REVIEW ARTICLE

Effectiveness of interventions in the improvement of muscle resistance in the elderly: a systematic review

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ABSTRACT

Global population aging has been much discussed in the last decade. China, Japan, and countries in Europe and North America have long lived with a large contingent of elderly people and all the problems associated with this aging process. However, the Brazilian elderly population, more specifically the female population, has been growing rapidly: the aging process in Brazil is occurring in a short period of time. With aging, loss of skeletal muscle mass as a whole is common. The impairment of muscle strength in the elderly individual is evident, since the loss of type II fibers is greater than type I. However, loss of type I muscle fibers also occurs during aging, and therefore, characteristics related to this type of fiber, such as muscular endurance, should also be considered by health professionals. **Objective:** The primary objective of this study was to perform a systematic review of the literature to determine the efficacy of intervention programs in improving muscular endurance in the elderly. The secondary objective was to evaluate the efficacy of these programs in improving other functional and health outcomes in this population. **Method:** Systematic review of literature based on the Prisma protocol (Pre- sent Reporting Items for Systematic Reviews and Meta- Analyzes), with searches in the MEDLINE, PEDro, LILACS and SCIELO databases, using a specific search strategy involving descriptors related to the elderly And muscular endurance. We included studies published in Portuguese and English, of the quasi-experimental (EQ) or randomized clinical trial (RCT), which involved elderly individuals and approached the skeletal muscles of lower limbs, upper limbs or trunk, and evaluated the efficacy of interventions for Improvement of muscular endurance. **Results:** A total of 133 studies were found with the electronic search. Of these, only 13 met the inclusion criteria, being 7 RCTs and 6 QE. The mean score obtained by the RCTs on the PEDro scale was 5.57, while the mean score obtained by the TRENDs was 18.57. Among the seven RCTs, all were classified as having adequate methodological quality. **Conclusion:** According to the results of most of the included studies, intervention programs elaborated according to the specific characteristics of the muscular endurance concept are effective in improving muscular endurance and other functional and health outcomes of healthy elderly. Further studies are needed to investigate the efficacy of interventions aimed at improving the muscular endurance of elderly individuals who have some associated health condition or specific disability.

Keywords: Resistance Training, Muscle Fatigue, Aged

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INTRODUCTION

Global population aging has been much discussed in the last decade. China, Japan, and countries in Europe and North America have long coexisted with a large contingent of elderly people and with all the problems associated with this aging process.[1] However, the Brazilian elderly population, especially the female population, has been growing in an accelerated way: the aging process in Brazil is happening in a short period of time. [2]

The elderly in Brazil today represent about 10% of the population of this country and have more health problems than the general population.[1] These factors characterize the challenges to be faced by the health system and by the entire Brazilian society in the aging process of their population.[3]

Aging is associated with a decline in most physiological systems in the body, including the musculoskeletal system. With aging, loss of skeletal muscle as a whole is very common.[4] This loss occurs mainly due to the marked infiltration of fibrous and adipose tissue into the skeletal muscle system and loss of muscle fibers of all types, with greater loss of type II fibers (related to muscle strength) than type I (related to muscular resistance). In this way, muscular performance characteristics, which include strength and endurance, are compromised.[5]

The impairment of muscle strength in the elderly is evident, since the loss of type II fibers is greater than type I.[5] This fact may be a justification for the large number of studies related to the evaluation and treatment of muscular strength of the elderly.[6] However, the loss of type I muscle fibers also occurs during aging and, therefore, characteristics related to this type of fiber, such as muscular resistance, should also be considered by health professionals.

In fact, although muscle strength is an important component of muscle performance, it is emphasized that more important than absolute strength gain is muscle endurance gains, since daily activities require muscular endurance and not just strength itself. In addition, this observed impairment in muscular endurance may be associated with important characteristics observed in this population, such as fragility, dependence and vulnerability. [4]

Muscle endurance is generally defined as the ability of a muscle or group of muscles to maintain a certain level of muscle strength or the ability to perform force repetitively. In other words, it represents a measure of the functional capacity of a muscle or muscle group.[4] Muscle resistance is currently considered a marker of health and well-being, in addition to being considered a predictor of mortality and independence.[7] It was observed that the elderly fallers needed more post-exercise recovery time than non-fallers and young women. In this context, changes in muscle endurance should be evaluated and quantified in rehabilitation programs.[8] It is recommended that these programs be based on protocols that include the use of eccentric and concentric muscle actions as well as multiple joints.[9]

Specifically, improvement of muscle endurance is important because the functional losses that occur with the elderly are possibly related to the inability to maintain repetitive efforts essential to perform activities of daily living. A small loss of strength due to muscle fatigue will result in significantly reduced muscle endurance. Increased muscular endurance in the elderly can lead to improved ability to perform submaximal tasks and recreational activities, leading to increased independence and ability to perform activities of daily living. In general, it can be said that the greater the state of localized muscular resistance of an individual, the better the autonomy in the performance of the ADLs, which consequently provides a better quality of life. [10]

The American College of Sports Medicine (ACSM)[11] recommends that resistance training be an integral part of a physical fitness program for adults and seniors. Their recommendations for the elderly include at least a series of 10-15 repetitions for the major muscle groups, often two to three times a week.[11] Muscle endurance tests are those in which various contractions are performed with submaximal loads. [12] The training which aims to improve muscular endurance should include variation of overload and give importance to rest interval.[9] It has already been demonstrated that exercises performed in gymnastics apparatus twice a week for 12 weeks with approximately 30 minute sessions involving trunk, lower limbs and improve muscular endurance and balance in the elderly. [12]

OBJECTIVE

Considering the importance of muscle resistance to the functionality and health of the elderly, the primary objective of this study was to conduct a systematic review of the literature to determine the effectiveness of intervention programs in improving muscular endurance in the elderly. The secondary objective of this study was to evaluate the efficacy of these programs in improving other functional and health outcomes in this elderly population

METHOD

It is a systematic review of literature prepared according to the Prisma protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes)[13,14] with all steps performed by two independent examiners. Divergences between these examiners were discussed until a consensus was reached. In the absence of consensus between the two examiners, a third examiner was involved to make the final decision.

In the first stage, searches were performed on the MEDLINE, PEDro, LILACS and SCIELO databases, using the descriptors elderly or aging, or old or older, combined with “muscular endurance” or “muscle endurance”. Subsequently, the studies found were evaluated for the following inclusion criteria: individuals of either sex aged 60 years or older (elderly), studies published in the English and Portuguese languages up to April/2016, being quasi-experimental (QE) or randomized clinical trial (RCT), addressing skeletal musculature of lower or upper limbs, or trunk, who have evaluated the effectiveness of interventions for the improvement of muscular endurance.

In the second stage, the study titles were evaluated and when the study clearly did not fit any of the inclusion criteria, it was excluded. The same procedure was adopted in the third stage during the analysis of the abstracts of the studies included in the second stage. In the fourth stage, all studies included in the third stage were read in full and all those that met the inclusion criteria were included. In the fifth step, an active manual search was performed on all the references of the included studies from the search in the electronic databases, following the same procedures.

The sixth step consisted of evaluating the methodological quality, using the PEDro[15,16] scale for RCTs and the TREND (Transparent Reporting of Evaluations with Nonrandomized Designs) scale[17,18] for the QE studies. The PEDro scale is composed of 11 items, each item contributing with 1 point (except for item 1 that is not punctuated) and the final score ranges from 0 to 10. A study of adequate quality is one with a score above four points and a low quality study one that scores below it.[16] The TREND school is a guideline composed of 23 items, each item contributing with one point to the total score, but there are still no determined criteria to classify the final score of this scale. [17,18]

Finally, the seventh and last stage involving the data extraction was performed. In order to meet the objectives of this systematic review, the following data were extracted from the included studies: population studied, type of physical exercise performed, intervention protocol, variables analyzed, method of measuring the outcomes, conclusion and results.

RESULTS

A total of 133 studies were found in the electronic databases, being 96 in the MEDLINE database, 30 in SCIELO and seven in PEDro. No studies were found in the LILACS database. In the first stage, 63 studies were excluded by reading their titles. Of these studies, there were five repeated articles from the 65 studies selected for reading their abstracts, then 25 were excluded and, therefore, a total of 40 studies were read, 27 of the 40 analyzed were eliminated. Therefore, 13 studies found in electronic databases were included. An active manual search was performed in these 13 studies, but no new studies were found that met the inclusion criteria and could be included.

Of the total of included studies, seven (53.85%) were RCT and six (46.15%) QE. The mean score obtained by the RCTs on the PEDro scale was 5.57 out of 10 points, while the average score obtained by the TREND scale QE was 18.57 out of 23 points. All RCT studies (100%) were classified as of adequate methodological quality (Chart 1 and 2).

Chart 1. Analysis of the methodological quality of the included randomized clinical trials according to the PEDro scale (n = 7)

Criteria of PEDro Scale	Candow et al.[19] 2004	de Vos et al.[20] 2005	Galvão et al.[21] 2012	Jacobson et al.[12] 2012	Kanitz et al.[22] 2015	Oh et al.[23] 2012	Staehle et al.[24] 2001
1- Elegibility	S	S	S	N	S	S	S
2- Random Allocation	S	S	S	S	S	S	S
3- Blind Allocation	S	N	N	N	N	N	N
4- Blind Participants	S	S	N	N	N	N	N
5- Blind Therapists	N	N	N	N	N	N	N
6- Blind Evaluators	S	N	N	N	N	N	S
7- Losses <15%	S	S	S	S	S	S	S
8- Intention to Treat Analysis	N	S	S	N	S	S	N
9- Difference between reported groups	S	S	S	S	S	S	S
10- Similarity between groups in the baseline	S	S	S	S	S	S	S
11- Reported variability and "point estimate	N	N	N	S	N	N	N
TOTAL	7	6	5	5	5	6	5

Y: yes; N: no.

Characteristics of the Participants

All 13 included studies included samples of elderly women and men aged between 60 and 84 years. Most of the studies (n=9, 69.23%) were performed in healthy elderly individuals (Chart 3), and it was specified that the elderly were sedentary in five studies (38.47%).

Other studies (30.77%) were performed with elderly individuals who presented a specific health condition: two with individuals who suffered acute myocardial infarction[24,27,31] one individual with Parkinson's Disease[28] and one with elderly individuals with a history of falls in the previous year[23] (Chart 4). In a study with healthy elderly individuals, individuals with a particular characteristic were included: Tai Chi Chuan practitioners and runners[26] (Chart 3).

Sample sizes of the studies ranged from 9 to 112 individuals. The number of intervention groups ranged from one to three groups (Chart 3 and 4).

Measurement of Muscle Endurance

Different methods were used to measure muscle endurance. In the majority of studies (69.23%), only the method of counting the largest number of repetitions of a given muscle movement/contraction was used: a larger number of biceps flexions performed with the dominant hand holding a weight of 1.8 Kg[30], From repetitions to supine exercise fatigue (shoulder and elbow extension) and leg press (hip and knee extension),[19] the largest number of concentric and eccentric contractions of knee extensors and flexors.[22]

In other studies (30.77%), the number of repetitions of a given muscle movement/contraction was counted in a given period of time (number of abdominal flexions in 30 seconds,[23,28] number of repetitions in 30 seconds of flexion of Elbow with internal rotation weight 2 kg[25] and number of repetitions in 30 seconds with chair-sit and stand-up exercises[25] and use of time individuals were able to withstand a given overload.[27] The isokinetic dynamometer was used in four studies to measure muscle endurance[22,24,26,29] (Charts 3 and 4).

Characteristics of Intervention Programs

The interventions most commonly used in the studies involved the training of muscular endurance with exercises of flexion, extension of hip, knee and shoulder in gymnastic apparatus (n=5; 38.46%)[12,19,20,21,25] hike (n=4, 30.77%),[23,24,25,28] running (n=2; 15.38%), muscle stretching (n=4, 30.77%),[24,30] The training overload varied from 55 to 90% of the maximum resistance, with repetitions varying from 8 to 10 repetitions. The duration of the interventions ranged from 8 to 24 weeks, with training sessions often ranging from 2 to 3 times a week, lasting between 30 and 120 minutes (Chart 3 and 4).

It is important to note that one of the studies evaluated whether suspension of oral creatine Monohydrate (0.3 g/kg body weight/day for 5 days, 0.07 g/kg) would have some impact on the muscle endurance and other variables. In this study, creatinine was used for 12 weeks, followed by 12 weeks without using this drug in the Control Group. After the suspension, muscle training was done two days per week, at least 48 hours, three sets of 10 repetitions, one minute of rest between sets, approximate intensity of 70% of 1-RM in the leg press, supine and knee extension.

The control group performed the same training as the experimental group and used Creatinine in the first twelve weeks, but in the

Chart 2. Analysis of the methodological quality of the included quasi-experimental studies according to the TREND scale (n = 6)

Criteria of Trend Scale	Nakamura et al.[25] 2015	Xu et al.[26] 2006	Pihl et al.[27] 2011	Peacock et al.[28] 2012	Grimby et al.[29] 1992	Ourania et al.[30] 2003
1- Title and Abstract - Allocation information, target population and structured abstract	Y	Y	Y	Y	Y	Y
2- Introduction - Scientific backgrou-nd and theoretical justification	Y	Y	Y	Y	Y	Y
3.1- Methods - Eligibility criteria, place and method of recruitment, collection site	Y	Y	Y	Y	Y	Y
3.2- Methods - Detailed intervention	Y	Y	Y	Y	Y	N
3.3- Methods - Specific objective and hypothesis	N	N	N	N	N	N
3.4- Methods - Primary and secondary outcomes, validity of instruments used	N	N	N	N	N	Y
3.5- Methods - Sample Size Deter-mination	Y	Y	Y	Y	Y	N
3.6- Methods: How the groups were divided	Y	Y	Y	Y	Y	Y
3.7- Methods - Evaluators, therapists and blind participants	Y	Y	Y	Y	Y	Y
3.8- Methods - Description of the analyzed unit, if it differs from the evaluation and adjustment of the standard error	Y	Y	Y	Y	Y	Y
3.9- Methods - Statistical analysis and software used, number of losses	Y	Y	Y	Y	Y	Y
4.1- Results - Participant flowcharts and protocol changes	Y	Y	Y	Y	Y	Y
4.2- Results - Recruitment and col-lection period	Y	Y	Y	Y	N	N
4.3- Results - Baseline evaluation data	Y	Y	Y	Y	Y	Y
4.4- Results - Equivalence between groups in the baseline evaluation	Y	Y	Y	Y	Y	Y
4.5- Results - Number of participants, main differences found and inten-tion to treat analysis	Y	Y	Y	Y	Y	Y
4.6- Results - Primary outcomes and possible null results	Y	Y	Y	Y	Y	Y
4.7- Results - Secondary analysis	N	Y	N	Y	N	N
4.8- Results - Adverse events	N	N	N	N	N	N
4.9- Results	Y	Y	Y	Y	Y	Y
5.1- Discussion - Interpretation of results	Y	Y	N	N	Y	Y
5.2- Discussion - Generalization (External Validity)	Y	Y	Y	Y	Y	Y
5.3- Discussion - General Evidence	Y	Y	Y	Y	Y	Y
TOTAL	19	20	18	19	18	17

Y: yes; N: no.

following twelve weeks, despite having continued to train, the participants used placebo instead of Creatinine. [19]

Only one of the studies performed some kind of follow-up after the end of the intervention, with evaluations 3, 6 and 12 months after the intervention.[27]

Efficacy of Interventions to Improve Muscle Endurance

In all studies (EQ) (100%), which were performed both with healthy elderly (Chart 1) and with elderly patients with some health condition (Chart 2), intervention programs investigated were effective in improving muscular endurance. Among the RCTs, in three (42.86%) the efficacy of the intervention of the experimental group (EG) in the improvement of muscular endurance was demonstrated in comparison with the control group. The other four (57.14%) studies did not show a significant improvement in muscle endurance in the intervention group compared to the control group. [19,22,23,24]

In one of these studies, the difference between EG and CG was the use of Creatinine.[19] In the other study, the EG received deep-water muscle-resistance training intervention and the CG strength training in deep water.[25] In the others Two RCTs, the sample consisted of individuals with specific health conditions[23,24] (Chart 4).

Efficacy of Interventions to Improve Other Functional and Health Outcomes

Among the included studies, 92.31% (n=12) also evaluated other functional and health outcomes. Muscle strength was the most evaluated outcome (n= 8, 61.53% of studies),[19,20,22,23,25,26,28,29] followed by balance (n=5, 38.46% of the studies),[12,23,25], 30 of the cardiovascular resistance (n=3, 23.08%),[22,25,28,29] of the flexibility (n=3; 23.08% of the studies) [22,23,30] and (n=2; 15.38% of the studies).[21,23] Other outcomes, such as muscle power, fear of falling, and quality of life were evaluated by only one study, as detailed (Tables 3 and 4).

Among the eight studies that evaluated muscle strength, in five, significant improvement was reported after the intervention. The balance showed a significant improvement in all the studies that evaluated this outcome,[12,23,25,30] as well as cardiovascular endurance[22,25,28] and flexibility.[23,25,30] The gait velocity showed a significant improvement in only one of the two studies that assessed it.[23] Most of the other functional and health variables also showed significant improvement after training to improve muscular endurance, such as muscle power, fear of falling, and quality of life[20,22,27] (Tables 3 and 4).

DISCUSSION

The objectives of this study were to perform a systematic review of the literature to determine the effectiveness of intervention programs in improving muscular endurance in

Chart 3. Characterization and results found by studies with healthy elderly (n=9)

Study and metho-dological design	Sample	Measurement of muscle endurance	Intervention protocol	Results found for muscle endurance and other functional and health outcomes
Grimby et al.[29] QE 1 group	9 men Age: 78-84 years	Dynamic muscle strength of knee extension measured by the isokinetic dynamometer before and after training from 50 concentric contractions repeated at an angular velocity of 180°/s.	25 sessions, 56-77 training days - 2 or 3 times/week. Training with Cybex II: 1) 8 concentric right and left knee extensions at 18°/s, 10 sec pause, 2) 2 isometric knee extensions at knee angle 60°/s for 4 sec., 10s pause, 3) 8 concentric knee extensions at 30°/s for 4 s, 10s pause, 4) 2 isometric knee extensions 30°/s for 4 sec, 10 sec. pause, 5) 8 concentric knee extensions at 180°/s for 4 sec, 10 sec pause, 6) 2 isometric knee extensions 60°/s for 4s. Training with Kin-Corn II: 8 repetitions of right and left eccentric knees, immediately followed by, concentric knee extension actions at 30., 5 min pause and repetition of the entire program, a further pause of 5 min, and 3th repetition of the entire program.	Improvement of muscular endurance: the fatigue index decreased significantly from 37.6 to 25.3. In relation to the evaluation made before the intervention. Muscle strength: no significant improvement
Ourania, et al.[30] QE 4 groups	55 women Age: 60-75 years TRT 1: 15 TRT 2: 15 TRT 3:15 CG: 10	> Number of biceps pushups in 30 sec. with dominant upper limb using a weight of 1.8 kg	12 weeks of exercises - 45 minutes each TRT 1: 1 X week, TRT 2: 2 X week. TRT 3: 3X week. Exercises: Flexibility of the lower back hip, running, coordination (manipulating cans in the required order), biceps pushups in 30 sec. With dominant upper limb using a weight of 1.8 kg. CG: Without intervention	Significant improvement of muscular endurance in the three groups, and in the TRT 3 group the improvement was greater. Flexibility, Coordination, Equilibrium: they improved significantly in the TTO3 group in relation to the control group
Xu et al.[26] QE 3 groups	61 elderly Age:64,9–66,2 years TRT TC:21 TRT cor.:18 CG: 22	Muscle endurance test, isokinetic dynamometer: flexors and knee extensors at 180°, after 20 min of relaxation. Muscle endurance test of ankle dorsiflexors and plantar flexors at 30°	TRT TC: Heating and stretching (8 min), TC practice 60 min, and cooling (7 min) TRT Jogging: No TC practitioners, runners for 4 years, 1 hour training per day, daily distance of 7.9 Km at 8.6 Km/h. CG: Sedentary individuals who have not performed any regular exercise for more than 5 years	Muscle endurance of knee extensors had a significant improvement in TC practitioners. Muscle strength of the knee joint between the three experimental groups were significant at the highest velocity. The forces of knee extensors and flexors in the control group were significantly lower than those in the jogging group and considerably lower than those in the TC group. For the ankle joint, subjects in the TC and jogging groups generated more torque in their ankle dorsiflexors.
Nakamura et al.[25] QE 4 groups	45 women Age:67,8-70 years G1:10; G2:10 G314; CG:11	Sit and Lift, Elbow Flexion with internal rotation (overload 2 kg). Higher number of repetitions in done 30 sec. evaluated	G1: 12 without training, 1 time per week, G2: 2 times per week. And G3: 3 times p/w, CG: No intervention. For 90 min: 10 min. 20 min of walking, 30 minutes of recreational activities (balance, agility and coordination using a rubber ball, 20 min resistance training (arm push-ups, squats, sit-ups, hip extensions, using body weight or Thera-Band1. 3 series of 10 repetitions per sec, 30 sec rest between sets), 10 min cooling.	Significant improvement in muscle endurance, dynamic balance, coordination, cardiorespiratory endurance and decrease of body fat in G3 in relation to the others. No improvement in muscle strength.
Candow et al.[19] ECA 2 groups	13 men Age: 61-83 years TRT (Cr): 8 CG: 5	Extension of shoulder and elbow (supine), extension of knee (Leg press). Evaluated> number of repetitions until fatigue. 70-80% 1-RM. 3 series w/ 1 min interval. Interval: 3 min.	TRT (Cr): 12 wk. with use of Cr and 12 without Cr, 2 days p/w. (48 hours intervention) 3 sets of 10 rep. with 1 min rest between sets for each exercise, intensity of approx. 70% of 1-RM for leg press, bench press, and knee extension. 10 rep. p/min for the other exercises. CG: No use of Creatinine.	No statistically significant difference in muscle endurance and muscle strength
de Vos et al.[20] ECA 4 groups	112 elderly Age: 67.6-69.4 years TRT 1:28; TRT 2: 28; TRT 3: 28 CG: 28	> number of repetitions of Leg press, Chest press, Leg extension, Seated row, Knee flexion, at 90% of 1 RM.	TRT: Resistance exercises 2 times per week, 8 to 12 weeks, training at 20% (TTO1), 50% (TTO2) and 80% (TTO3) of 1 RM. 3 sets of 8 rep. of fast concentric and 2 sets of rep. Slow eccentric. CG: were instructed to maintain their current level of physical activity during the study	Significant improvement in muscle endurance in all TRT groups compared to CG. Muscle power improved significantly in the TRT group relative to CG
Galvão et al.[21] ECA 2 groups	32 elderly Age: 65-78 years TRT 1: 12 TRT 2: 16	> Number of repetitions performed at 70% of 1 RM: Chest press and leg press	TRT 1: 1 set of 8 reps each, 2 times per week, 20 weeks. TRT 2: 3 sets of 8 repetitions each, 2 times a week, 20 weeks. Exercises: pectoral extension, bicep curl, triceps extension, biceps flexion, hip and knee extension, knee flexion in bodybuilding apparatus, with focus on upper and lower limbs for both groups in both groups	TTO2 group showed a statistically significant improvement in muscle resistance in relation to TTO1 Functional performance (sit and stand up, 6 m backward walk, 6 min walk, 6 min fast walk, 400m walk, climb, floor lift): no difference between groups compared to pre-intervention data.
Jacobson et al.[12] ECA 2 groups	53 elderly Age 76.2-81.3 years TRT: NI CG: NI	Greater number of repetitions for: Chest Press: cadence of 30 rep. / S with weights of 80 pounds and 35 pounds for men and women, respectively. Leg Extension: Measured in 50% repetitions of body weight for both men and women. Triceps extensions: were made with sheave, overload connected to weight, load of 33% of weight for both men and women.	TRT: 2 times p/ w, 12 wk, 30 min sessions. Concentric contractions using 6 specific devices for the muscles of the legs, trunk, upper limbs the body and arms. In each machine, for 5 min. with speeds between 14 and 16 repetitions per min. CG: Without intervention	Significant improvement in muscle strength in the TRT group compared to pre-intervention TRT group improved significantly in balance, functional mobility (Timed Up and Go Test) in the TRT group except in the chair lift test

Continuation Chart 3.

Kanitz et at.[22] ECA 2 groups	34 men Age: 65.2 ± 3.8 anos Endurance Training TR:16 Strength Training TF: 18	Localized muscle strength with concentric and eccentric contractions. (Repeat max. 1.5 rep. at 60% 1RM) for knee extensors and flexors.	12 weeks, 45 minutes each session as below: Resistance training in deep water: 6 times per week for 30 minutes: *1st - 4th week: 4 min 85-90% FC. Max. + 1 min at 85% FC max. * 5th-8th week: 4 min 90-95% FC. Max. + 1 min at 85% FC max. * 9th-12th week: 4 min 95-100% FC. Max. + 1 min at 85% FC max. Strength training in deep water, interval between sets of 1 minute and 20 seconds: *1st-4th week: 2 times/week, 20s of flexion and extension of right knee, 20s of flexion and extension of left knee, 20s adduction and hip abduction (right and left together), total of 3 min and 20s. *5th-8th week: 3 times / week, 20s of flexion and extension of right knee, 20 seconds of flexion and extension of left knee, 20s of adduction and hip abduction (right and left together), total of 5 min and 40s. * 9th-12th week: 4 times per week, 15s of flexion and extension of right knee, 15s of flexion and extension of left knee, 15s of adduction and hip abduction (right and left together, total of 7 min and 45 s). Overload at 60% 1 RM	There was no improvement in muscle strength in either group. Cardiorespiratory endurance: Resting heart rate decreased significantly in both groups, VO2peak and VO2VT2 showed significant increases in both groups, with no significant difference between groups, but VO2VT2 resulted in significantly higher values for ET compared to the TC group after training. Strength: significant increase in maximal dynamic force of knee extensors in both groups compared to pre-workout not between groups

RCT = Randomized Clinical Trial; QE = Near-Experimental; MR: Maximum Repetition; TRT: Treatment; Cr: Creatinine CG: Control Group; d: days; w: week; rep: repetition; min: minutes, s: seconds TC: Tai Chi; NI: not informed; F: for; Interv .: interval; No.: number; HR max: maximum heart rate; 1MR: 1 maximum repetition; VO2peak (peak oxygen uptake): peak in oxygen consumption; VO2VT2 (oxygen uptake in the second ventilatory threshold): Absorption of oxygen at the second ventilatory threshold

Chart 4. Characterization and results found by studies with healthy elderly (n=9)

Study and methodological design	Sample	Measurement of muscle endurance	Intervention protocol	Results found for muscle endurance and other functional and health outcomes
Pihl et al.[27] QE 2 groups	TRT:29 Controle: 31 Elderly who suffered acute myocardial infarction Age: 74.4 to 76.2 years TRT: 29 Control: 31	Bilateral isometric abduction: Seated on a bench with back touching the wall with a 3 kg--dumbbell in each hand and both arms raised to 90° of shoulder abduction. Position held while possible. Right and left shoulder flexion: sitting on a bench with the back touching the wall a weight of 3 kg for males and 2 kg for females. Held in the arm's hand to be tested. Orientation of raising the arm, from 0 to 90° of flexion as many times as possible, with a speed of 20 push-ups per minute.	TRT: 12 months of home workout 3x week and 1x week treatment center. In the last 6 months 1x per month in the center and 3x week at home Exercise with music to get up and walk for 10 min for heating. 45 min of exercises of limbs superior and inferior to 75% of RM with resistive elastic band. Follow-up of physical capacity and HRQoL done in 3,6 and 12 months. CG: Without intervention	Significant improvement of muscle endurance, Flexibility, Balance, Cardiovascular Endurance and Post-intervention Strength in the healthy elderly (CG). Muscle resistance increased from 12.7 repetitions:
Peacock et al.[28] QE 2 groups	Elderly people with Parkinson's disease and healthy elderly Age: 67.5 ± 7.9 years TRT DP: 13 CG: 9	Increased number of abdominal crunches in 30 sec.	TRT DP: 8 weeks active-assisted cycling exercise (arm cycle ergometer, exercise bike), 3 x sem., 30 min, 85 rpm leg 75 rpm respectively. Resistance training, 3 x week, 30 min, 55-67% of 1-RM; Flexibility training, 3 x week, 20 s stretching the limb fully for 10 min; Training (walking and balance), 3 x week, 5 min. CG: Healthy elderly people performed the same exercises	Significant improvement of muscle endurance, Flexibility, Balance, Cardiovascular Endurance and Post-intervention Strength in the healthy elderly (CG). Muscle resistance increased from 12.7 repetitions.
Staehle et al.[24] ECA 2 groups	31 elderly that had an acute coronary condition Age: 71-74 TRT:17 CG:14	Fatigue test in the isoskektic dynamometer, evaluating knee extensor resistance in 3 sessions of 30 maximal concentric voluntary knee extensions. Angle velocity 180 ° assessment at baseline and follow-up at 3 and 6 months.	TRT: Hospital: 1 daily walk in comfortable speed, gradually increasing the time, length and speed of the walk. They were encouraged to come up with a 12-13 effort on the Borg effort scale. After hospital discharge, aerobic training (3 peaks of 4 min. 85% HR max), followed by activity of squatting, toe climbing, hip flexion, raising of arms, stretching. Duration of 50 min., 3 times a week for 3 months. After another 3 months 1 time per week CG: without intervention	No group showed improvement in muscular endurance
Oh et al.[23] ECA 2 groups	65 elderly (fall) TTO: 36 Age: 66.2 ± 3.2 CG: 29 Age: 68.7 ± 5.4	Increased number of flexions in 30 sec.	TRT: 12 weeks, 120 min, 3 times/week. In 4 phases: 40 min. stretching, resistance training, 10 min. Warm-up: walking/ stretching, 20 min. of solo exercises for abdominal strength, 20 min of strength exercises for both legs, 20 minutes of balance exercise and 10 min of cooling activities. GC: without interventio	No group showed improvement in muscle endurance. In the TRT group, it was seen improvement in walking speed, balance, strength of the back muscles, lower extremities, and flexibility

RCT = Randomized Clinical Trial; QE = Quasi-Experimental; MR: Maximum Repeat; TRT: Treatment; Cr: Creatinine CG: Control Group; s: seconds, d: days; w: week; rep: repetition; min: minute; Intens: Instensity, PD: Parkinson's disease, Kg

the elderly and the efficacy of these programs in improving other functional and health outcomes in this elderly population. In general, the interventions used, in their great majorities constituted by specific training protocols for muscle endurance, were effective for improving muscular endurance in the elderly and most other functional and health outcomes that were evaluated (muscle strength, balance, cardiovascular resistance, flexibility, walking speed, muscle power, fear of falling, and quality of life).

Most of the studies included[23,25-30] were of the RCT type and with adequate classification of methodological quality. The other studies,[11,19,20,21,22,24] of the QE type, although not counting on the randomization of the individuals, important characteristics of the RCT, had adequate methodological quality according to TREND criteria. This scale still does not present a clear cut-off point to classify the studies, but all scored higher than 50%.

Regarding the characteristics of the elderly included in the studies, it is highlighted that the majority involved healthy individuals, of whom the majority were sedentary.[11,19,20,21,25,29,30] However, studies were also included with the elderly Who suffered acute myocardial infarction,[24,27] with Parkinson's disease,[28] and with a history of falls.[23] The approach to a diverse population is of great importance, as investigating the efficacy of interventions in individuals with different characteristics allows the application of the results obtained in a larger number of individuals.

Muscle endurance is defined as the ability of a muscle or group of muscles to maintain a certain level of muscle strength or the ability to perform force in a repetitive manner.[4] Adequate assessment of muscle endurance should include variation in overload and give importance to rest interval.[9] In addition, the overload should be moderate, with large number of repetitions.

With the exception of one study, muscle endurance was adequately assessed by all other studies. The method of evaluation of questionable muscular endurance was the one that used 90% load of 1-MR (Maximum Repetition): 20 maximum tests do not match muscular endurance evaluation.[9]

Observing the characteristics and results obtained by the studies included in this systematic review, it can be stated that the use of specific training protocols for muscle endurance training, following the essential characteristics of the concept, are effective for the improvement of the muscular endurance of the elderly. In one of the RCTs, it was possible to observe that the group that performed three daily sets of pectoral extension exercises, biceps threading, triceps extension, biceps flexion, hip and knee extension, knee flexion in bodybuilding apparatuses presented better results in muscle endurance than the group that did the same exercises in only one daily series. [29] It was possible to observe in an QE study that the group that trained more frequently per week with exercises of hip flexibility, running, coordination (handling cans in required order), biceps pushups in 30 seconds with dominant upper limbs using a weight of 1.8 kg also showed greater improvement in muscular endurance than the group that did the same exercises training once and twice a week.[30]

In the study by Nakamura et al.[25] also of the QE type, the result was similar: individuals who trained more times per week also had greater improvement in muscular endurance than the group that trained once or twice a week.

Four (30.77%) studies did not show significant improvement in muscle endurance in the intervention group compared to the control group. Possibly, the imposition of maximum load on interventions or limitations in methods of measuring muscle endurance may be related to these results. [19,22,23,24]

Considering other functional and health outcomes evaluated, muscle strength improved in five of the eight (62.5%) who evaluated it,[23,22,25,26,29] balance,[11,23,25] cardiovascular resistance[22,25,28] and flexibility[23,28,30] showed a significant improvement in all the studies that evaluated these outcomes, gait speed improved in one of the studies[23] among two that evaluated this outcome, and most of the other variables of functionality and health also presented significant improvement after training to improve muscular endurance, such as muscle power, fear of falling and quality of life.[20,21,27] The improvement of these variables associated with improved muscular endurance indicates that the protocols used are not only effective for improvement of a single outcome, but for other important outcomes for functionality and health of the elderly.

CONCLUSION

According to the results of most of the included studies, intervention programs developed following the specific characteristics of the concept of muscular endurance are effective for improving muscular endurance and other functional and health outcomes of healthy elderly. More studies are needed to investigate the efficacy of interventions aimed at improving the muscular endurance of elderly people who have some associated health condition or specific disability.

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