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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).

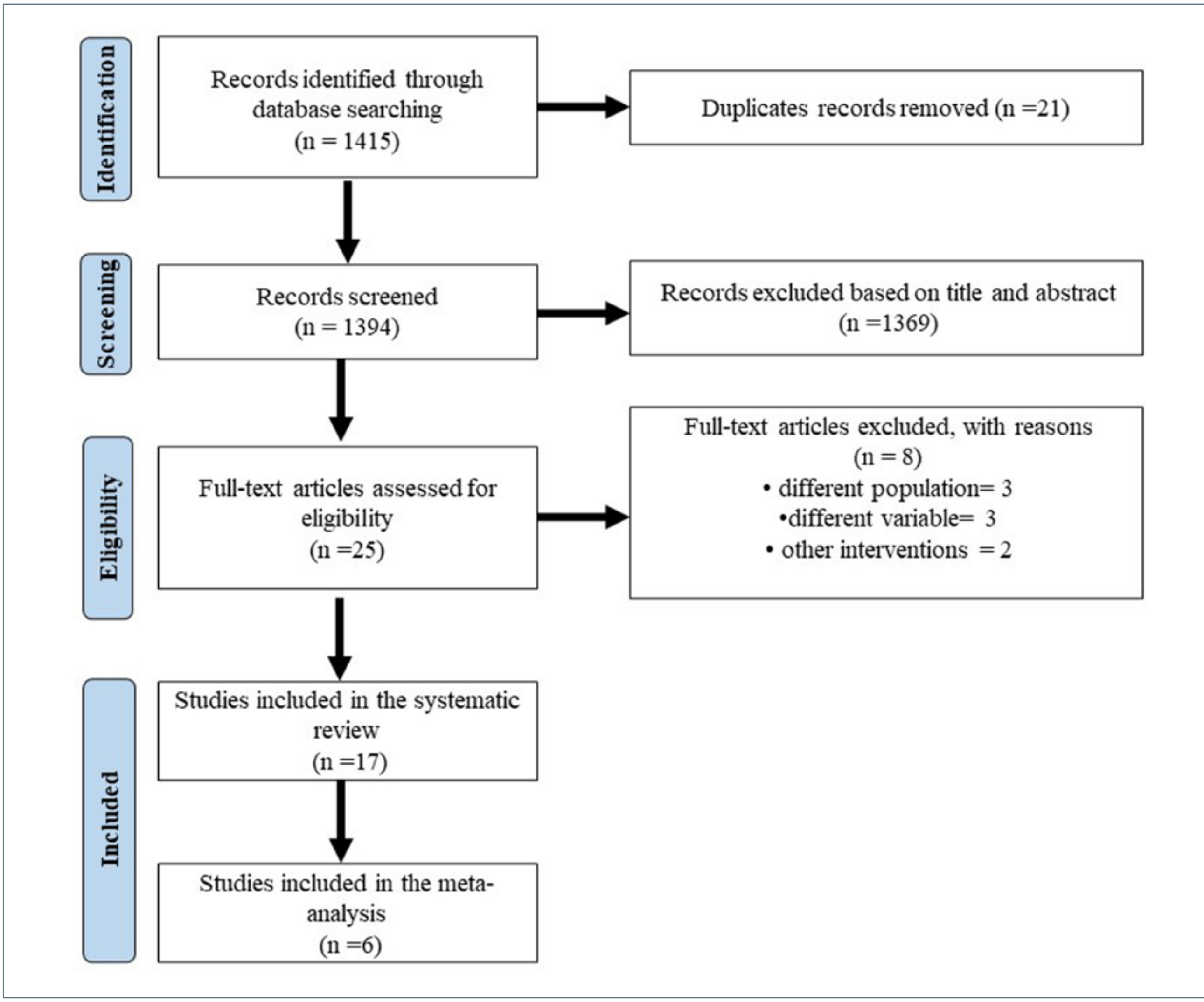

Figure 1. PRISMA flow diagram of study selection.

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.

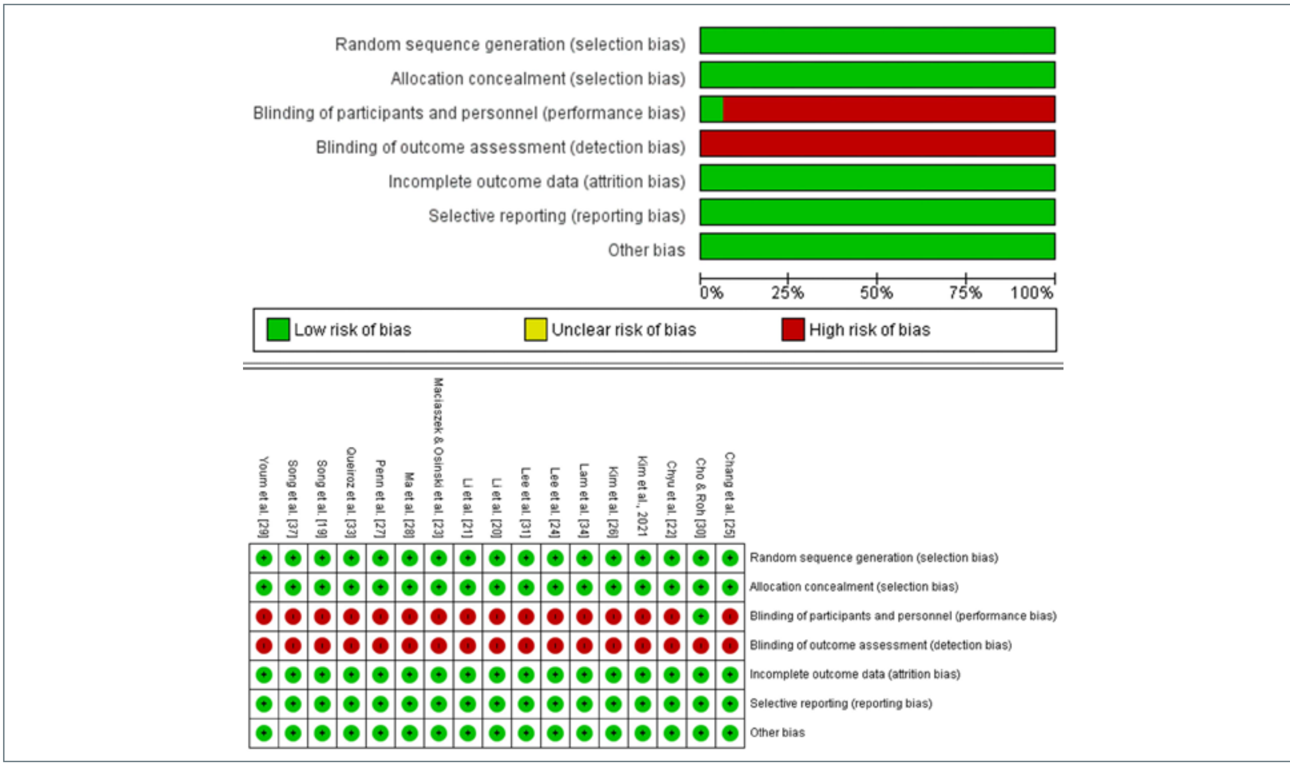

Figure 2. Analysis of risk of bias summary and graph in included RCTs (Cochrane Collaboration tool).

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.

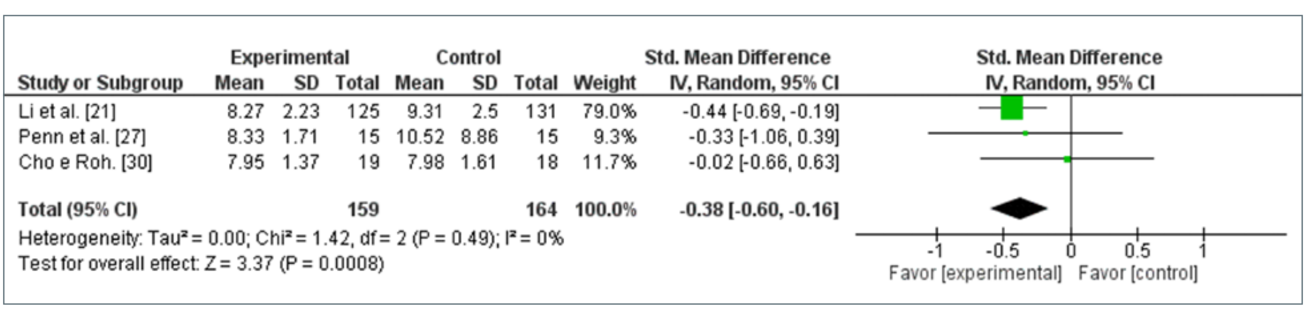

Figure 3. Time Up Go test (TUG) analysis.

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Lam et al. [34]	53.4	2.3	96	52.3	3.4	169	46.6%	0.36 [0.11, 0.61]
Li et al. [21]	49.28	4.15	125	47.15	4.22	131	47.9%	0.51 [0.26, 0.76]
Penn et al. [27]	51.33	4.79	15	45.87	12.36	15	5.5%	0.57 [-0.17, 1.30]
Total (95% CI)			**236**			**315**	**100.0%**	**0.44 [0.27, 0.61]**

Heterogeneity: Chi² = 0.78, df = 2 (P = 0.68); I² = 0%
Test for overall effect: Z = 5.03 (P < 0.00001)

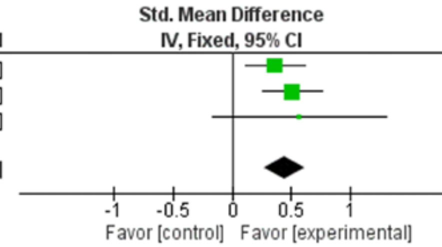

Figure 4. Analysis of the Berg Balance Scale (BBS).

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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