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Effects of resistance training on the functional autonomy of middle-aged and older women: a systematic review and meta-analysis of randomized controlled trials

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Background. Resistance training (RT) is a modality of physical training widely prescribed for middle-aged and older women, who tend to suffer declines in functional autonomy, which is the ability to perform activities of daily living independently. We conducted a systematic review and meta-analysis to identify and summarize the effects of RT on the functional autonomy of middle-aged and older women.
Methods. This study followed the PRISMA guidelines and was registered on PROSPERO, as number CRD42021245475. We searched MedLine (via PubMed), Scopus, LILACS (via BVS), and ScienceDirect for eligible randomized controlled trials that observed middle-aged and older women submitted to RT programs that reported functional autonomy outcomes. The methodological quality and the risk of bias were assessed using the Jadad scale and Cochrane tool, respectively.
Results. Twelve eligible studies were included. Although the practice of RT at least twice a week for 12 weeks showed to be effective in improving the functional autonomy of the participants, the study protocols present a high heterogeneity, with training session times lasting between 45 to 150 minutes and different exercise configurations. According to the Jadad scale, most studies (n = 7) had low methodological quality and 5 studies had good methodological quality. The Cochrane tool showed one study with a low risk of bias, 10 studies at uncertain risk, and one study with a high risk of bias.
Conclusions. RT showed to be efficacious to improve the functional autonomy of middle-aged and older women. However, the interventions need greater standardization and the studies require higher methodological quality to establish further conclusions.

Key words: resistance training, aged, functional status, exercise

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INTRODUCTION

Society has been aging and this trend can be observed worldwide. The fraction of individuals over 60 years increased from 9.2% in 1990 to 11.7% in 2013. It is estimated that the proportion of older people in the world population will increase substantially over the coming decades, which represent 21.1% by 2050 [1,2].

Aging is defined as an inexorable, dynamic, and multidimensional process, characterized by the decay of the activities of organs, tissues, and cells. This process tends to reduce the effectiveness of several physiological and mechanical processes, such as gait difficulties and reductions in flexibility, muscle strength, aerobic capacity, and postural balance [3-5].

Inside this scenario, changes in the physiological and hormonal system differ by sex [6,7]. Women generally have an earlier physiological and hormonal reduction rate than men, with a decline in physical performance accentuated by menopause [8,9]. According to a meta-analysis, the overall mean menopausal age was 48.8 years and the mean age ranged from 46 to 52 years [10]. Thus, although life expectancy of women is higher, they tend to suffer more from disease and disability than men [11].

The practice of regular physical activity and exercises is recommended for the general population and, specifically, for older people [12]. The prescription of exercises for these individuals should consider health status, as well as functional autonomy [13]. Additionally, one of the recommendations by the World Health Organization's Physical Activity Guidelines is the practice of muscle-strengthening activities at least twice a week [14].

Among the main markers related to health and the performance of activities of daily living (ADL) in adults and older people, functional autonomy stands out [15]. This variable is understood as the ability to perform ADL that encompasses sensorimotor, psychosocial, and cognitive aspects. Moreover, it involves the possibility of performing activities without the help of others [16].

The term functional autonomy is found in the literature with some synonyms, such as functional capacity [17], functional performance [18], functional ability [19], functional status [20], functional factors [21], and functional capability [22]. Therefore, there are studies with different instruments to assess this variable. These instruments range from tests or test batteries, which result in a score or index, such as the Latin American Group for Maturity (GDLAM) protocol [3], senior fitness test [23], functional autonomy measurement system (SMAF) [24], 8-foot up-and-go (8FUG) test [25], sit-to-stand test [26], assessment of daily activity performance (ADAP) [27], and timed up and go (TUG) test [28].

The GDLAM protocol is composed of five tests: walking 10 m; rising from the sitting position; rising from a ventral decubitus position; sitting in, rising from, and walking around a chair; putting on and taking off a t-shirt. The results (in seconds) of these tests are calculated to inform the GDLAM autonomy index. According to this index, better results are represented by lower score values [3]. The Senior Fitness Test comprises six tests: 30-second chair stand, 30-second arm curl, 6-minute walk (or 2-minute step test), chair sit-and-reach, back scratch, and 8FUG. Those tests encompass upper and lower limbs strength, upper and lower limbs flexibility, agility/dynamic balance, and aerobic capacity related to ADL [23].

The practice of resistance training has been widely recommended as far as age advances as a strategy to increase the functional autonomy of middle-aged and older women [15,29,30]. Faced with these scientific recommendations, a diverse range of training intensity and volume (duration and frequency), sample size and characteristics, accessories used in training, and order of exercise prescription are observed. Consequently, the effects of resistance training on functional autonomy levels of middle-aged and older individuals remain controversial.

Increasing information about resistance training may help to verify the effectiveness of training programs for maintaining or improving functional autonomy levels and enable a more accurate and efficient prescription for these individuals. Therefore, the current study aimed to identify and summarize the effects of resistance training on the functional autonomy of middle-aged and older women.

METHODS

This study is a systematic review conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) recommendations [31]. The research protocol was previously registered on the International Prospective Register of Systematic Reviews (PROSPERO), as number CRD42021245475.

Eligibility criteria

We included experimental randomized controlled trials (RCTs) conducted with community-dwelling middle-aged postmenopausal women (≥ 46 years old) [10] and older women (≥ 65 years old) who underwent a resistance training protocol and who had functional autonomy as an outcome assessed through validated tests or test batteries, such as the GDLAM protocol, Rikli and Jones protocol, SMAF, 8FUG test, sit-to-stand test, ADAP, and TUG test. Records that included cross-sectional studies, studies with animals, with individuals who had some disease (e.g., diabetes, hypertension, cancer, or

hyperlipidemia), women with premature menopause, those without a control group (CG), or those with male subjects were excluded. Additionally, we excluded studies written in Chinese or Japanese languages since the researchers do not domain these languages.

Search strategy

We searched MedLine (via PubMed), Scopus, LILACS (via BVS), and ScienceDirect electronic databases, in March 2021, without language or date filter. We used the descriptors "resistance training" and "elderly", available in the Health Sciences Descriptors (DeCS) and the Medical Subject Headings (MeSH), combined with the term "functional autonomy" and their synonyms. These words and their synonyms were combined using the Boolean operators OR (between synonyms) and AND (between terms) to form the search phrase. When necessary, due to the specifics of the databases, this phrase was properly adapted. References extracted using the search phrase were exported to an EndNote shared library. Two researchers conducted the search independently. Any divergence was resolved through the consultation of a third researcher. References from selected studies and other sources were checked to maximize the search.

Research question

We based the research question and strategy of our study on the Population, Intervention, Comparison, and Outcome (PICO) model, frequently used in evidence-based practice and recommended for systematic reviews [32]. Hence, the Population was middle-aged postmenopausal women and older women, the Intervention was resistance training, the Control was the group of participants that did not practice resistance training, and the Outcome was functional autonomy. Therefore, the final PICO question was "Does resistance training increase the functional autonomy of middle-aged postmenopausal women and older women?".

Methodological quality analysis

For the analysis of the methodological quality of the included RCTs, we used the Jadad scale [33]. This scale consists of three items with a total of five points. The Jadad scale considers the following methodological criteria: 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 greater than or equal to 3 are considered of good methodological quality. Two researchers carried out the methodological quality analysis. Any divergences in the analysis were sent to a third researcher.

Risk of bias analysis

Two authors independently performed the risk of bias assessment of each included study using the Cochrane tool [34]. If the score was inconsistent between them, a third author was consulted to decide the final score. This tool has seven categories that analyze the risk of bias from the RCTs: 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 category has the risk of bias classified as "high", "uncertain", or "low". The study was classified as high risk, uncertain risk, or low risk if at least one domain had a high risk, uncertain risk or if no domain had a high or uncertain risk of bias, respectively.

Data collection process

Two authors extracted independently the data from the included publications related to the sample characteristics, interventions, assessments, and results of the studies. Any differences were settled in a consensus meeting with a third author. The following data were extracted from the included studies: sample size, number of participants in each group, age, study nationality, characteristics of the intervention, protocol for analyzing functional autonomy, and main results.

Meta-analysis

We used the Review Manager 5.3 program, available at (http://tech.cochrane.org/revman) to analyze data regarding the effects of resistance training on the functional autonomy of middle-aged and older women. 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. The risk of publication was analyzed with the Egger test, on Stats Direct Software, version 3.

Evidence level assessment

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used by two independent researchers to assess the evidence level of the investigated outcome. A third researcher solved any disagreements between the two researchers through arbitration. The quality of evidence is classified by one of the four classification levels: high, moderate, low, and very low. RCTs start with high quality of evidence, while observational studies begin with low

quality of evidence. Five aspects can reduce the quality of the 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 [35].

RESULTS

Study selection

The initial database search yielded 122 potential studies (PubMed = 49; Scopus = 25; BVS = 22; ScienceDirect = 26). Furthermore, three studies were manually included [17,36,37] via reviewing reference lists and lists of citing publications. After applying the eligibility criteria, 12 studies were included in the qualitative analysis and six studies provided data to be included in the pooled analysis (Fig. 1).

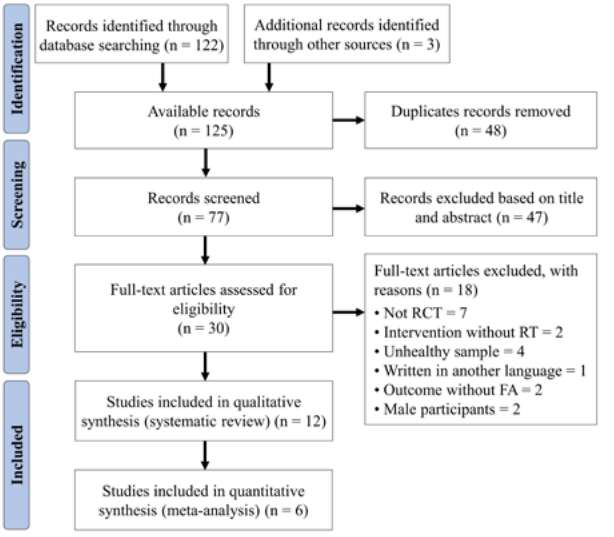
Study characteristics

The included studies were published between 2005 and 2020. Most of the studies (n = 9) were written in English, two studies [20,38] were written in Spanish, and one study [39] was written in Portuguese. Table I presents the descriptive characteristics of the participants of the included studies. The total sample comprised 554 individuals with a mean age of 68.87 ± 5.86 years. The sample size of the included studies ranged from 24 to 68 participants. The experimental group (EG) had a total of 300 participants and the CG had 254 participants. The sample size of the EG ranged from 12 [40] to 45 [41] participants. The sample size of the CG ranged from 10 [42] to 64 [43] participants. Although some studies used other interventions, for this study, every intervention other than resistance training was considered as a CG, like the study of Carrasco-Poyatos et al. [21] and Vreede et al. [42].

Table II shows the methodological characteristics and the main results of the included studies. Most studies (n = 7) [20,21,36-38,40,43] used the GDLAM protocol to assess the functional autonomy of the participants. The other studies (n = 5) [17,39,41,42,44] used the Rikli and Jones protocol, SMAF, 8FUG test, sit-to-stand test, ADAP, or TUG to assess functional autonomy in the pre- and post-intervention periods.

Methodological quality and risk of bias

Table III shows the methodological quality of the studies assessed by the Jadad scale. According to this scale, five studies (41.7%) [21,38,41-43] had a good methodological quality, and seven studies (58.3%) [17,20,36,37,39,40,44] were classified as low quality. The highest score (5 points) on the Jadad scale was achieved by one study [21].



RCT: randomized controlled trial; RT: resistance training; FA: functional autonomy.

Figure 1. PRISMA flow diagram of study selection.

Table IV presents the risk of bias analyzed by the Cochrane tool. One study (8.3%) [21] attained the better grading and was classified as having a low risk of bias, ten studies (83.3%) [17,20,36-40,42-44] were at uncertain risk of bias, and one study (8.3%) [41] was classified as having a high risk of bias.

Outcomes

Table V shows the extraction of outcomes from the GDLAM protocol, presented as mean and standard deviation of the extracted results, to calculate the effect size (*d*) intragroup, which were interpreted as weak (< 0.2), moderate (0.2 to 0.79), or strong (> 0.8) [45]. The data extracted corresponds to the GDLAM index of autonomy, which is the score that results from the calculation of the five tests that comprise the GDLAM protocol [29]. Most of the studies presented a strong *d*, which demonstrates the magnitude of the results after the intervention. Although Dib et al. [40] used the GDLAM protocol, the authors did not use all five tests, therefore, it was not possible to calculate the autonomy index.

Meta-analysis

Figure 2 presents the results of the meta-analyses of the studies that used the GDLAM protocol to evaluate functional autonomy. Since the meta-analyses can only be performed when two or more studies can be pooled, it was not possible to compare the other studies since they used other protocols to assess functional

Table I. Characterization of study participants.

Author	Year	Country	EG (n)	CG (n)	Total (n)	Age (years)
Borba-Pinheiro et al. [43]	2016	Brazil	EG1: 20	16	52	EG1: 56.3 ± 5.2
			EG2: 16			EG2: 60.6 ± 7.5
						CG: 55.3 ± 6.8
Carrasco-Poyatos et al. [21]	2019	Spain	20	CG1: 20	60	EG: 73.36 ± 4.84
				CG2: 20		CG1: 67.5 ± 3.87
						CG2: 65.89 ± 4.54
Daniel et al. [36]	2012	Brazil	20	20	40	EG: 68.51 ± 5.02
						CG: 67.01 ± 3.51
Dib et al. [40]	2020	Brazil	EG1: 15	–	45	EG1: 70.9 ± 6.1
			EG2: 15			EG2: 68.9 ± 5.8
			EG3: 15			EG3: 67.9 ± 4.5
Geraldes et al. [39]	2007	Brazil	12	12	24	EG: 67.75 ± 6.21
						CG: 68.67 ± 8.87
Lauzé et al. [41]	2017	Canada	21	10	31	EG: 80.1 ± 7.5
						CG: 83.2 ± 6.7
Mazini Filho et al. [44]	2018	Brazil	34	31	65	EG: 70 ± 10.67
						CG: 70 ± 11.28
Pereira et al. [20]	2007	Brazil	13	11	24	EG: 65.6 ± 5.3
						CG: 71.4 ± 5.7
Ramírez-Campillo et al. [17]	2014	Chile	EG1: 15	15	45	EG1: 66.3 ± 3.7
			EG2: 15			EG2: 68.7 ± 6.4
						CG: 66.7 ± 4.9
Silva et al. [38]	2009	Brazil	20	20	40	EG: 65.62 ± 5.36
						CG: 71.45 ± 5.72
Vale et al. [37]	2018	Brazil	15	15	30	EG: 68 ± 4.4
						CG: 69 ± 8.9
Vreede et al. [42]	2005	Netherlands	34	CG1: 33	68	EG: 74.8 ± 4.0
				CG2: 31		CG1: 74.7 ± 3.5
						CG2: 73.0 ± 3.2

EG: experimental group; CG: control group

autonomy. 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 resistance 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 the same way.

Table VI shows the result of the evidence level evaluated by the GRADE tool in the GDLAM protocol. It was not possible to include the other studies in this evaluation because they used distinct protocols to assess functional autonomy. The analysis was classified as high, which means that there is strong confidence that the true effect is close to the estimated result.

DISCUSSION

The present study aimed to identify and summarize the effects of resistance training on the functional autonomy of middle-aged and older women. The 12 included studies found positive results in functional autonomy outcomes in EG after the intervention period, which varied from 12 to 24 weeks. The training session lasted between 45 to 70 minutes, although one study [40] did not give this information. The training frequency of the studies was twice or three times a week (Tab. II). These findings reinforce the effectiveness of supervised and controlled resistance training exercises to enhance functionality in middle-aged and older women.

It should be highlighted, though, that the intervention protocols of the included studies showed high heterogeneity, including a wide range of training intensities and types of exercises. As for the control of the

Table II. Methodological data extracted from included studies.

Study	Intervention	Training volume	FA assessment	Results
Borba-Pinheiro et al. [43]	EG1 and EG2: 60 to 90% of 10RM. Linear periodization with 3 sets per exercise	EG1: 3×/wk	GDLAM protocol	↑ FA (EG1 and EG2, $p < 0.01$; EG1 *vs* EG2, $p < 0.05$ EG1 and EG2 *vs* CG, $p < 0.05$)
	Exercises: leg press 45°; knee extension; plantar flexion; squats; hip adduction; glut; elbow flexion; elbow extension; shoulder adduction	EG2: 2×/wk 1 h		
	CG: no exercising	13 months		
Carrasco-Poyatos et al. [21]	EG: muscular exercise program, beginning at a moderate intensity (6-7 points of the OMNI scale) and finishing at a moderate-to-vigorous intensity (8-9 points). Sessions with 3 phases: 1) warm-up, consisting of dynamic range of motion exercises (10 min); 2) main part (40 min); 3) cool-down (10 min)	2×/wk 1 h	GDLAM protocol	↑ FA (EG and CG1 pre *vs.* post; $p < 0.001$; CG2 pre *vs* post; $p < 0.05$ CG1 *vs* CG2; $p = 0.041$ CG1 *vs* EG; $p = 0.042$)
	CG1: structured mat Pilates-based exercises (same intensity and phases of the EG)	18 wks		
	CG2: maintained normal physical activity habits			
Daniel et al. [36]	EG: exercise program, divided into the following five phases: a) 10 min warm-up with joint mobility exercises and light stretching of the main joints; b) 20 min walk; c) 15 min of localized exercises for the major muscle groups (2 sets of 15 repetitions: squats, elbow flexion and extension, shoulder horizontal flexion and extension, plantar flexion, and abdominal crunches; d) maximum static stretching for 10 min; e) neuromuscular relaxation for 5 min	2×/wk 1 h	GDLAM protocol	↑ FA (EG pre *vs* post; $p < 0.05$; CG pre *vs* post; $p > 0.05$). EG *vs* CG; $p > 0.05$)
		12 wks		
	CG: no exercising			
Dib et al. [40]	EG1: multi-joint to single-joint	3×/wk	4 tests of the GDLAM protocol	↑ FA (EG1; EG2 and EG3 pre *vs* post; $p < 0.05$. EG1 *vs* EG2 *vs* EG3; $p > 0.05$)
	Order (MJ-SJ)	NI		
	EG2: single-joint to multi-joint order (SJ-MJ)	24 wks		
	EG3: alternating between upper and lower body order			
Geraldes et al. [39]	EG: 50 to 70% of 10RM. Linear periodization with 3 sets per exercise. 10 exercises: leg press; front pull on the high pulley; knee flexion; straight supine with barbell; development with dumbbells; adduction chair; biceps curl; plantar flexion in the standing position; extension of both hips standing position; extension of both elbows on a high pulley; partial supraumbilical abdominal	2×/wk 1 h	a) 10-meter walk b) rise from the kneeling position	↑ FA (EG pre *vs* post; $p < 0.05$) EG *vs* CG; $p < 0.05$)
	CG: maintained eating and physical activity habits	12 wks	c) stand up and sit on a chair	
Lauzé et al. [41]	EG: warm-up, 7 aerobic exercises, 8 resistance and balance exercises, and a cool-down period using gerontechnology	2×/wk	SMAF	↑ FA (EG *vs* CG; $p = 0.05$)
	CG: no exercising	45 min 24 wks		TUG ($p = 0.04$ in EG *vs* CG)

▶

Table II. continues.

Study	Intervention	Training volume	FA assessment	Results
Mazini Filho et al. [44]	EG: 50 to 70% of 10RM. Linear periodization with 2 sets per exercise. Exercises: leg press, frontal high pulley, leg curl, chest fly machine, leg abduction machine, triceps (using pulley), barbell curl (biceps), and standing calf raise	2×/wk	Rikli and Jones protocol	↑ FA (EG pre *vs* post; p = 0.02)
		45 min		TUG (CG pre *vs* post; p > 0.05)
	CG: no exercising	12 wks		TUG (EG *vs* CG; p = 0.03)
Pereira et al. [20]	EG: exercises program: knee extension, supine, sitting	2×/wk	GDLAM protocol	↑ FA (GE pre *vs* post; p < 0.05) (GC pre *vs* post; p > 0.05)
	Unilateral knee flexion, and triceps work on the pulley	45 min		
	CG: no exercising	20 wks		(EG *vs* CG; p < 0.05)
Ramírez-Campillo et al. [17]	EG1: high-speed resistance training group, 45-75% of 1RM, concentric velocity: 1 s or less	3×/wk	8FUG and STS	↑ FA (EG1 pre *vs* post; p < 0.05) (EG2 pre *vs* post; p < 0.05) (CG pre *vs* post; p > 0.05) EG1 and EG2 *vs* CG, p < 0.05) EG1 and EG2 *vs* CG, p < 0.05)
	EG2: low-speed resistance training group, 75% of 1RM, concentric velocity: 3 s.	70 min		
	EG1 and EG2: warm-up with stretching (10 min), 6 exercises (bench press, standing upper row, biceps curl, leg press, prone leg curl, leg extension), cool-down with abdominal crunches + prone superman. 3 sets of 8 reps. Eccentric velocity: 3 s. Rest between sets: 1 min.	12 wks		
	CG: did not undergo any specific type of physical activity			
Silva et al. [38]	EG: 90 and 100% of 1RM. Exercises program: knee extension, right knee flexion, left knee flexion, straight supine, and triceps curl on the pulley	3×/wk	GDLAM protocol	↑ FA (EG pre *vs* post; p < 0.05) (CG pre *vs* post; p > 0.05) EG *vs* CG; p < 0.05)
	CG: no exercising	1 h		
		20 wks		
Vale et al. [37]	EG: muscular exercise program, beginning at a moderate intensity (3-5 points of the OMNI scale) and finishing at a moderate-to-vigorous intensity (5-7 points). Sessions with 3 phases: 1) warm-up: submaximal stretching exercises and dynamic movements in the main joints (10 min); 2) resistance exercises: squats, elbow flexion and extension, knee and hip flexion and extension, horizontal flexion and extension of shoulders, plantar flexion, sit-ups (35 min); 3) cool-down: muscle release and relaxation exercises (5 min).	3×/wk	GDLAM protocol	↑ FA (EG and CG1 pre *vs*. post; p<0.05)
		50 min		
	CG: structured walk-based exercises, divided into 3 phases: a) warm-up: submaximal stretching and dynamic mobility exercises to the main joints (10 min); b) main part: walking with exertion control (3-5 points on the Borg CR-10) (35 min); c) cool-down: muscle relaxation and release exercises (5 min).	24 wks		

▶

Table II. continues.

Study	Intervention	Training volume	FA assessment	Results
Vreede et al. [42]	EG: warm-up (10 min): aerobic exercises; main part (40 min): intensity: 7-8 on a 10-point rating perceived exertion scale, strengthen the muscle groups important for ADL: elbow flexors and extensors; shoulder abductors, adductors, and rotators; trunk flexors and extensors; hip flexors, extensors, abductors, and adductors; knee flexors and extensors; and ankle dorsal and plantar flexors, 3 sets of 10 reps with dumbbells (0.5-8 kg), elastic tubing (3 resistances of elastic bands), ankle weights (0.25-10 kg), and body weight; cool-down (10 min): flexibility exercises for limbs and trunk.	3×/wk	1) ADAP	↑ ADAP total score of CG1 *vs* EG ($p = 0.007$) or CG ($p = 0.001$).
	CG1: core exercises to improve ADL performance, e.g., moving with a vertical/ horizontal component, carrying an object, changing between lying-sitting-standing position. 3 sessions of 5–10 reps. Program divided into: practice phase (2 wks), variation phase (4 wks), daily tasks phase (6 wks).	1 h	2) TUG	ADAP total score (EG *vs* CG, $p > 0.05$)
		12 wks		TUG ($p > 0.05$ in EG, CG1, and CG2)
	CG2: no exercising.			

EG: Experimental group; CG: Control group; FA: Functional autonomy; ADL: Activities of daily living; ADAP: Assessment of Daily Activity Performance; RM: Repetitions maximum; GDLAM: Latin American Group for Maturity; SMAF: Functional Autonomy Measurement System; OMNI: Resistance exercise scale of perceived exertion; TUG: Timed up and go; 8FUG: 8-foot up-and-go test; STS: Sit-to-stand test; wk: week; wks: weeks; min: minutes; s: seconds; reps: repetitions; NI: not informed.

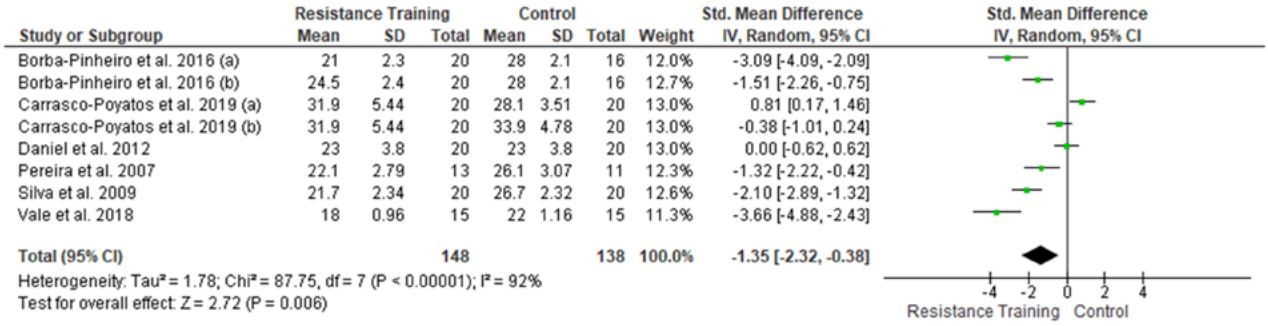
resistance exercises intensity, some studies [39,43,44] used different percentage values of 10 repetitions maximum (RM) as a control load, ranging from 50 to 100% of ten-repetition maximum (10RM). Other studies [17,38] adopted percentage values of one-repetition maximum (1RM), and other RCTs [21,37,42] used the OMNI scale. Concerning the different types of resistance training employed, it was found protocols that included exclusively resistance training in the EG and others that combined with joint mobility, walking, or balance exercises. Moreover, some studies adopted multi-joint to single-joint order, single-joint to multi-joint order, and alternating between upper and lower body order. The execution speed was another variable explored in some of the included studies. The materials and equipment also varied, including resistance training machines and/or dumbbells, elastic tubing, ankle weights, and body weight. The training frequency and duration (training volume) of the interventions were also divergent, ranging from two training sessions per week for 12 weeks to three training sessions per week for 13 months (Tab. II).

Of the 12 studies included in our systematic review, six were comprised in the meta-analysis since they used the same protocol to measure functional autonomy. The meta-analysis showed that resistance training, for at least 12 weeks, with at least two training sessions per week, can be effective in improving the functional autonomy of

Table III. Scores of the Jadad scale used to assess the methodological quality of the included studies.

Studies	1a	1b	2a	2b	3	Total
Carrasco-Poyatos et al. [21]	1	1	1	1	1	5
Vreede et al. [42]	1	1	0	1	1	4
Borba-Pinheiro et al. [43]	1	1	0	0	1	3
Lauzé et al. [41]	1	1	0	0	1	3
Silva et al. [38]	1	1	0	0	1	3
Dib et al. [40]	1	-1	0	1	1	2
Geraldes et al. [39]	1	1	0	0	0	2
Daniel et al. [36]	1	-1	0	0	0	0
Mazini Filho et al. [44]	1	-1	0	0	0	0
Pereira et al. [20]	1	-1	0	0	0	0
Ramírez-Campillo et al. [17]	1	-1	0	0	0	0
Vale et al. [37]	1	-1	0	0	0	0

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



Borba-Pinheiro: (a) 3×/week; (b) 2×/week; Carrasco-Poyatos: comparison of the resistance training with the control group - (a) pilates; (b) no exercise.

Figure 2. Forest plot (GDLAM protocol).

Table IV. Risk of bias of the studies included through the Cochrane tool.

Studies	1	2	3	4	5	6	7	Risk
Carrasco-Poyatos et al. [21]	Low	Low	Low	Low	Low	Low	Low	Low
Borba-Pinheiro et al. [43]	Low	Low	Uncertain	Low	Low	Low	Low	Uncertain
Daniel et al. [36]	Low	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
Dib et al. [40]	Low	Uncertain	Uncertain	Low	Low	Low	Low	Uncertain
Geraldes et al. [39]	Low	Low	Uncertain	Uncertain	Low	Low	Low	Uncertain
Mazini Filho et al. [44]	Low	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain	Uncertain
Pereira et al. [20]	Low	Uncertain	Uncertain	Uncertain	Low	Low	Low	Uncertain
Ramírez-Campillo et al. [17]	Low	Uncertain	Uncertain	Uncertain	Low	Low	Low	Uncertain
Silva et al. [38]	Low	Low	Uncertain	Uncertain	Low	Low	Low	Uncertain
Vale et al. [37]	Low	Uncertain	Uncertain	Uncertain	Low	Low	Low	Uncertain
Vreede et al. [42]	Low	Low	Uncertain	Low	Low	Low	Low	Uncertain
Lauzé et al. [41]	Low	Low	High	High	Low	Low	Low	High

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

predominantly healthy, community-dwelling middle-aged and older women. The meta-analysis of the RCTs [20,21,36-38,40,43] (Fig. 1) showed the result of the functional autonomy test with an average difference of -2.32 to -0.38 and a significant improvement was found in the EG *versus* CG ($p = 0.006$). The study by Vale et al. [37] showed GDLAM values significantly lower than the other studies. These lower score values represent better results [3]. Our results are comparable with the findings of Marcos-Pardo et al. [15] and Pina et al. [46]. These RCTs found significant improvements in functional autonomy after the intervention period. However, their samples included male participants and we only analyzed female participants in the included studies, mainly due to hormone differences between the sexes that affect physiological and adaptative responses [6,7]. It is worth noting that, in addition to physical exercise, other factors of daily life can interfere with functional autonomy, such as the surrounding population and multidisciplinary health care programs [47].

Regarding the methodological quality of the included studies, according to the Jadad scale, most of the RCTs [17,20,36,37,39,40,44] (were classified as low methodological quality. The Cochrane tool signaled a study [41] classified as high risk of bias, where evaluators were blind out incongruously. Moreover, ten studies [17,20,36-40,42-44] were classified as having an uncertain risk of bias due to the lack of detailing of randomization and blinding of participants and evaluators, which were not mentioned in the studies and are factors that can distort the results. The sample size of the included studies ranged from 24 [39] to 68 [42] participants, with a total of 554 individuals analyzed. A large sample number contributes to external validity. This provides the extrapolation of the study results to individuals with similar characteristics in a different setting [48]. Thus, the internal and external validity of the analysis of the effect of systematic resistance training practice on functional autonomy is important to verify whether interventions with resistance training can bring benefits to practitioners.

Table V. Results of data extractions.

Studies	Group	GDLAM mean (SD)		Effect size
		Pre	Post	*d*
Borba-Pinheiro et al. [43]	EG1 (a)	28.4 (3.53)	21.0 (2.30)	2.48
	EG2 (b)	28.1 (2.99)	24.5 (2.40)	1.32
	CG	28.1 (2.18)	28.0 (2.10)	0.04
Carrasco-Poyatos et al. [21]	EG	36.5 (6.59)	31.9 (5.44)	0.76
	CG1 (a)	32.5 (4.57)	28.1 (3.51)	1.07
	CG2 (b)	36.2 (6.18)	33.9 (4.78)	0.41
Daniel et al. [36]	EG	29.3 (3.37)	23.0 (3.80)	1.75
	CG	30.1 (4.61)	30.4 (4.42)	0.06
Pereira et al. [20]	EG	30.1 (5.05)	22.1 (2.79)	1.96
	CG	25.2 (3.23)	26.1 (3.07)	0.28
Silva et al. [38]	EG	29.4 (4.65)	21.7 (2.34)	2.09
	CG	25.9 (2.35)	26.7 (2.32)	0.34
Vale et al. [37]	EG	21.3 (1.85)	18.0 (0.96)	2.17
	CG	21.6 (1.25)	22.0 (1.16)	0.33

Borba-Pinheiro: (a) 3×/week; (b) 2×/week; Carrasco-Poyatos: Control group - (a) Pilates; (b) no exercise; EG: Experimental group; CG: Control group; DS: standard deviation; *d*: effect size

It is also important to mention a multicomponent intervention, which can combine resistance, aerobic, balance, and flexibility training. Although this type of intervention was not evaluated in this review, as we focused on resistance training, the potential benefits of exercise on functional autonomy are likely to be increased in a multicomponent intervention [49]. Furthermore, the specificity of the resistance training performed, such as relative strength, strength endurance, power training, and absolute strength training can also represent different effects on the functional autonomy of older women [50]. However, the resistance training programs of the included studies prescribed the traditional strand, that is, the relative strength training.

This systematic review with meta-analysis presents some limitations. One of them was the low number of RCTs included. Additionally, of the 12 included studies, the majority (n = 8) were carried out in Brazil (Tab. I), leaving a gap regarding this type of intervention in other countries. A possible explanation for this result is that the GDLAM protocol was validated in Brazil, where there is a very large older population. Thus, the GDLAM is still consolidating in other countries. Another limitation was the wide variety of terms that exist to address functional autonomy. This lack of standard/consensus in the scientific literature may have caused the non-inclusion of some studies that also investigated this variable. Furthermore, MeSH recently added the term functional status (available at: https://www.ncbi.nlm.nih.gov/mesh/2052133), which can also be considered a synonym for functional autonomy. Therefore, the findings of this study must be interpreted with caution.

Our results reveal that there is still a lack of standardization in resistance training protocols for this population.

Table VI. Level of evidence (GRADE).

Certainty assessment							No. of patients		Effect		Certainty	Importance
No. of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	EG	CG	Relative (95% CI)	Absolute (95% CI)		
Functional autonomy (analyzed with GDLAM protocol)												
8	RCTs	not serious	not serious	not serious	not serious	none	148	138	–	mean -135 highest (2.32 lower to 0.38 higher)	⊕⊕⊕⊕ HIGH	Important

RCTs: randomized controlled trials; EG: experimental group; CG: control group; GDLAM: Latin American Group for Maturity; CI: confidence interval

Furthermore, other aspects, which can affect the methodological quality and are considered sources of bias, were found in some studies, such as the inappropriateness of randomization and the lack of blinding of evaluators and participants. These aspects can lead to overestimating or misjudging the intervention effect size, which may cause some conflicting results between trials and meta-analyses.

CONCLUSIONS

The evidence from the included studies showed that the practice of resistance training, for at least 12 weeks, with at least two training sessions per week, can be effective in increasing the functional autonomy of predominantly healthy, community-dwelling middle-aged and older women. Nonetheless, we detected a high heterogeneity among studies, including different training protocols, intervention times, and instruments to evaluate functional autonomy. Therefore, these findings should be analyzed with caution and new studies should be conducted with greater methodological control and a more detailed description of the protocols used in the interventions. Physical exercises involving other types of nonmedicated treatments, such as resistance training associated with other types of intervention, such as aerobic training, and core training, among others, should also be performed, helping people to maintain their functional autonomy for longer.

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Conflict of interest

The Authors declare no conflict of interest.

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Author contributions

FBM, JBPC, AOBS, GCPSMS, RGSV, EHMD: conceptualization; FBM, JBPC, AOBS, GCPSMS: methodology; FBM, JBPC, AOBS, GCPSMS, CJN, ACG, VPL, RGSV, EHMD: writing; FBM, JBPC, AOBS, GCPSMS, RGSV, EHMD: editing.
All Authors have read and agreed to the published version of the manuscript.

Ethical consideration

Not applicable.

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