40 to 80% using the physiological parameters heart rate and scores of 9 to 13 on the rating of perceived exertion (RPE-Borg). The training volume ranged from 6 to 17 weeks, 45 to 60 minutes per week, and 3 to 5 sessions per week.

Table 4
Study intervention data.

Study	Intervention	Duration (weeks)	VT
Baek et al., 2021	EG: Warm-up, walking, stretching, taekwondo-specific exercises, and cool-down Intensity: 1 to 6 weeks with RPE 10 and 11 7 and 12 weeks with RPE 12 and 13 CG: No exercise	12	60 min 3×/week
Brudnak et al., 2002	EG: Taekwondo training	17	NI
Cho & Roh, 2019	EG: Warm-up, walking, stretching, taekwondo training, and cool-down Intensity: 50–80% HRmax CG: No exercise	16	60 min 5×/week
Kim & Park, 2012	EG: Warm-up, taekwondo training, and cool-down	6	45 min 3×/week
Kim et al., 2021	EG: Warm-up, taekwondo training, and cool-down Intensity: weeks 1 to 4: 40–59% of HRR weeks 5 to 12: 60–75% of HRR CG: No exercise	12	90 min 3×/week
Lee et al., 2019	EG: Warm-up, taekwondo training, and cool-down Intensity: week 1 to 4: 30–40% of HRR last 4 weeks: increased up to 50–60% of HRR CG: No exercise	12	60 min 3×/week
Youm et al., 2011	EG1: Warm-up, taekwondo training, and cool-down EG2: Warm-up, stretching, walking, and cool-down Intensity (EG1 and EG2): weeks 1 to 4: 40–50% HRmax and 9–11 RPE weeks 5 to 12: 50–60% of HRmax and 9–13 RPE CG: No exercise	12	60 min 3×/week

EG: experimental group; CG: control group; VT: volume of training; RPE: rating of perceived exertion; HRmax: maximum heart rate; HRR: heart rate reserve; min: minutes; ×/week: times a week; NI: not informed.

Table 5 presents the extracted data regarding the evaluation and results. According to each study, the evaluation variable was divided between 1 and 4 moments. Functional fitness and balance appeared more frequently in the included studies. Variables such as muscle strength, depression, body composition, and physiological markers were also analysed. Regarding the statistical treatment performed in the studies, all authors, except for Brudnak et al. (2002), used a significance level of $p<0.05$ in inter and intra-group comparisons.

Discussion

The present study aimed to identify the effects of taekwondo on variables related to physical and mental health in older people. The analysis of the 7 included studies showed that taekwondo practice for at least 6 weeks, 3 sessions with 45 minutes per week, can be effective in the performance of balance and gait of elderly people.

In the study by Baek et al. (2021), functional fitness and depression were evaluated. After the intervention with taekwondo, positive results were observed in increasing functional fitness and reducing levels of depression in the elderly. In a similar study, Lee et al. (2019) found improvement in physical fitness results with the application of taekwondo techniques compared to the CG, which did not perform physical exercises. Those studies used different instruments to assess the same variable, including anthropometry, physical fitness, biochemical factors, and cognitive activity. However, regarding physical fitness, studies by Cho and Roh (2019) and Kim et al. (2021) found similar significant results on increased post-taekwondo intervention physical fitness in older adults.

Studies by Kim and Park (2012) and Brudnak et al. (2002) analysed body positioning during walking and balance and Youm et al. (2011) verified the balance. In the studies conducted by Kim and Park (2012), Brudnak et al. (2002), and Youm et al. (2011), the balance variable showed significant improvement after the intervention. Regarding the body position variable, there was a significant improvement ($p < 0.05$) in the studies presented by Kim and Park (2012) and Brudnak et al. (2002).

Studies involving other martial arts corroborate this systematic review, such as the experimental study by Cojocariu and Cuza (2012). Eight individuals aged between 50 and 60 years practiced martial arts exercises for 6 months, 2 times a week, 1 hour per session. The authors found an increase in cardiorespiratory function (mL/kg·min), a reduction in resting heart rate (bpm), a reduction in systolic blood pressure at rest (mmHg), and an increase in lung elasticity (cm). Likewise, Kim et al. (2021) found significant improvements in the assessment of cardiovascular factors after 12 weeks of taekwondo practice, 3 times a week, 90 minutes per session.

Table 5
Evaluation data and results of the included studies.

Study	Assessment	Results (EG)
Baek et al., 2021	Physical fitness	↑ hand grip strength (*d*=1.81); ↑ gait speed (*d*= 2.00)
	Body composition	↓ BMI (*d*=-0.29); %BF (*d*=-0.56)
	Mental health	↑ GDS-K (*d*=1.41); ↑ K-DSQ (*d*=-0.95)
	Biochemical markers	↓ total cholesterol (*d*=-1.25); ↓ LDL (*d*=-1.07); ↓ adiponectin (*d*= 0.98); ↓ arteriosclerosis index (*d*= -1.39); ↓ β-amyloid (*d*=-0.51); ↔ irisin (*d*=-0.50)
Brudnak et al., 2002	Physical fitness	↑ 3.5-inch flexibility; ↑ one leg balance; ↑ pushups
Cho & Roh, 2019	Physical fitness	↑ 30 s chair stand (*d*=0.65); ↑ chair sit-and-reach (*d*=0.21); ↑2 min step (*d*=0.36); ↔ 30 s arm curl (d=0.03); ↔ back scratch (*d*=-0.07); ↔ 2.44 m up-and-go (*d*=-0.18)
	Neurotrophic growth	↑ BDNF (*d*=0.65); ↑ VEGF (*d*=0.15); ↑ IGF-1 (*d*=0.27)
	CBF velocity	↔ SFV (*d*=0.02). DFV (*d*=0.07). and MFV (*d*=0.05) of MCAs
	Cognitive function	↑ MMSE-DS (*d*= 0.37); ↑ color-word test (*d*=0.47)
Kim & Park, 2012	Physical fitnes	↑ maximum oscillation (*d*=-3.56); ↑ oscillation distance (*d*=-2.29); ↑oscillation area (*d*=-0.87)
	Gait	↑ BBS (*d*=0.08); ↔ gait time (*d*=0.00); ↑ step length (*d*=1.79); ↓ right base of support (*d*=-3.89); ↓right limb support time (*d*=-3.57); ↑ left stride length; ↔ right stride length (*d*=2.36)
Kim et al., 2021	Physical fitness	↑ moderate-high intensity physical activity (*d*=3.42); ↑ handgrip strength (*d*=0.76); ↑ step count (*d*=4.41); ↑ trunk flexion in a sitting position (*d*=0.76); ↑ 2 min walk (*d*=0.96)
	Body composition	↓ BMI (*d*=-0.16); ↑ lean body mass(*d*=0.57); ↓ %BF (*d*=-0.75); ↓ hip circumference (*d*=-0.65)
	CVD risk factors and EAT	↓ total cholesterol (*d*=-0.77); ↓ triglycerides (*d*=-0.77); ↑ HDL (*d*=1.32); ↓ LDL (*d*=-0.77); ↓ interleukin-1β (*d*=-1.00); ↓ TNF1 (*d*=-0.89); ↓ MVO_2 rest (*d*=-1.29); ↓ diastolic blood pressure (*d*=-2.58); ↓ systolic blood pressure (*d*=-1.75); ↓ EAT (*d*=-0.11) ; ↔ mean blood pressure (*d*=-2.32)
Lee et al., 2019	Physical fitness	↓ HR (*d*=-0.77). ↓ systolic blood pressure (*d*=7.00); ↓ diastolic blood pressure (*d*=-5.50); ↑ hand grip strength (*d*=-0.75); ↑ leg strength (*d*= 0.33)
	Body composition	↓ BMI (*d*=-0.63)
	Biochemical marker	↓ epinephrine
	Pulse wave velocity	↓ brachial-ankle pulse wave velocity
Youm et al., 2011	Physical fitness	↓ COP trajectories (*d*=-1.32)

EG: experimental group; BMI: body mass index; %BF: body fat percentage; GDS-K: Geriatric Depression Scale-Korea; K-DSQ: Korean Dementia Screening Questionnaire; MMSE-DS: Mini-Mental State Examination for dementia screening; LDL: low-density lipoprotein; HDL: high-density lipoprotein; CBF: cerebral blood flow; SFV: systolic flow velocity; DFV: diastolic flow velocity; MFV: mean flow velocity; MCAs: middle cerebral arteries; BDNF: brain-derived neurotrophic factor; VEGF: vascular endothelial growth factor; IGF-1: insulin-like growth factor I; BBS: Berg balance scale; CVD: cardiovascular disease; TNF1: tumor necrosis factor-1; MVO_2: measurement of the oxygen consumed by the myocardium muscle; EAT: epicardial adipose tissue; HR: heart rate; COP: center of pressure; *d*: Cohen's *d* effect size. ↑ increase; ↔ maintenance; ↓ reduction.

The study conducted by Mendonça et al. (2017) compared 20 older Kendo fighters in terms of quality of life, strength (kg), balance, and body composition (kg). Participants were divided into 2 groups: the Kendo group (age: 71.8 ± 5.4 years) and the CG (age: 73.1 ± 4.8 years). The results showed gains in strength, balance, quality of life, and better body composition in the EG compared to the CG.

Ma et al. (2019) analysed 33 older people who received an intervention with 1 hour per session, and 2 sessions per week for 3 months. The results revealed that the mean latency of onset of gastrocnemius muscle activation (ms) was significantly higher in the EG after the intervention. The time to peak strength in the knee flexors (kg) was significantly longer in the EG but not in the CG at post-test compared to the pre-test value.

Following the same line of intervention, Kim et al. (2019) analysed a total of 46 older women divided into 2 groups, group 1 (Tai chi) and group 2 (Taekkyon), with a mean age of 71.4 ± 3.3 and 70.9 ± 4.3 years, respectively. Both groups completed 1 hour of Tai chi or Taekkyon exercises twice a week for 12 consecutive weeks (24 sessions in total). The study aimed to compare the effects of Tai chi and Taekkyon exercise programs on lower limb strength, balance, and gait ability in community-dwelling elderly women as a method of preventing falls. Both groups showed improvements ($p < 0.05$) in balance (s), muscle strength (kg), and spatiotemporal gait parameters (cm/s), except for step width.

Additionally, Lip et al. (2015) investigated 12 elderly people divided into 2 groups: EG (n=12; age: 69.0 ± 7.3 years) and CG (n= 27; age: 74.0 ± 4.7 years). The intervention lasted 3 months in the EG while the CG did not receive any type of training. This study investigated the effects of the Chinese martial art Ving Tsun on radial bone strength, upper and lower limb muscle strength (kg), shoulder joint mobility, and balance performance. The results showed that there was no statistically significant difference in time interaction effect, group effect, and time effect for all outcome variables. However, general maintenance trends or improvement in all outcome parameters were observed to a greater extent in the EG than in the CG.

In evaluating the risk of bias in the studies, according to the ROBINS-I tool, two studies (Baek et al., 2021; Kim & Park, 2012) were classified as "moderate risk of bias", presenting an intervention activity in disagreement with the study. The study by Brudnak et al. (2002) was classified as "high risk of bias", as data were omitted, confusing the allocation of participants, reliability of assessments, and lack of statistical data. However, four studies (Kim et al., 2021; Lee et al., 2019; Youm et al., 2011; Cho & Roh, 2019) presented significant sample numbers, statistical data, and results within the evaluation criteria according to the Cochrane Collaboration tool, ranking them at low risk of bias. A strong point in the included studies was the intervention, which was characterised by warm-up, stretching, specific taekwondo techniques involving kicking, punching, forms, fighting techniques, and cool-down, factors that improve physical fitness and development of functional autonomy.

Some variations in the results related to the physical fitness variable in the studies included in the present systematic review can be justified due to the different intervention methods, time, volume, and training intensity. It should be considered that taekwondo has a variety of techniques and movements that can generate different physiological responses after a training period.

The present study has some limitations. The first limitation was the low number of studies that were screened according to the search strategy addressing the effectiveness of taekwondo in older people. The second limitation was the presence of different intervention methods in analysing the effects of taekwondo in older people.

Conclusion

Taekwondo presented itself as an intervention that brings positive responses to health by promoting improvements in physical fitness, physiological, biochemical, and cognitive variables of older individuals. Increases in physical fitness, improvements in physiological components, and cognitive activities were verified in the studies included in this systematic review, confirming that Korean martial art can improve the health of the older population. Thus, the practice of taekwondo regularly can be an efficient intervention strategy to minimize the deleterious effects of aging and provide a better perception of the health state and well-being of older people.

However, further experimental studies are needed to verify the effects of taekwondo in this population, which, due to senescence, present physiological degenerative processes in different body systems. It is suggested that future studies analyse possible changes in aspects of exercise science, such as bone mineral density, cardiac alterations, and muscle markers to elucidate other effects of taekwondo in older individuals.

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5 IMPACTO DO TAEKWONDO SOBRE OS MARCADORES FISIOLÓGICOS DE REMODELAGEM ÓSSEA, FORÇA MUSCULAR, AUTONOMIA FUNCIONAL, AUTOESTIMA E AUTOIMAGEM EM IDOSAS: UM ENSAIO CLINICO RANDOMIZADO

Impacto do taekwondo sobre os marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosas: um ensaio clinico randomizado

RESUMO

Contextualização: O envelhecimento biológico está associado a redução na capacidade reparadora e potencial regenerativa em tecidos e órgãos. A atividade física como intervenção não farmacológica é recomendada de maneira adequada e por longos períodos no tratamento da osteoporose, pois não produz efeitos colaterais. Desta forma, o taekwondo pode apresentar melhoras no desenvolvimento esquelético, coordenação motora geral e equilíbrio em indivíduos de qualquer idade, sobretudo em idosos. **Objetivo:** Este estudo teve como objetivo verificar os efeitos do treinamento do taekwondo sobre marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosos. **Métodos:** Trata-se de uma pesquisa experimental com desenho para dois grupos onde foram avaliados pré e pós período de intervenção. A amostra foi composta por 27 mulheres idosas inexperientes com a prática do taekwondo com a faixa de idade entre 60 e 70 anos distribuidos randomicamente. Foram avaliados a autoestima, autoimagem, medidas antropométricas, autonomia funcional e biomarcadores ósseos (fosfatase alcalina, fósforo sérico, vitamina B12, vitamina D e PTH). **Resultados:** Houve melhora ($p<0,05$) da autoestima e autoimagem na comparação intergrupo e intragrupo. A força muscular foi uma das variáveis investigadas neste estudo, os testes de flexão de cotovelo e, sentar e levantar foram utilizados, no GE aumentos ($p<0,05$) da força muscular foram encontrados na comparação intragrupo e intergrupo (pós-teste) em ambos os testes. Na avaliação da autoestima foram encontradas diferenças ($p<0,05$) nos GE e GC na comparação intragrupo e intergrupo indicando aumentos da autoestima. Na autonomia funcional, foi utilizado o protocolo GDLAM, houve aumento ($p<0,05$) no GE na avaliação intragrupo. Na avaliação dos biomarcadores ósseos foram encontradas diferenças ($p<0,05$) em todas as variáveis analisadas na comparação intragrupo (pré *vs* pós) no GE. **Conclusão:** Os resultados encontrados neste estudo experimental apoiam a eficácia da prática do taekwondo nos marcadores fisiológicos de remodelagem óssea, na força muscular, na autonomia funcional e na automiagem de idosos.

Palavras-Chave: Idosos. Taekwondo. Remodelagem óssea. Atividades da vida diária.

ABSTRACT

Background: Biological aging is associated with a reduction in repair capacity and regenerative potential in tissues and organs. Physical activity as a non-pharmacological intervention is appropriately recommended and for long periods in the treatment of osteoporosis, as it does not produce side effects. In this way, taekwondo can improve skeletal development, general motor coordination and balance in individuals of any age, especially in the elderly. **Objective:** This study aimed to verify the effects of taekwondo training on physiological markers of bone remodeling, muscle strength, functional autonomy, self-esteem and self-image in the elderly. **Methods:** This is an experimental study designed for two groups where pre and post intervention periods were evaluated. The sample consisted of 27 elderly women inexperienced with the practice of taekwondo with the age range between 60 and 70 years distributed randomly. Self-esteem, self-image, anthropometric measurements, functional autonomy and bone biomarkers (alkaline phosphatase, serum phosphorus, vitamin B12, vitamin D and PTH) were evaluated. **Results:** There was an improvement ($p<0.05$) in self-esteem and self-image in the intergroup and intragroup comparison. Muscle strength was one of the variables investigated in this study, the elbow flexion and sitting and standing tests were used, in the EG increases ($p<0.05$) of muscle strength were found in the intragroup and intergroup comparison (post-test) in both tests. In the evaluation of self-esteem, differences ($p<0.05$) were found in the EG and CG in the intragroup and intergroup comparison, indicating increases in self-esteem. In functional autonomy, the GDLAM protocol was used, there was an increase ($p<0.05$) in EG in the intragroup evaluation. In the evaluation of bone biomarkers, differences ($p<0.05$) were found in all variables analyzed in the intragroup comparison (pre vs. post) in the EG. **Conclusion:** The results found in this experimental study support the effectiveness of taekwondo practice on physiological markers of bone remodeling, muscle strength, functional autonomy and self-image in the elderly.

Keywords: Older. Taekwondo. Bone remodeling.

INTRODUÇÃO

O envelhecimento biológico está associado a uma redução na capacidade reparadora e potencial regenerativo em tecidos e órgãos. Esta redução se manifesta como diminuição da reserva fisiológica em resposta ao estresse (denominada homeostenose), que é caracterizada pela imunossenescência, sendo considerado como um processo degenerativo progressivo no sistema imunológico (EL-KADER et al., 2018; KHAN et al., 2017).

No envelhecimento, a busca pela independência é importante e a perda de massa óssea e muscular aparecem como fatores negativos na obtenção desse resultado. Nesse contexto, a osteoporose se apresenta como um problema de saúde pública e é correlacionada por riscos de fraturas devido a fragilidade (CURTIS et al., 2015). Em indivíduos adultos, o osso sofre mudanças levando a um processo de remodelagem e reabsorção constante. Assim, marcadores ósseos específicos podem quantificar esses processos que representam indicadores precoce de alterações patológicas ósseas como a osteoporose, além de trazer dados mais rápidos que a medida óssea (RADUT et al., 2019).

A prevalência de sarcopenia pode variar de 3% a 24% dependendo dos critérios de diagnóstico usados e aumenta com a idade (TOURNADRE et al., 2018). Assim, a sarcopenia pode reduzir a função muscular e execução das atividades da vida diária (AVD) (CURTIS et al., 2015). Nesse sentido, indivíduos idosos necessitam preservar a autonomia funcional para otimizar suas AVD. Assim, atividade física regular pode contribuir positivamente sobre a autonomia funcional, redução do risco de quedas e prevenção de doenças crônico não transmissíveis. A força muscular pode impactar diretamente sobre as AVD e aspectos relacionados a autoestima e autoimagem. (ARAÚJO-GOMES et al., 2020; MARCOS-PARDO et al., 2019; TYLKA; WOOD-BARCALOW, 2015; WEBB; WOOD-BARCALOW; TYLKA, 2015).

Na remodelagem óssea, deficiências nutricionais, como vitamina B12), causam doenças graves como insuficiência de crescimento e estresse oxidativo (HUEMER; BAUMGARTNER, 2019). Outro marcador ósseo é o fósforo sérico em que os níveis sofrem influência do hormônio da paratireóide, fator de crescimento de fibroblastos23 e vitamina D nos rins, ossos e sistema digestivo. Pessoas com 50 anos ou mais apresentam riscos altos de doenças ósseas, que aumentam o fósforo sérico e, consequentemente, podem elevar os riscos de mortalidade e doenças cardiovasculares (SUKI; MOORE, 2016). A suplementação de vitamina D3 mostrou resultados positivos ao sistema musculoesquelético em idosos, aumento na área de secção transversa das fibras musculares do tipo II, ganho de força muscular e redução

do risco de queda (ANTONIAK; GREIG., 2017). Para a manutenção da saúde óssea, recomenda-se uma ingestão ideal de cálcio, vitamina D e proteínas (GROENENDIJK et al., 2020). Outros marcadores como propeptídeo aminoterminal do procolágeno tipo 1 (P1NP) e osteocalcina se fazem presentes nesse contexto, pois existe correlação entre danos no metabolismo ósseo e concentrações elevadas de fosfatase alcalina em diferentes patologias (MILIONI et al., 2014).

O envelhecimento ativo, por meio da atividade física regular, estimula a formação óssea. Benedetti et al. (2018), Jakovljevic (2018) e Honisett et al. (2016) mostraram que a terapia hormonal e exercícios têm efeitos protetores bem estabelecidos nos parâmetros ósseos e a utilização de marcadores fisiológicos são importantes na análise da maturação óssea.

A atividade física como intervenção não farmacológica é recomendada de maneira adequada e por longos períodos no tratamento da osteoporose, pois não produz efeitos colaterais (ZHANG et al., 2019). O nível de esforço para atividade física deve ser relativo ao nível de aptidão e habilidade do adulto mais velho (MORA; VALENCIA, 2017). O osso responde melhor a cargas mecânicas, levando a modificações ósseas e da massa e força muscular (WATSON et al., 2017). Essas alterações favorecem a percepção de autoestima e autoimagem por aumentarem o desempenho sobre as AVD (ARAÚJO-GOMES et al., 2020; MARCOS-PARDO et al., 2019; TYLKA; WOOD-BARCALOW, 2015; WEBB; WOOD-BARCALOW; TYLKA, 2015). Dentre as diferentes variações de atividades físicas, o taekwondo e muitos outros esportes de lutas vêm se popularizando nas últimas décadas com um crescente número de participantes. A pratica regular de taekwondo em idosos melhora a aptidão física e a função cognitiva. (CHO et al., 2018; MA et al., 2018; WAZIR et al., 2020).

A perda óssea relacionada com a perda de força muscular pode afetar as condições de realização das AVD e, por consequência, a autoestima e autoimagem em idosos. Dessa forma, o objetivo do presente estudo foi analisar os efeitos do treinamento do taekwondo sobre marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em mulheres idosas.

MÉTODOS

Delineamento

Trata-se de uma pesquisa experimental com desenho para dois grupos onde foram avaliados pré e pós período de intervenção (THOMAS; NELSON; SILVERMAN., 2012).

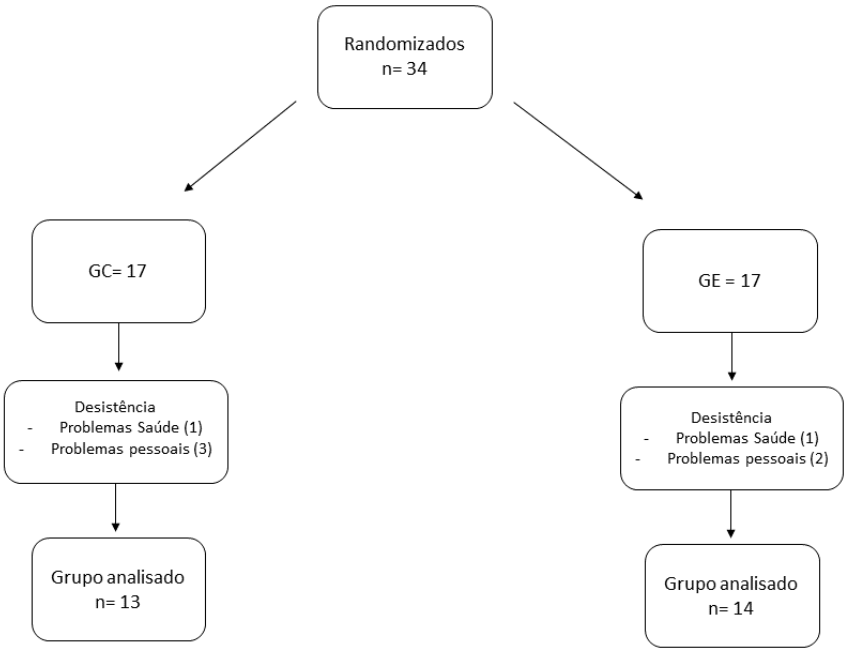
Participantes

A amostra foi composta por indivíduos idosos sedentários e inexperientes com a prática do taekwondo, moradores da cidade de Campos dos Goytacazes -RJ, pertencentes a faixa de idade entre 60 e 70 anos. O tamanho da amostra estimado pelo software G-Power, versão 3.1.9.4 foi de 24 indivíduos (FAUL et al., 2007). Para tal estimativa, as seguintes informações foram introduzidas: ANOVA com medidas repetidas para dois grupos em dois momentos de avaliação, tamanho do efeito de 0,30, alfa de 0,05, poder do experimento de 0,80 e correlação entre as medidas de 0,5 (BECK, 2013). No entanto, prevendo desistências, foram recrutadas 34 pessoas idosas.

Os participantes foram distribuídos randomicamente em dois grupos, utilizando-se a função aleatória do software Excel. Foram incluídos aqueles que não estivessem praticando exercícios físicos por pelo menos 6 meses. Foram excluídos os participantes que apresentaram alguma contraindicação para a prática regular de exercícios físicos, como lesões osteomioarticulares, metabólicas ou cardiovasculares, aqueles que estiveram fazendo reposição hormonal ou apresentem risco alto na triagem pré-exercício proposto pelo PAR-Q.

Todos os indivíduos concordantes com a participação do presente estudo assinaram o Termo de Consentimento Livre e Esclarecido (TCLE), respeitando a resolução 466/12 do Conselho Nacional de Saúde. O estudo foi submetido a um comitê de ética e pesquisa pela plataforma Brasil com aprovação do Hospital Universitário Pedro Ernesto/Uerj sob o registro CAAE: 51572321.6.0000.5259 e na REBEC sob o registro RBR-5jzcc5q.

Figura 1. Fluxograma de coleta de dados



Fonte: Autoria própria.

Procedimentos de coleta de dados

Na primeira visita foi esclarecido para cada indivíduo os procedimentos do estudo. Foi solicitado o preenchimento do termo de consentimento livre e esclarecido (TCLE) e da triagem pré-exercício do PAR-Q, anamnese e liberação médica por atestado para a pratica de exercícios físicos. Foram aplicados os instrumentos de avaliação da autoestima e autoimagem e em seguida serão feitas as avaliações antropométricas. Anamnese, aplicação do PARQ e explicação do estudo foram utilizadas para a garantia de segurança de que o indivíduo esteve qualificado para a realização dos testes. O PAR-Q é umquestionário composto por 7 perguntas com o intuito de detectar possíveis riscos para a realização de alguma atividade física. Caso alguma das perguntas tenha resposta positiva, o indivíduo será aconselhado a não realizar a atividade e será sugerido que se encaminhe para avaliação médica (WARBURTON et al., 2011).

No segundo dia de visita foram realizados os testes de força muscular e autonomia funcional. No terceiro dia de visita foram realizadas as coletas sanguíneas dos grupos experimental e controle para análise dos marcardores fisiológicos: fosfatase alcalina, vitamina B12, fósforo sérico, Vitamina D e PTH e o exame de densidade mineral óssea.

Em seguida os participantes realizaram 12 semanas de intervenção específica para cada grupo e por último uma nova coleta de dados de todas as variáveis do estudo com exceção da densidade mineral óssea que foi realizada somente antes da intervenção.

Avaliação Antropométrica

Para a avaliação da massa corporal total e da estatura dos indivíduos participantes foi utilizada uma balança mecânica com estadiômetro da marca Filizola®, máx. 150kg, min. 2,5kg e=100g. Apenas um único avaliador aferiu as medidas de todos os participantes do estudo e essas medidas foram posteriormente utilizadas para a realização do cálculo do índice de massa corporal (IMC) (MARFELL-JONES; STEWART; RIDDER., 2012).

Autoestima

Para a avaliação da autoestima, a escala de autoestima de Rosenberg (Rosenberg Self-Esteem Scale – RSES) foi utilizada. Ela é formada por 10 questões que avaliam a autoestima. A RSES é avaliada somando os itens tipo Likert de 4 pontos (discordo fortemente = 0, discordo = 1, Concordo = 2, Concordo fortemente = 3). As afirmações positivas (1, 2, 4, 6, 7) e as negativas (3, 5, 8, 9, 10) estão misturadas e o resultado é obtido através da soma da pontuação

de acordo com as respostas dos participantes. Uma pontuação inferior a 15 indica uma autoestima muito baixa, entre 15 e 25 pontos demonstra uma autoestima saudável e uma pontuação maior que 25 nos mostra uma pessoa forte e sólida. Porém, pode indicar que o participante não está sendo verdadeiro com as suas respostas, sendo o ideal, a pontuação está entre 15 e 25 pontos (PECHORRO et al., 2011; ROSENBERG, 1989).

Autoimagem

Para a avaliação da imagem corporal, foi aplicado o questionário de imagem corporal. O instrumento é composto de 22 itens agrupados em quatro dimensões: condição física (CF, itens 1 a 4); habilidades corporais (HC, itens 5 a 8); saúde (S, itens 9 a 18) e aparência (A, itens 19 a 22). O respondente avalia cada um dos itens segundo uma escala de 0 a 2 pontos, onde o nível 0 corresponde a "Não Forte", o nível 1 a "Forte" e o nível 2 a "Bastante Forte". O escore do teste varia de zero a 44 pontos, permitindo ao indivíduo fornecer informações acerca de como percebe o seu corpo (GAMA et al., 2019).

Força muscular

Os testes de flexão de cotovelos e sentar e levantar (RIKLI e JONES, 1999) foram aplicados para avaliar a força muscular dos membros superiores e inferiores, respectivamente.

Autonomia funcional

Na avaliação da autnomia funcional foi utilizado o protocolo de GDLAM de autonomia funcional voltado para a realização das atividades da vida diária (AVD) (DANTAS e VALE, 2004; VALE, 2005; DANTAS et al., 2014), composto dos testes C10m (caminhar 10 metros)(SIPLA et al., 1996), LPS (levantar da posição sentada) (GURALNIK et al., 1994), LPDV (levantar da posição de decúbito ventral) (ALEXANDER et al., 1997), VTC (vestir e tirar a camisa) (VALE et al., 2006) e LCLC (levantar da cadeira e locomover-se pela casa) (ANDREOTTI e OKUMA., 1999). Todos os testes foram aplicados duas vezes com um intervalo de cinco minutos e o melhor tempo de execução, em segundos, foi coletado. Em seguida, o índice de autonomia GDLAM (IG) foi calculado para a análise geral da autonomia funcional.

Fórmula: IG=[(((C10m+LPS+LPDV+VTC)x2)+LCLC)]÷4

Coleta sanguínea e exame de densidade mineral óssea

Na coleta sanguínea, a análise do paratormônio (PTH) ocorreu pelo método quimioluminescência. Já a vitamina B12 e vitamina D foram avaliadas pelo método cromatografia líquida de alta performance – hplc. A fosfatase alcalina utilizou o método cinético optimizado e o fósforo sérico será analisado pelo método cinético u.v. (PARDINI., 2016).

O exame de densidade mineral óssea da coluna lombar e do colo do fêmur foi feito por um aparelho de absortometria de Raios X de dupla energia (DXA) da marca QDR (Hologic, Inc., Marlborough, MA, EUA) (LEE et al., 2017; PORCELLI et al., 2020).

Os exames de coleta sanguínea foram realizados 24 horas antes do inicio da intervenção e 72 horas após a intervenção. A densidade mineral óssea foi realizada antes do inicio da intervenção apenas para caracterização da amostra. Todos os exames dos marcadores bioquímicos foram duplicados e o coeficiente de variação (CV) foi menor que 3%.

Intervenção

O taekwondo foi aplicado 3 vezes por semana com 40 minutos por sessão por um período de 12 semanas. Cada sessão foi composta por 5 minutos de aquecimento, 30 minutos do taekwondo e 5 minutos de volta à calma.

O aquecimento foi composto por exercícios de mobilidade articular envolvendo articulações do punho, cotovelos, ombros, pescoço, quadril, joelhos e tornozelos totalizando 3 minutos. O alongamento estático ativo foi realizado nas articulações dos punhos, ombros, quadris, joelhos e tornozelos totalizando 2 minutos (MCGORM et al., 2018; THOMAS et al., 2018).

Os exercícios de taekwondo foram compostos por movimentos ondulatórios, técnica específica do do taekwondo no estilo da International Taekwondo Federation (ITF), em diferentes bases de membros inferiores; chutes (mais baixos e mais simples que os convencionais) e socos (movimentos mais simples) ajustados, realizados individualmente e em duplas; realização das formas (*Tulls*) (Tabela 1), ou seja, sequência de movimentos combinados específicos do taekwondo ITF (CHOI, 1985). A volta à calma foi composta por exercícios de relaxamento em posição em pé, seguida das posições sentada e em decúbito dorsal, envolvendo as articulações e músculos envolvidos na intervenção proposta, totalizando 5 minutos (CALLEJA-GONZALEZ et al., 2018). O controle de intensidade das sessões de

taekwondo ajustado foi realizado pela percepção subjetiva de esforço (PSE) por meio da escala OMNI-RES (ROBERTSON et al., 2003), utilizando-se os níveis entre 3 e 4 nas primeiras 4 semanas de intervenção e níveis entre 5 e 7 nas demais semanas. Foram utilizados implementos (aparadores de chute e soco) para execução dos movimentos.

Os indivíduos do grupo controle participaram de palestras educacionais sobre temas relacionados a saúde e qualidade de vida 1 por semana, atividades recreacionais (jogos de tabuleiro) 1 vez por semana e caminhada 1 vez por semana com 40 minutos por sessão, durante 12 semanas.

Tabela 1. Programa de taekwondo

Item	**Conteúdo**	**Tempo (min)**
Aquecimento	Exercícios de mobilidade articular e alongamento estático envolvendo articulações do punho, cotovelos, ombros, pescoço, quadril, joelhos e tornozelos	5 min
Taekwondo	1 - 6 semanas; PSE: 2 - 4 7- 12 semanas; PSE: 5 - 8	30 min
	Movimentos ondulatórios em diferentes bases do taekwondo (anun sogi, niunja sogi, ogun sogi); chutes (Najunde Chagi, Dollyo Chagi, Yop Dollyo Chagi, Ap Chagi, an chagi, neryo chagi) e socos (Gunnun So Baro Jirugi, Gunnun So Bandae Jirugi) mais baixos e mais simples que os convencionais; formas (Tulls)	
Volta a calma	Exercícios de relaxamento em posição em pé, seguida das posições sentada e em decúbito dorsal, envolvendo as articulações e músculos envolvidos na intervenção proposta	5 min

PSE: percepção subjetiva de esforço (OMNI-RES).

Análise de Dados

Os dados coletados foram tratados pelo software IBM SPSS Statistics 25 e apresentados como média e desvio padrão. O teste t-Student para amostras independentes foi aplicado no inicio do estudo para verificar se os grupos eram diferentes no *baseline*. A normalidade e esfericidade dos dados foi verificadas por meio dos testes de Shapiro-Wilk e Bartlett, respectivamente. A análise de variância (ANOVA 2 x 2) com medidas repetidas, seguida do post hoc de Bonferroni ajustado, foi aplicada para analisar as possíveis diferenças entre as variáveis dependentes. O estudo admitiu o nível de $p<0,05$ para a significância estatística. O tamanho do efeito (*d*) de Cohen foi utilizado para a análise do impacto clínico

nas variáveis de interesse. Foram interpretados de acordo com a padronização a seguir: 0,2 (pequeno), 0,5 (médio) e 0,8 (grande) (COHEN, 1992).

RESULTADOS

A tabela 2 apresenta a caracterização da amostra por grupos, em valores de média e desvio padrão quanto ao peso, a estatura, a idade, e o IMC. O teste t para amostras independentes mostrou que os grupos eram semelhantes no início do estudo, pois não houve diferença (p>0,05) entre as variáveis analisadas.

Tabela 2. Características básicas dos participantes

	GC (n=13)	GE (n=14)	Valor p
Idade (anos)	66,00 ± 5,18	65,71 ± 5,65	0,892
MCT (kg)	67,64 ± 8,04	65,63 ± 9,03	0,548
Estatura (m)	1,63 ± 0,07	1,63 ± 0,06	0,906
IMC (kg/mt^2)	25,60 ± 3,01	25,63 ± 3,99	0,981
Lombar (g/cm^2)	0,910 ± 0,06	0,97 ± 0,06	0,085
Femur (g/cm^2)	0,856 ± 0,06	0,98 ± 0,06	0,054

* p<0,05; MCT: Massa Corporal Total; IMC: Indice de Massa Corporal

Na tabela 3 foram mostrados os valores médios dos dados obtidos no questionário de autoimagem, a análise ocorreu em 4 dimensões (Condição Física, Habilidade Corporal, Saúde e Aparência). Melhoras (p<0,05) da condição física e habilidade corporal foram encontrados no grupo experimental quando comparados ao grupo controle.

Tabela 3. Análise da autoimagem entre os grupos controle (GC) e experimental (GE)

Variável	Grupo	Média pré ± DP	Média pós ± DP	Δ%	*d*	Valor p*	Valor p†
Condição Física	GC	3,00 ± 1,08	3,31 ± 1,18	10,3	0,29	0,192	**<0,001**
	GE	3,43 ± 1,02	5,21 ± 0,80	51,9	1,75	**<0,001**	
Habilidade corporal	GC	3,31 ± 0,63	3,61 ± 0,65	9,1	0,48	0,126	**<0,001**
	GE	3,00 ± 0,89	5,50 ± 0,76	83,3	2,81	**<0,001**	
Saúde	GC	11,08 ± 1,04	11,38 ± 1,26	2,7	0,29	0,441	0,110
	GE	10,86 ± 1,54	12,29 ± 0,15	13,2	0,93	**0,001**	
Aparência	GC	4,92 ± 0,76	4,77 ± 0,83	-3,0	- 0,20	0,291	0,748

GE	4,36 ± 0,84	4,64 ± 1,15	6,4	0,33	0,581

* p < 0,05, pré vs. pós; † p < 0.05, GC pós vs. GE pós; *d:* effect size (Cohen); DP: Desvio Padrão.

A tabela 4 verificou a autoestima dos participantes desta pesquisa, foram comparados os valores de médios intergurpo e intragrupo, o nivel de significância e o tamanho de efeito das variáveis do grupo experimental. Houve melhora (p<0,05) da autoestima na comparação intergrupo e no grupo experimental intragrupo.

Tabela 4. Autoestima

Variável	Grupo	Média pré ± DP	Média pós ± DP	Δ%	d	Valor p*	Valor p†
Autoestima	GC	14,69 ± 1,70	15,00 ± 1,29	2,1	0,24	0,540	**p<0,001**
	GE	14,71 ± 1,33	23,50 ± 1,34	59,8	6,61	**p<0,001**	

* p < 0,05, pré vs. pós; † p < 0.05, GC pós vs. GE pós; *d:* effect size (Cohen); DP: Desvio Padrão.

Na tabela 5 foram verificados os resultados da força muscular pelos testes de flexão de cotovelo e, sentar e levantar. Foram comparados os valores médios das variáveis verificando as possíveis diferenças significativas ao nível de p<0,05. Aumentos (p<0,05) da força muscular foram encontrados nos membros inferiores e superiores na comparação intragrupo e intergrupo no grupo exerimental.

Tabela 5. Análise de força muscular

Variável	Grupo	Média pré ± DP	Média pós ± DP	Δ%	*d*	Valor p†	Valor p*
Flexão de cotovelo	GC	20,77 ± 1,21	20,39 ± 1,08	-1,8	-0,31	0,403	0,015
	GE	16,14 ± 1,16	19,21 ± 1,04	19	2,65	**<0,001**	
Sentar e levantar	GC	18,54 ± 0,98	18,00 ± 0,75	-2,9	0,55	0,131	0,011
	GE	17,71 ± 2,64	21,36 ± 2,76	20,6	1,38	**<0,001**	

* p < 0,05, pré vs. pós; † p < 0.05, GC pós vs. GE pós; *d:* effect size (Cohen); DP: Desvio Padrão.

Na tabela 6 foi avaliada a autonomia funcional pelo protocolo GDLAM. Os resultados foram dispostos em valores de média e desvio padrão nos grupos controle e experimental. A comparação foi realizada intragrupo e intergrupo. Houve melhora (p<0,05) da autonomia funcional (C10m, LPS, LPDV e IG) no grupo experimental e intragrupo (C10m, LPS, LPDV, VTC, LCLC e IG)

Tabela 6. Análise da autonomia funcional (GDLAM)

Variável	Grupo	Média pré ± DP	Média pós ± DP	Δ%	*d*	Valor p*	Valor p†
C10m	GC	6,16 ± 0,83	6,18 ± 0,84	0,3	0,02	0,938	**0,039**
	GE	6,77 ± 1,11	5,62 ± 0,44	-17,0	-1,04	< **0,001**	
LPS	GC	9,70 ± 0,82	9,64 ± 0,84	-0,6	-0,07	0,796	**<0,001**
	GE	9,06 ± 2,01	7,54 ± 1,50	-16,8	-0,76	< **0,001**	
LPDV	GC	5,27 ± 1,03	5,29 ± 1,06	0,4	0,02	0,915	**0,002**
	GE	4,35 ± 1,74	3,74 ± 1,28	-14,0	-0,35	< **0,001**	
VTC	GC	13,05 ± 1,94	12,45 ± 3,00	-4,6	-0,31	0,244	0,642
	GE	15,34 ± 4,28	12,02 ± 2,62	-21,6	-0,78	< **0,001**	
LCLC	GC	34,26 ± 4,62	34,18 ± 4,34	-0,2	-0,02	0,890	0,431
	GE	36,80 ± 3,00	33,18 ± 1,73	-9,8	-1,21	< **0,001**	
IG	GC	25,66 ± 1,77	25,32 ± 2,10	-1,3	-0,19	0,401	**0,003**
	GE	26,96 ± 3,68	22,76 ± 2,03	-15,6	-1,14	< **0,001**	

* p < 0,05, pré vs. pós; † p < 0.05, GC pós vs. GE pós; *d:* effect size (Cohen); DP: Desvio Padrão.

Na tabela 7 foram analisados os biomarcadores ósseos (Vitamina B12, Vitamina D, Fósforo, Fosfatase alcalina e PTH). Os resultados foram dispostos em média , desvio padrão, nivel de significância e tamanho de efeito (*d*). Houve melhora (p<0,05) dos biomarcadores (Vitamina B12, Vitamnina D, Fósforo, Fosfatase alcalina e PTH) (p<0,05) nos grupos submetidos a intervenção.

Tabela 7. Análise de biomarcadores ósseos

Variável	Grupo	Média pré ± DP	Média pós ± DP	Δ%	*d*	Valor p*	Valor p†
Vitamina B12 (pg/ ml)	GC	263,31 ± 121,21	261,69 ± 121,72	-0,62	-0,01	0,912	**0,002**
	GE	268,50 ± 39,40	324,64 ± 78,33	20,91	1,42	< **0,001**	
Vitamina D (ng/ml)	GC	29,16 ± 5,58	28,95 ± 5,88	-0,7	-0,04	0,796	**0,002**
	GE	28,36 ± 4,05	37,89 ± 7,04	33,6	2,35	**0,005**	
Fósforo (mg/ dl)	GC	4,08 ± 0,85	4,25 ± 1,19	4,2	0,20	0,796	**0,003**
	GE	4,07± 0,56	3,47 ± 0,42	-14,74	-1,07	**0,005**	
Fosfatase alcalina (U/L)	GC	74,08 ± 13,05	74,15 ± 13,26	0,1	0,01	0,407	**0,025**
	GE	83,5 ± 16,54	90,93 ± 21,82	8,90	0,45	**0,018**	
PTH (pg/ ml)	GC	51,85 ± 17,66	52,92 ± 17,11	2,1	0,06	0,791	**0,033**
	GE	55,21 ± 30,98	36,86 ± 19,6	-33,2	-0,59	< **0,001**	

*p < 0,05, pré vs. pós; † p < 0.05, GC pós vs. GE pós; *d:* effect size (Cohen); DP: Desvio Padrão; PTH: paratormônio

DISCUSSÃO

Este estudo, um ensaio clinico randomizado, teve como objetivo analisar os efeitos de 12 semanas do treinamento do taekwondo sobre marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em mulheres idosas, a intervenção apresentou respostas positivas em todas as variáveis analisadas.

Os dados foram discutidos decorrentes da análise estatística do cruzamento entre o pré e pós-teste no inter e intragrupo. Alguns estudos que não utilizaram o taekwondo ou esporte de combate como intervenção foram utilizados para discutir os resultados encontrados nesse estudo experimental em função da escassez de pesquisas clinicas com o taekwondo.

A força muscular foi uma das variáveis investigadas neste estudo, os testes de flexão de cotovelo e, sentar e levantar foram utilizados, no GE aumentos (p<0,05) da força muscular foram encontrados na comparação intragrupo e intergrupo (pós-teste) em ambos os testes. O GC não apresentou diferenças significativas na avaliação da força muscular. Corroborando, um estudo realizado por Ku et al. (2021) avaliou 16 mulheres, (GC=8/ GE=8) com idade

média de 50 anos utilizando o Taekwondo como intervenção, aplicados durante 12 semanas, 3 vezes por semana, 60 minutos por dia e não foram encontradas diferenças ($p>0,05$) na força muscular na comparação intergrupo. Segundo Araújo-Gomes et al. (2020) a força muscular é importante na obtenção de melhor qualidade de vida em indivíduos idosos, o aumento da força muscular nessa população melhora a realização das AVD.

Na avaliação da autoestima foram encontradas diferenças ($p<0,05$) nos GE e GC na comparação intragrupo e intergrupo indicando aumentos da autoestima. Em relação a autoimagem foram verificados aumentos ($p<0,05$) na habilidade corporal e condição física na comparação intragrupo. Na comparação intergrupo (GE vs. GC) foram relatados aumentos ($p<0,05$) na habilidade corporal, condição física e saúde no pós-teste do GE, enquanto no GC não foram verificadas diferenças intergrupos. Corroborando, Dąbrowska-Galas et al. (2021) realizou um estudo com mulheres com idade entre 51 e 60 anos o efeito do nível de atividade física na autoestima e foram encontradas melhora na autoestima, porém não havendo relação entre autoestima e imagem corporal. Enquanto o estudo realizado por Ginsberg et al. (2015) realizou um estudo longitudinal com 93.676 mulheres com idade média de 64 anos e os resultados mostraram que o IMC foi um grande e significativo contribuinte para a insatisfação com imagem corporal.

Outro parâmetro avaliado foi a autonomia funcional, foi utilizado o protocolo GDLAM, houve aumento ($p<0,05$) no GE na avaliação intragrupo nos testes: C10m, LPS, VTC, LPDV, LCLC e no IG, esses resultados são expressos pelas reduções dos valores equivalentes as médias no tempo de execução dos testes. Na comparação intergrupo, o grupo experimental apresentou melhora ($p<0,05$) quando comparado ao GC nos testes C10m, LPS, LPDV e no IG. Vale ressaltar que a autonomia funcional leva ao idoso a possibilidade de liberdade, dignidade e integridade, é essencial na melhora e manutenção da saúde. (Borges et al., 2017). Corroborando com os resultados encontrados neste estudo, Cardoso et al. (2021) analisaram 13 mulheres com idade média de 61 anos que realizaram exercícios multicomponentes com o treinamento resistido, treinamento funcional e Judô adaptado na mesma sessão durante 12 semanas. Foram verificadas melhoras ($p<0,05$) em todas as variáveis de autonomia funcional utilizando o protocolo GDLAM na comparação intragrupo. Da mesma forma, o estudo conduzido por Carrasco-Poyatos et al. (2018) analisou 60 idosas com idade média de 69 anos divididos em 3 grupos, grupo 1 (Pilates), grupo 2 (treinamento de força) e grupo 3 (controle) durante 9 meses, 2 x semana e 60 min x sessão e encontrou melhoras na autonomia funcional utilizando o GDLAM como protocolo de testagem.

Para avaliação dos biomarcadores ósseos foram coletadas amostras de Vitamina B12, Vitamina D, Fosforo, Fosfatase Alcalina e PTH. Foram encontradas diferenças ($p<0,05$) em todas as variáveis analisadas na comparação intragrupo (pré *vs* pós) no GE, enquanto o GC não apresentou diferenças ($p>0,05$). Em relação a comparação intergrupo houve melhora em todas as variáveis no GE quando comparado ao GC. Foi verificado que a vitamina B12, a vitamina D e a fosfatase alcalina apresentaram aumentos ($p<0,05$), entretanto, houve redução ($p<0,05$) do fósforo e PTH no GE na comparação intragrupo. Na comparação intergrupo houve aumento ($p<0,05$) da Vitamina D e fosfatase no GE quando comparado ao GC. Corroborando, um estudo realizado por Shen et al. (2012) com 171 mulheres com idade média de 57 anos que receberam a arte marcial Tai Chi Chuan durante 6 meses, 3 vezes por semana e 60 minutos por dia, apresentaram melhora dos biomarcadores de formação óssea, dentre eles o PTH, e melhoraram a taxa de renovação óssea. Outro estudo, Groenendijk et al. (2020) verificaram 180 idosos de ambos os sexos (idade: 61 anos) que receberam exercícios de força muscular, equilíbrio e aeróbico durante 12 e 24 semanas, 2x/ semana e 60 min/dia. Apresentaram melhoras dos biomarcadores de formação óssea (PTH e Vitamina B12) e da taxa de renovação óssea.

Uma limitação do estudo foi a falta de análise de outros biomarcadores (Piridinolina, Hidroxiprolina, Osteocalcina, Propeptídeos do Colageno tipo I) que poderiam dar mais robustez nos resultados encontrados neste estudo.

CONCLUSÃO

Os resultados encontrados neste estudo experimental apoiam a eficácia do taekwondo nos marcadores fisiologicos de remodelagem óssea, na força muscular, na autonomia funcional, na automiagem e na autoestima de idosos. Os biomarcadores de remodelagem óssea apresentaram resultados positivos com a aplicação da intervenção durante 12 semanas, esses resultados são importantes nesta população devido aos processos degenerativos ocasionados pela senescência. Foram encontrados aumentos da força muscular em membros inferiores e superiores. Houve melhora da autonomia funcional, da autoestima e da autoimagem.

De acordo com os resultados encontrados neste experimento recomenda-se a inserção do Taekwondo nos clubes, academias e afins para a população idosa. Estes resultados sustentam beneficios na aptidão física dessa população com consequente melhora da autonomia funcional.

Recomendam-se estudos envolvendo um número amostral maior e a utilização de outros marcadores de remodelagem óssea (Piridinolina, Hidroxiprolina, Osteocalcina, Propeptídeos do Colageno tipo I) podem ser importantes para confirmar os achados encontrados neste estudo.

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CONCLUSÃO

Os estudos utilizados nesta dissertação envolvendo mulheres idosas mostraram os efeitos do exercício físico na saúde física e mental utilizando os esportes de combate e em especial o Taekwondo.

No capítulo 1, a revisão sistemática envolvendo o taekwondo mostrou melhoras nas capacidades físicas e mentais de mulheres idosas. O capítulo 2, uma revisão sistemática com metanálise verificou que exercícios multicomponentes mostraram melhoras na aptidão física, na densidade mineral óssea e podem ser eficazes no tratamento da osteoporose. O capítulo 3, uma revisão sistemática verificou que as artes marciais podem ser eficazes na saúde física e mental da pessoa idosa, melhoras na qualidade de vida e no sono foram encontradas. O capítulo 4, uma revisão sistemática com estudos randomizados e controlados apontou a eficácia de diferentes EC na aptidão física, e no desempenho das atividades da vida diária em idosos. No capítulo 5, um ensaio clinico randomizado, verificou em idosas melhoras na força muscular, autoestima, autoimagem, biomarcadores ósseos e autonomia funcional no grupo experimental submetidos a 12 semanas, 3 x por semana, 40 min por sessão de taekwondo .

Os estudos de revisão sistemática com e sem metanálise apontaram melhoras na aptidão física, remodelagem óssea, autonomia funcional e autoimagem. Estes resultados demonstram que o esporte de combate pode ser uma alternativa interessante como prática de exercício físico para essa população.

Em resposta aos objetivos primários dessa dissertação pode-se concluir que o taekwondo foi eficaz na melhoria da condição física, da autonomia funcional, da autoimagem, dos biomarcadores ósseos e consequentemente na realização das AVD.

Outros estudos utilizando o taekwondo e outros esportes de combate devem ser investigados analisando as respostas físicas e mentais em mulheres idosas. Por fim, o esporte de combate tem sido praticado cada vez mais pela população idosa, esta que expira um cuidado especial, conhecer os possíveis efeitos em diferentes variáveis físicas pode auxiliar instrutores dessa modadalidade levando segurança e qualidade aos participantes.

Vale ressaltar a inclusão do taekwondo em programas de políticas públicas para idosos pelo baixo custo de implementação.

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ANEXO A – Parecer Consubstanciado do CEP

HOSPITAL UNIVERSITÁRIO
PEDRO ERNESTO/UERJ

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Análise de marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosos submetidos ao Taekwondo adaptado

Pesquisador: Diego Gama Linhares
Área Temática:
Versão: 2
CAAE: 51572321.6.0000.5259

ANEXO B – Registro Brasileiro de Ensaios Clinicos (REBEC)

RBR-5jzcc5q Analysis of physiological markers, physical fitness, self-esteem and self-image in elderly people undergoing adapted Tae...

Date of registration: 02/18/2022 (mm/dd/yyyy)

Last approval date : 02/18/2022 (mm/dd/yyyy)

Study type:

Interventional

Scientific title:

en	pt-br	es
Analysis of physiological markers of bone remodeling, muscle strength, functional autonomy, self-esteem and self-image in elderly undergoing adapted Taekwondo	Análise de marcadores fisiológicos de remodelagem óssea, força muscular, autonomia funcional, autoestima e autoimagem em idosos submetidos ao Taekwondo adaptado	Analysis of physiological markers of bone remodeling, muscle strength, functional autonomy, self-esteem and self-image in elderly undergoing adapted Taekwondo

Trial identification

- **UTN code:** U1111-1273-2914
- **Public title:**