Asian J Sports Med. 2020 December; 11(4):e103000. doi: 10.5812/asjsm.103000.

Published online 2020 November 28. **Review Article**

# Do All Resistance Exercise Protocols Improve the Functional Parameters of the Elderly? A Review Study

Fabiano de Jesus Almeida [1], Maycon Henrique Melo [2], Raquel Nogueira [3], Jozimar Prazeres [3], Cyrene Costa [3, 4] and Bruno Bavaresco Gambassi [1, 3, *]

[1] Curso de Educação Física, Universidade Ceuma, São Luís, MA, Brazil
[2] Programa de Pós-Graduação em Meio Ambiente, Universidade Ceuma, São Luís, MA, Brazil
[3] Programa de Pós-Graduação em Gestão de Programas e Serviços de Saúde, Universidade Ceuma, São Luís, MA, Brazil
[4] Curso de Odontologia, Universidade Ceuma, São Luís, MA, Brazil

[*] *Corresponding author*: Programa de Pós-Graduação em Gestão de Programas e Serviços de Saúde, Universidade Ceuma, São Luís, MA, Brazil. Email: professorbrunobavaresco@gmail.com

**Received** 2020 March 26; **Revised** 2020 July 16; **Accepted** 2020 July 24.

## Abstract

**Context:** Aging has been associated with negative changes in the neuromuscular system, significantly impairing the performance of daily life activities. A number of studies have validated functional tests (e.g. timed-up-and-go, gait speed) for the assessment of daily activity performance in the elderly. Thus, it is critical to understand the role of exercise training in this context. The practice of resistance training (RT) has been found to promote muscle strength in the elderly; however, we cannot safely state that any of these resistance exercise protocols would lead to improved performance of functional parameters (e.g. timed-up-and-go, gait speed, getting out of a chair) of this population. To assess the effects of RT on functional parameters of the elderly and to undertake a detailed assessment of the exercise protocols surveyed.
**Methods:** PubMed, Cochrane CENTRAL, and PEDro databases were used to search the literature. A total of 917 articles were initially selected, of which 10 peer-reviewed articles met the search criteria.
**Results:** In the included studies, the positive effects of RT on the functional parameters of the elderly were observed. The training protocols presented the following characteristics: duration of 12 – 16 - 24 - 36 - 60 - 72 sec and 96 sessions; frequency of 1 - 3 sessions per week; training volume of 2 - 5 sets of 4 - 15 repetitions; 40 - 60 - 90 - 120 - 180 sec rest interval between sets; 40 - 60 - 90 - 120 - 180 sec rest interval between exercises; 24 - 48 - 72 hour rest interval between sessions; 40 - 85% intensity of one maximum repetition; isotonic contractions, contraction velocity (as fast as possible-1 - 2 - 3 seconds to concentric and 2 - 3 seconds to eccentric phases).
**Conclusions:** Although the benefits of RT were observed, it was not possible to determine that any of these resistance exercise protocols would lead to improved performance of functional parameters (e.g. timed-up-and-go, gait speed, getting out of a chair) of this population, given the limitations we found in the research papers reviewed.

*Keywords:* Aging, Components of Functional Capacity, Activities of Daily Living, Intervention, Exercise

## 1. Context

Aging may be regarded as a natural, progressive, and irreversible process characterized by an overall functional decline of the organism (1-5), and it is closely associated with negative alterations in the neuromuscular system, with consequent impairments in the performance of daily life activities (6-8).

On the other hand, several studies have demonstrated that resistance training (RT) is promising for disease prevention and rehabilitation in this population. According to Gambassi, dos Santos and Almeida (9) RT may be defined as any exercise which promotes force movements against the opposition of some type of resistance. When prescribing this type of training, a range of variables and protocols may be used, e.g. periodization (periodized vs. non-periodized); types and order of exercises; types of contractions; contraction velocity; range of motion; rest between sets, exercises, and sessions; duration (number of exercises, number of sets, and number of repetitions) (9).

It is now widely acknowledged that the practice of exercise training may provide several benefits for the overall health of the elderly (10-19). Additionally, it has been demonstrated that RT resulted in small to moderate significant improvements in physical ability (15). Liu and

Latham (15) have demonstrated improved strength and performance of simple and more complex activities of the elderly. In this sense, an elegant study conducted by Lopez et al. (16) has shown positive effects of RT (i.e., included or not in multimodal training) on muscle strength, muscle power, and functional outcomes in the physically frail elderly. In addition, these positive structural and functional changes in the neuromuscular system have been found to decrease the risk of depression, falling, and problems with and quality of life (20, 21).

Usually, review studies on RT and functional parameters focus on the effects of protocols. Given the many ways of manipulating RT variables and the several protocols used in the literature, we can safely state that any of these resistance exercise protocols would lead to improved performance of activities of daily living (functional parameters - e.g. timed-up-and-go, gait speed, getting out of a chair) of the elderly? Lopez et al. (16) have demonstrated benefits in functional outcomes in physically frail elderly undertaking RT alone or combined with a multimodal exercise intervention.

Thus, since the important role of RT in improving functional parameters has been widely acknowledged, the next step would be to safely state that any of these resistance exercise protocols would be effective for this purpose. In this sense, further studies are needed with a more detailed and accurate assessment of the different RT protocols, using functional tests (directly related to daily activities) in the elderly population.

The aim of this review study was to assess the effects of RT on functional parameters (e.g. timed-up-and-go, gait speed, getting out of a chair) among elderly people and undertake a detailed analysis of the exercise protocols surveyed.

## 2. Methods

This review was conducted following both the Systematic Reviews and Meta-Analyses (PRISMA) guidelines and the methodology adopted in recent studies (22-24).

### 2.1. Elegibility Criteria

The PICOD strategy (population, intervention, control/comparison outcome variables, and study design) was used for the search criteria. Studies were selected for inclusion if they met the following 4 criteria: (P) humans aged over 60 years of both sexes; (I) structured RT protocols with a clear description of the variables related to intensity, volume, and duration; (C) controlled/intervention; (O) benefits on functional parameters (e.g., timed-up-and-go, gait speed, getting out of a chair, eight-foot up-and-go) and (D) randomized controlled trials (Figure 1).

### 2.2. Study Identification and Selection

Relevant studies were identified through computerized and manual searches. For data collection, PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), and Physiotherapy Evidence Database (PEDro) databases were systematically searched between 2009 (January) and 2020 (May). The following keywords were used for our search: elderly; older; functional capacity, functional fitness, physical function, functional autonomy, functional performance, physical capacity; resistance training; and resistance exercise (Figure 1).

The screening phase was performed by 2 independent reviewers. For each article, any discrepancy between the 2 reviewers was resolved by third reviewers reading and further analysis. In the first screening stage, studies were selected by titles plus abstracts, while the second screening stage required the assessment of full texts. The reviewers evaluated the methodological quality of the studies and extracted relevant data.

### 2.3. Article Quality Assessment

The methodological quality of the studies was evaluated by two independent reviewers using the PEDro scale (25).

The PEDro scale evaluates the following methodological quality aspects: 1- detailed eligibility criteria, 2- random allocation, 3- concealed allocation, 4- baseline prognostic similarity, 5- participant blinding, 6- physical therapist blinding, 7- outcome assessor blinding, 8- more than 85% follow-up for at least one primary outcome, 9- intention-to-treat analysis, 10- between- or within-group statistical analysis for at least one primary outcome, and 11- point estimates of variability given for at least one primary outcome. A study with a PEDro score of 6 is equated to a level 1 of evidence (6 – 8 good, 9 –10 excellent), while a study with a score of 5 is given a level 2 of evidence (4 – 5 acceptable, 4 poor).

### 2.4. Data Extraction

The following characteristics were recorded for all articles: type of study; author; year of publication; participants (age); functional parameters (functional capacity, functional fitness, physical function, functional autonomy, functional performance, physical capacity; and details of RT protocols used (intensity, volume, and duration).

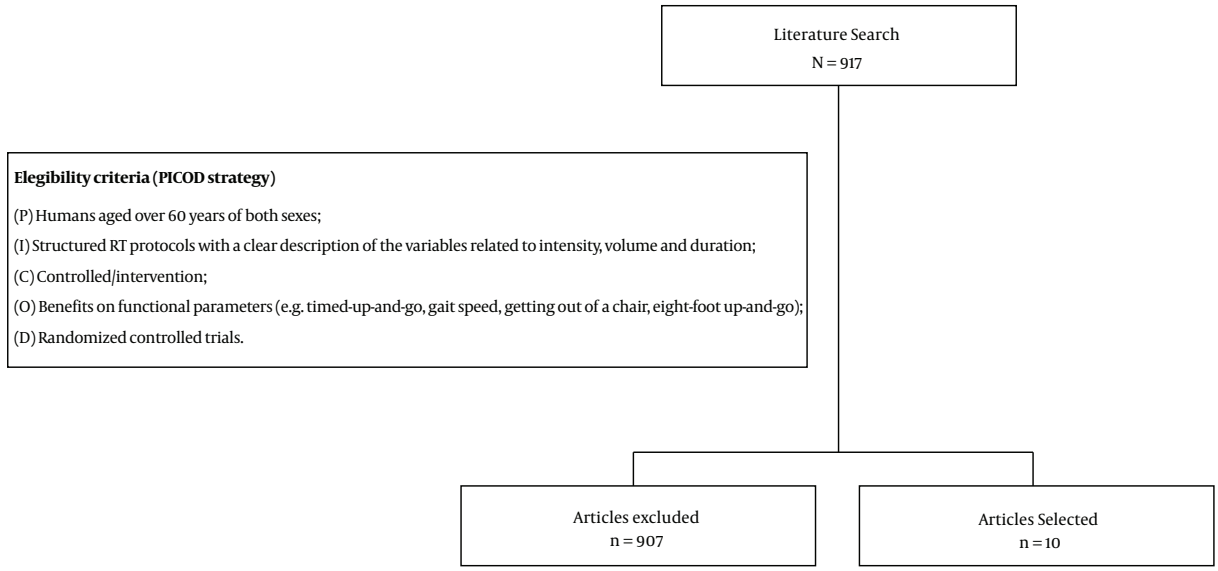


**Figure 1.** Flowchart of the literature review process

## 3. Results

A total of 917 articles were initially selected, of which 10 peer-reviewed articles met the search criteria. The 10 studies involved 433 elderly individuals (289 females, 144 males). The extracted data and population characteristics, outcomes and details of the RT protocols used are shown in Tables 1 and 2.

There were no accidents with individuals during the protocol (physical exercise sessions) in the 10 studies selected. However, individuals were excluded for the following reasons: absence from training days; lack of motivation; lack of interest; scheduling conflicts, health problems; problems with evaluation; cardiac arrhythmia; back pain; family factors; hospitalization for reasons unrelated to the study; personal reasons; being part of the control group; and dropping out of the study.

## 4. Discussion

To date, this is the first review study investigating the effects of RT on functional parameters of the elderly, after undertaking a detailed analysis of the exercise protocols surveyed (Tables 1, 2). We cannot safely state that any of these resistance exercise protocols would lead to improved performance of functional parameters (eg timed-up-and-go, gait speed, getting out of a chair) of this population, given the limitations we found (e.g. lack of description of important RT variables and methodological quality in most of the studies).

For elderly individuals, due to their loss of fast twitch fibers, moderate to high intensity training is recommended after an adaptation phase (35). In this sense, an interesting way to prioritize the recruitment of these fibers is to perform isotonic resistance exercises with the fastest contraction possible during the concentric phase. Gray et al. (14) have demonstrated improved physical function among community-dwelling older adults using a RT protocol performed with rapid contractions. Similarly, Beltran Valls et al. (29) and Ramírez-Campilloet al. (30) have used protocols involving rapid contractions and found positive effects on the components of the functional capacity of the elderly.

Additionally, it was possible to observe improvements in functional parameters through other resistance exercise protocols. Kalapotharakos et al. (28) have demonstrated positive changes in functional parameters of the elderly after only 16 and 28 sessions of RT. In this sense, other relevant studies conducted by da Silva et al. (26) and Emerson et al. (27) have observed positive effects on the functional capacity components of elderly women after only 12 RT sessions. The findings of these studies are probably associated with the effects of RT on the neural system, which promote positive changes in the frequency of firing of the nerve impulses, better intra and intermuscular recruitment, and greater synchronization of motor units.

**Table 1.** Main Characteristics of Randomized Controlled Trials Included (n = 8)

| Authors | Year | Samples | Positive Aspects of the Study | Negative Aspects of the Study | Main Findings | Quality (PEDro Scale) |
|---|---|---|---|---|---|---|
| **da Silva et al.** (26) | 2009 | 40 subjects (females) were randomized to either the experimental group (EG; n = 20; mean age of 64.5 ± 3.7 years) or control group (CG; n = 20; mean age of 71.9 ± 5.8 years) | Experimental study with the design of randomized groups tests before and after treatment. Adequate description of the variables of the resistance training. | Evaluations were not conducted by blinded investigators. | functional autonomy and general GDLAM index | Poor (3) |
| **Emerson et al.** (27) | 2015 | 23 subjects (females and males) were randomized to either the resistance exercise group (EXE; n = 11; mean age of 72.1 ± 6.6 years) or control group (CG; n = 12; mean age of 70.3 ± 5.6 years) | Experimental study with the design of randomized groups tests before and after treatment. | Lack of description about contraction velocity (concentric and eccentric phases) Evaluations were not conducted by blinded investigators. | chair ri cdse test | Poor (3) |
| **Kalapotharakos et al.** (28) | 2010 | 22 subjects (males) were randomized to either the resistance exercise group (RT; n = 7; mean age of 83.4 ± 2.8 years), resistance-exercise detraining (RDT; n = 8; mean age of 82.2 ± 2.2 years) or control group (CG; n = 7; mean age of 82.5 ± 3 years) | Experimental study with the design of randomized groups tests before and after treatment. | Lack of description about: contraction velocity (concentric and eccentric phases); rest interval between sets and exercises during the sessions. | timed-up-and-go and chair rising time tests | Acceptable (5) |
| **Beltran Valls et al.** (29) | 2013 | 23 subjects (11 females, 12 males) were randomized to either the trained group (TG) (n = 13) (mean age of 72 ± 1 years) or control group (CG) (n = 10) (mean age of 72 ± 1 years) | Experimental study with the design of randomized groups tests before and after treatment. | Lack of description about: rest interval between the sessions; Evaluations were not conducted by blinded investigators. | functional capacity | Acceptable (4) |
| **Ramírez-Campillo et al.** (30) | 2014 | 45 subjects (females) were randomized to either the high-speed resistance training group (n = 15; mean age of 66.3 ± 3.7 years), low-speed resistance training group (n = 15; mean age of 68.7 ± 6.4 years) or control group (CG; n = 15; mean age of 66.7 ± 4.9 years) | Experimental study with the design of randomized groups tests before and after treatment. | Lack of description about: rest interval between the sessions; rest interval between exercises during the sessions; Evaluations were not conducted by blinded investigators. | functional capacity for both RT interventions | Acceptable (4) |
| **Turpela et al.** (31) | 2017 | 92 subjects (50 females, 42 males) were randomized to either the training one group (EX1; n = 24; mean age of 70 ± 3 years), training two group (EX2; n = 23; mean age of 69 ± 3 years), training three group (EX3; n = 25; mean age of 70 ± 3 years) or control group (CON; n = 20; mean age of 69 ± 2 years) | Experimental study with the design of randomized groups tests before and after treatment. The long duration of the exercise program. | Lack of description about: contraction velocity (concentric and eccentric phases); number of exercises performed during each session; rest interval between exercises during the sessions; Evaluations were not conducted by blinded investigators. | functional parameters and functional capacity | Acceptable (5) |
| **Marcos-Pardo et al.** (32) | 2019 | 45 subjects (27 females, 18 males) (65-75 years) were randomized to either the moderate-to-high intensity resistance circuit training group (MHRCTG; n = 24) and control group (CG; n = 21). | Experimental study with the design of randomized groups tests before and after treatment. | Lack of description about: contraction velocity (concentric and eccentric phases); number of sets; rest interval between the exercises during the sessions. Evaluations were not conducted by blinded investigators. | functional tests | Acceptable (4) |
| **Liao et al.** (33) | 2017 | 46 subjects (females) were randomized to either the experimental group (EG; n = 25; mean age of 66.3 ± 4.4 years) or control group (CG; n = 21; mean age of 68.4 ± 5.8 years) | Experimental study with the design of randomized groups tests before and after treatment. Patients and examiners were blinded to the group assignment. | Lack of description about: number of exercises performed during each session; rest interval between sets and exercises during the sessions; rest interval between exercises during the sessions. | functional tests | Good (7) |
| **Gray et al.** (14) | 2018 | 53 subjects (36 females, 17 males) (≥ 70 years) were randomized to either the resistance training high-velocity group (HV; n = 20), resistance training low-velocity group (LV; n = 25), or active group (AG; n = 8) | Experimental study with the design of randomized groups tests before and after treatment. The long duration of the exercise program. | Lack of description about: rest interval between sets and exercises during the sessions; rest interval between exercises during the sessions; Evaluations were not conducted by blinded investigators. | agility (eight-foot up-and-go) | Good (6) |
| **Botton et al.** (34) | 2018 | 44 subjects (22 females, 22 males) were randomized to either the resistance training group (RTG; n = 22; mean age of 70.6 ± 6.7years) or control group (CG; n = 21; mean age of 68.6 ± 7.06) | Experimental study with the design of randomized groups tests before and after treatment. The allocation was blinded also with a response email containing a respective group that patient was allocated. | Lack of description about: rest interval between exercises during the sessions; rest interval between exercises during the sessions; Fewer patients than we expected attended to 70% or more of interventions sessions | functional tests | Good (7) |

In addition, Liao et al. (33) have found improvements in the components of the functional autonomy of the elderly after the practice of RT for 12 weeks. A key finding of their study was the positive effects of elastic bands in RT since this is a cost-effective, user-friendly protocol (36).

As mentioned before, many conditioning and strength professionals prescribe exercises based on the available literature, and this led us to discuss some key issues observed in the studies selected for this review study. In this sense, we observed (Table 2) a lack of description of some key variables (14, 27-34) in the prescription of RT [contraction velocity (concentric and eccentric phases); number of sets; number of exercises performed during each session; rest interval between sets and exercises during the sessions; rest interval between the sessions]. Other non-randomized studies have likewise observed the same problem (10, 37).

**Table 2.** Main Characteristics of the Different Resistance Training Protocols Applied on Functional Parameters of the Elderly (n = 8)

| Authors | Year | Number of Sets and Repetition | Intensity | Number of Exercises | Weekly Frequency and Duration of Program | Rest Interval | | | Type of Contraction | Contraction Velocity (Concentric and Eccentric Phases) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Between Sets | Between Exercises | Between Sessions | | |
| da Silva et al. (26) | 2009 | 3 X 13 | 50% of 1RM | 7 | 3 days per week for 20 weeks | 40 seconds | 40 seconds | 48 to 72 hours (4 weeks) | Isotonic | Slow to moderate |
| | | 3 X 6 | 90 - 100% of 1RM | | | 1-2 minutes | 1-2 minutes | 48 to 72 hours (16 weeks) | | |
| Emerson et al. (27) | 2015 | 3 X 8 - 15 | 70 - 85% of 1RM + OMNI scale ranging from 0 to 10 | 12 | 2 days per week for 6 weeks | 90 seconds | 90 seconds | 48 hours | Isotonic | - |
| Kalapotharakos et al. (28) | 2010 | 3 X 10 | 70% of 3RM | 6 | 2 days per week for 14 weeks | - | - | 24 hours | Isotonic | - |
| Beltran Valls et al. (29) | 2013 | 1 - 2 weeks: 4 X 15 | 40 - 50% de 1RM | 4 | 2 days per week for 12 weeks | 2 minutes | 3 minutes | - | Isotonic | As quickly as possible/ moderate |
| | | 3 - 12 weeks: 3 - 4 X 10 - 12 | 70% of 1RM | | | | | | | |
| Ramírez-Campillo et al. (30) | 2014 | 3 X 8 | 45 - 75% of 1RM | 6 | 3 days per week for 12 weeks | 1 minute | - | - | Isotonic | High-speed resistance training group: 1 second or less / 3 seconds |
| | | 3 X 8 | 75% of 1RM | | | | | | | Low-speed resistance training group: 3 seconds / 3 seconds |
| Turpela et al. (31) | 2017 | 2 - 5 x 4-12 | 70% - 100% of 1 RM) and 75% - 85% and 100% of 10 RM | - | EX1 group: 1 day per week; EX2 group: 2 days per week; EX3 group: 3 days per week; 6 months for all groups | 1-3 minutes | - | 24 hours | Isotonic | - |
| Marcos-Pardo et al. (32) | 2019 | 8 - 12 | 60 - 80% of 1RM | 6 | 3 days per week for 12 weeks | 1-2 minutes | - | 24 hours - | Isotonic | - |
| Liao et al. (33) | 2017 | 3 X 10 | rate of perceived exertion: moderate | - | 3 days per week for 12 weeks | - | - | - | Isotonic | slow |
| Gray et al. (14) | 2018 | high-velocity: 3 X 10 | 50 - 80% of 1 RM | 8 | 2 days per week for 48 weeks | - | - | - | Isotonic | High-velocity: as quickly as possible / 2 seconds |
| | | low-velocity: 3 X 10 | 80% of 1 RM | | | | | | | low-velocity: 2 seconds / 2 seconds |
| Botton et al. (34) | 2018 | 2-3 X 10 - 15 | OMNI scale ranging - 6 | 11 | 3 days per week for 12 weeks | 60 - 90 seconds | - | - | Isotonic | slow to moderate |

Although Gray et al. (14) and Liao et al. (33) have demonstrated positive effects of RT, they did not describe the rest intervals used between sets in their research. In addition, we found it difficult to identify the number of exercises performed and the rest interval between the exercises in the otherwise interesting studies conducted by these authors.

Furthermore, another important variable in the prescription of RT is intensity, based on percentages of one repetition maximum (1RM). In the study conducted by da Silva et al. (26), RT was administered in the following way: 4 weeks (3 sets of 13 repetitions at 50% of 1RM) plus 16 weeks (3 sets of 6 repetitions at 90 - 100% of 1RM). However, performing 6 repetitions with a pre-determined intensity does not seem feasible; according to Gambassi et al. (9) and Baechle and Earle (38), it is only possible to perform a maximum of 6 repetitions at 85% of 1RM.

This review study found that the practice of different resistance exercise protocols (duration, frequency, and pre-established intensity) may promote improvements in the functional parameters of the elderly (e.g., timed-up-and-go, gait speed, getting out of a chair, eight-foot up-and-go). However, only 3 of the included studies presented good methodological quality (PEDro Scale), and the main RT variables were described in only 1 research. Given the above, we cannot state, with a reasonable degree of certainty, that the majority of the RT protocols surveyed are indeed effective in improving the functional parameters of the elderly. Thus, strength and conditioning professionals should exercise caution when choosing a resistance exercise protocol aimed at improving the functional parameters of the elderly.

## Footnotes

**Authors' Contribution:** Substantial contributions to the conception or design of the work - Raquel M. da R. Nogueira, Fabiano de Jesus F. Almeida, Cyrene P. S. Costa,

Bruno B. Gambassi. Acquisition, analysis or interpretation of data - Raquel M. da R. Nogueira, Fabiano de Jesus F. Almeida, Maycon Henrique F. de Melo, Jozimar Prazeres, Bruno B. Gambassi. Drafting the work or revising it critically for important intellectual content - Fabiano de Jesus F. Almeida, Bruno B. Gambassi. Final approval of the version published - Raquel M. da R. Nogueira, Fabiano de Jesus F. Almeida, Maycon Henrique F. de Melo, Jozimar Prazeres, Cyrene P. S. Costa, Bruno B. Gambassi. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved - Raquel M. da R. Nogueira, Fabiano de Jesus F. Almeida, Maycon Henrique F. de Melo, Jozimar Prazeres, Cyrene P. S. Costa, Bruno B. Gambassi

**Conflict of Interests:** The authors declare that they have no conflict of interest.

**Funding/Support:** No disclosure was received from the authors.

## References


1. Sauaia BA, Gambassi BB. ENVELHECER: uma transformação natural, aos olhos da microscopia. *Revista de Investigação Biomédica*. 2015;**7**(1):91. portuguese. doi: 10.24863/rib.v7i1.23.
2. Tsai SF, Ku NW, Wang TF, Yang YH, Shih YH, Wu SY, et al. Long-term moderate exercise rescues age-related decline in hippocampal neuronal complexity and memory. *Gerontology*. 2018;**64**(6):551–61. doi: 10.1159/000488589. [PubMed: 29734165].
3. Herr M, Jeune B, Fors S, Andersen-Ranberg K, Ankri J, Arai Y, et al. Frailty and associated factors among centenarians in the 5-COOP countries. *Gerontology*. 2018;**64**(6):521–31. doi: 10.1159/000489955. [PubMed: 30032145].
4. Jonkman NH, Del Panta V, Hoekstra T, Colpo M, van Schoor NM, Bandinelli S, et al. Predicting trajectories of functional decline in 60- to 70-Year-old people. *Gerontology*. 2018;**64**(3):212–21. doi: 10.1159/000485135. [PubMed: 29232671]. [PubMed Central: PMC5969068].
5. Schosserer M, Grillari J, Wolfrum C, Scheideler M. Age-induced changes in white, brite, and brown adipose depots: A mini-review. *Gerontology*. 2018;**64**(3):229–36. doi: 10.1159/000485183. [PubMed: 29212073].
6. Faulkner JA, Larkin LM, Claflin DR, Brooks SV. Age-related changes in the structure and function of skeletal muscles. *Clin Exp Pharmacol Physiol*. 2007;**34**(11):1091–6. doi: 10.1111/j.1440-1681.2007.04752.x. [PubMed: 17880359].
7. Lang T, Streeper T, Cawthon P, Baldwin K, Taaffe DR, Harris TB. Sarcopenia: etiology, clinical consequences, intervention, and assessment. *Osteoporos Int*. 2010;**21**(4):543–59. doi: 10.1007/s00198-009-1059-y. [PubMed: 19779761]. [PubMed Central: PMC2832869].
8. Narici MV, Maffulli N. Sarcopenia: characteristics, mechanisms and functional significance. *Br Med Bull*. 2010;**95**:139–59. doi: 10.1093/bmb/ldq008. [PubMed: 20200012].
9. Bavaresco Gambassi B, Lopes Dos Santos MD, Furtado Almeida FJ. Basic guide for the application of the main variables of resistance training in elderly. *Aging Clin Exp Res*. 2019;**31**(7):1019–20. doi: 10.1007/s40520-019-01181-y. [PubMed: 30929226].
10. Bacelar SN, Almeida FJ, Sauaia BA, Novais TM, Furtado AE, Quintanilha LM, et al. Effects of moderate intensity resistance training on bone mineral density and muscle strength of elderly women. *J Exerc Physiol Online*. 2015;**18**(6).
11. Gambassi BB, dos Santos CPC, Queiroz C, Mesquita F, Santos PR, Almeida AEAF, et al. Effects of a four-exercise resistance training protocol on functional parameters in sedentary elderly women. *Sport Sci Health*. 2020;**16**(1):99–104.
12. Gambassi BB, da Penha Carnevali M, de Oliveira DC, Costa M, Melo CD, Almeida AF. Effects of a 4-exercise resistance training protocol on the muscle strength of the elderly. *J Exerc Physiol Online*. 2019.
13. Sakugawa RL, Moura BM, Orssatto L, Bezerra ES, Cadore EL, Diefenthaeler F. Effects of resistance training, detraining, and retraining on strength and functional capacity in elderly. *Aging Clin Exp Res*. 2019;**31**(1):31–9. doi: 10.1007/s40520-018-0970-5. [PubMed: 29777475].
14. Gray M, Powers M, Boyd L, Garver K. Longitudinal comparison of low- and high-velocity resistance training in relation to body composition and functional fitness of older adults. *Aging Clin Exp Res*. 2018;**30**(12):1465–73. doi: 10.1007/s40520-018-0929-6. [PubMed: 29569116].
15. Liu CJ, Latham NK. Progressive resistance strength training for improving physical function in older adults. *Cochrane Database Syst Rev*. 2009;**X**(3):X–X. doi: 10.2522/ptj.20100270. [PubMed: 21123213].
16. Lopez P, Pinto RS, Radaelli R, Rech A, Grazioli R, Izquierdo M, et al. Benefits of resistance training in physically frail elderly: a systematic review. *Aging Clin Exp Res*. 2018;**30**(8):889–99. doi: 10.1007/s40520-017-0863-z. [PubMed: 29188577].
17. Gambassi BB, Uchida MC, Sousa TMS, Schwingel PA, Pulcherio JOB, Almeida FJF. Effects of a new combined training approach on components of the functional autonomy of healthy elderly women. *J Exerc Physiol Online*. 2017;**20**(3):45–52.
18. Sousa T, Rodrigues B, Uchida MC, Ruberti OM, Schwingel PA, Novais TMG, et al. Novel combined training approach improves sleep quality but does not change body composition in healthy elderly women: A preliminary study. *J Aging Res*. 2017;**2017**:8984725. doi: 10.1155/2017/8984725. [PubMed: 29062575]. [PubMed Central: PMC5618778].
19. Arfa-Fatollahkhani P, Safar Cherati A, Habibi SAH, Shahidi GA, Sohrabi A, Zamani B. Effects of treadmill training on the balance, functional capacity and quality of life in Parkinson's disease: A randomized clinical trial. *J Complement Integr Med*. 2019;**17**(1). doi: 10.1515/jcim-2018-0245. [PubMed: 31433785].
20. Szlejf C, Suemoto CK, Brunoni AR, Viana MC, Moreno AB, Matos SMA, et al. Depression is associated with sarcopenia due to low muscle strength: Results from the Elsa-brasil study. *J Am Med Dir Assoc*. 2019;**20**(12):1641–6. doi: 10.1016/j.jamda.2018.09.020. [PubMed: 30409492].
21. Trombetti A, Reid KF, Hars M, Herrmann FR, Pasha E, Phillips EM, et al. Age-associated declines in muscle mass, strength, power, and physical performance: impact on fear of falling and quality of life. *Osteoporos Int*. 2016;**27**(2):463–71. doi: 10.1007/s00198-015-3236-5. [PubMed: 26194491]. [PubMed Central: PMC4960453].
22. Gambassi BB, Almeida FDJF, Almeida AEAF, Ribeiro JA, Novais TMG, Schwingel PA, et al. Effects of exercise training on cardiovascular and autonomic parameters in stroke survivors: A systematic review. *Int J Cardiovasc Sci*. 2019;**32**(4):408–13.
23. de Jesus Furtado Almeida F, Gambassi BB, Schwingel PA, Almeida AERAF, Sauaia BA, da Silva Sousa TM, et al. Possible benefits of different physical exercise programs after coronary artery bypass graft surgery: a minireview of selected randomized controlled trials. *Sport Sci Health*. 2017;**13**(3):477–83. doi: 10.1007/s11332-017-0400-7.

24. Gambassi BB, Coelho-Junior HJ, Schwingel PA, Almeida FJF, Gaspar Novais TM, Lauande Oliveira PL, et al. Resistance training and stroke: A critical analysis of different training programs. *Stroke Res Treat*. 2017;**2017**:4830265. doi: 10.1155/2017/4830265. [PubMed: 29423327]. [PubMed Central: PMC5750509].
25. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther*. 2003;**83**(8):713–21. [PubMed: 12882612].
26. da Silva JG, Cader SA, Dopico X, Iglesias Soler E, Martin Dantas EH. [Strength training, level of muscular strength and functional autonomy in a population of elderly women]. *Rev Esp Geriatr Gerontol*. 2009;**44**(5):256–61. doi: 10.1016/j.regg.2009.04.005. [PubMed: 19709782].
27. Emerson NS, Stout JR, Fukuda DH, Robinson EH, Scanlon TC; Iv, et al. Resistance training improves capacity to delay neuromuscular fatigue in older adults. *Arch Gerontol Geriatr*. 2015;**61**(1):27–32. doi: 10.1016/j.archger.2015.04.002. [PubMed: 25957058].
28. Kalapotharakos VI, Diamantopoulos K, Tokmakidis SP. Effects of resistance training and detraining on muscle strength and functional performance of older adults aged 80 to 88 years. *Aging Clin Exp Res*. 2010;**22**(2):134–40. doi: 10.1007/BF03324786. [PubMed: 20440099].
29. Beltran Valls MR, Dimauro I, Brunelli A, Tranchita E, Ciminelli E, Caserotti P, et al. Explosive type of moderate-resistance training induces functional, cardiovascular, and molecular adaptations in the elderly. *Age (Dordr)*. 2014;**36**(2):759–72. doi: 10.1007/s11357-013-9584-1. [PubMed: 24136652]. [PubMed Central: PMC4039278].
30. Ramirez-Campillo R, Castillo A, de la Fuente CI, Campos-Jara C, Andrade DC, Alvarez C, et al. High-speed resistance training is more effective than low-speed resistance training to increase functional capacity and muscle performance in older women. *Exp Gerontol*. 2014;**58**:51–7. doi: 10.1016/j.exger.2014.07.001. [PubMed: 25014621].
31. Turpela M, Hakkinen K, Haff GG, Walker S. Effects of different strength training frequencies on maximum strength, body composition and functional capacity in healthy older individuals. *Exp Gerontol*. 2017;**98**:13–21. doi: 10.1016/j.exger.2017.08.013. [PubMed: 28821427].
32. Marcos-Pardo PJ, Orquin-Castrillon FJ, Gea-Garcia GM, Menayo-Antunez R, Gonzalez-Galvez N, Vale RGS, et al. Effects of a moderate-to-high intensity resistance circuit training on fat mass, functional capacity, muscular strength, and quality of life in elderly: A randomized controlled trial. *Sci Rep*. 2019;**9**(1):7830. doi: 10.1038/s41598-019-44329-6. [PubMed: 31127163]. [PubMed Central: PMC6534570].
33. Liao CD, Tsauo JY, Lin LF, Huang SW, Ku JW, Chou LC, et al. Effects of elastic resistance exercise on body composition and physical capacity in older women with sarcopenic obesity: A CONSORT-compliant prospective randomized controlled trial. *Medicine (Baltimore)*. 2017;**96**(23). e7115. doi: 10.1097/MD.0000000000007115. [PubMed: 28591061]. [PubMed Central: PMC5466239].
34. Botton CE, Umpierre D, Rech A, Pfeifer LO, Machado CLF, Teodoro JL, et al. Effects of resistance training on neuromuscular parameters in elderly with type 2 diabetes mellitus: A randomized clinical trial. *Exp Gerontol*. 2018;**113**:141–9. doi: 10.1016/j.exger.2018.10.001. [PubMed: 30296453].
35. Fragala MS, Cadore EL, Dorgo S, Izquierdo M, Kraemer WJ, Peterson MD, et al. Resistance training for older adults: Position statement from the national strength and conditioning association. *J Strength Cond Res*. 2019;**33**(8):2019–52. doi: 10.1519/JSC.0000000000003230. [PubMed: 31343601].
36. Gambassi BB, Coelho-Junior HJ, Paixao Dos Santos C, de Oliveira Goncalves I, Mostarda CT, Marzetti E, et al. Dynamic resistance training improves cardiac autonomic modulation and oxidative stress parameters in chronic stroke survivors: A randomized controlled trial. *Oxid Med Cell Longev*. 2019;**2019**:5382843. doi: 10.1155/2019/5382843. [PubMed: 31827679]. [PubMed Central: PMC6886348].
37. Gambassi BB, Rodrigues B, de Jesus Furtado Almeida F, Sotão SS, da Silva Souza TM, Chaves LFC, et al. Acute effect of resistance training without recovery intervals on the blood pressure of comorbidity-free elderly women: a pilot study. *Sport Sciences for Health*. 2016;**12**(3):315–20. doi: 10.1007/s11332-016-0290-0.
38. Baechle TR, Earle RW. *Essentials of strength training and conditioning*. Human kinetics; 2008.