

# Effects of resistance training in elderly women with cognitive decline

*Efeitos do treinamento resistido em idosas com declínio cognitivo*

Beatriz de Sousa Ferreira <sup>\*</sup>

Rafael Durans Pereira 

Daiane Pereira da Silva 

Andressa Coelho Ferreira 

Cristiano Mostarda 

Janaina de Oliveira Brito-Monzani 

Universidade Federal do Maranhão, Postgraduate Program in Physical Education (PPGEF/UFMA), São Luís, MA, Brazil

**Date of first submission:** August 27, 2021

**Last received:** January 4, 2022

**Accepted:** March 30, 2022

**Associate editor:** Mariana Asmar Alencar Collares

**\* Correspondence:** beatriz.sf@discente.ufma.br

## Abstract

**Introduction:** With aging, it is common for some changes to occur in different areas of cognition, such as memory, executive function, language and psychomotor speed. However, regular physical activity has been described as an excellent way to alleviate the degeneration caused by aging within the various physical, psychological and social domains. **Objective:** To evaluate the effects of resistance training in elderly women with mild cognitive impairment. **Methods:** Experimental study with 31 sedentary elderly women divided into control (CG; n=15) and resistance training (RTG; n=16) groups who underwent assessment of anthropometric measures, body composition, maximum strength, heart rate and blood pressure and questionnaire application (Mini-Mental State Examination). **Results:** Cognitive ability increased in RTG (post  $26.00 \pm 2.13$  vs. CG  $22.24 \pm 3.82$  vs. pre  $24.06 \pm 2.38$  RTG). In RTG, there was a reduction in systolic blood pressure (post  $107.50 \pm 11.97$  vs. CG  $126.00 \pm 9.72$  vs. pre  $124.13 \pm 12.55$  mmHg RTG), diastolic blood pressure (post  $68.50 \pm 8.15$  vs. CG  $81.73 \pm 4.59$  vs. pre  $74.69 \pm 6.87$  mmHg RTG) and double product (post  $7746 \pm 1244$  vs. CG  $9336 \pm 1595$  vs. pre  $9286 \pm 1309$  mmHg x bpm RTG), but not in heart rate (post  $72.00 \pm 7.40$  vs. CG  $74.00 \pm 10.50$  vs. pre  $74.94 \pm 8.42$  bpm RTG). Regarding muscle strength, an increase was evident in all exercises. **Conclusion:** The present study showed that resistance training in elderly women increased muscle strength and reduced hemodynamic variables. But the most important finding was that there was an increase in cognitive capacity.

**Keywords:** Aging. Cognition. Mild cognitive impairment. Resistance training. Seniors.

## Resumo

**Introdução:** Com o envelhecimento, é comum ocorrerem alterações em diferentes áreas da cognição, como a memória, função executiva, linguagem, desenvolvimento psicomotor e função visoespacial. A atividade física regular, contudo, tem sido descrita como um excelente meio de atenuar as degenerações provocadas pelo envelhecimento dentro dos domínios físico, psicológico e social. **Objetivo:** Avaliar os efeitos do treinamento resistido em idosas com comprometimento cognitivo leve.

**Métodos:** Estudo experimental com 31 idosas sedentárias, divididas em grupo controle (GC; n = 15) e grupo treinamento resistido (GTR; n = 16), submetidas a avaliações antropométricas, composição corporal, força máxima, frequência cardíaca (FC), pressão arterial (PA) e aplicação de questionário (Mini Exame do Estado Mental). **Resultados:** Observou-se aumento da capacidade cognitiva no GTR (pós 26,00 ± 2,13 vs. GC 22,24 ± 3,82 vs. pré 24,06 ± 2,38 GTR) e redução na PA sistólica (pós 107,50 ± 11,97 vs. GC 126,00 ± 9,72 vs. pré 124,13 ± 12,55 mmHg GTR), PA diastólica (pós 68,50 ± 8,15 vs. GC 81,73 ± 4,59 vs. pré 74,69 ± 6,87 mmHg GTR) e duplo produto no GTR (pós 7746 ± 1244 vs. GC 9336 ± 1595 vs. pré 9286 ± 1309 mmHg x bpm GTR). Não houve redução na FC no GTR (pós 72,00 ± 7,40 vs. GC 74,00 ± 10,50 vs. pré 74,94 ± 8,42 bpm GTR). Em relação à força muscular, observou-se aumento em todos os exercícios.

**Conclusão:** O presente estudo mostrou que o treinamento resistido aumentou a força muscular e que houve redução de variáveis hemodinâmicas; entretanto, o achado mais importante desse estudo foi o aumento na capacidade cognitiva das idosas.

**Palavras-chave:** Envelhecimento. Cognição. Comprometimento cognitivo leve. Treinamento resistido. Idosas.

## Introduction

The elderly population represents 12% of the world population, with this number expected to double by 2050 and triple in 2100.<sup>1</sup> In Brazil, the growth of this population does not differ from the rest of the world, where in 2060, older people are predicted to make up 25.5% of the population (58.2 million).<sup>2</sup> Aging is characterized as a natural process marked by important changes, both biological and physiological, which vary from individual to individual and depend on several factors, including lifestyle,<sup>3</sup> and can be accompanied by a decline in physical and cognitive abilities.<sup>4</sup>

With aging, changes in different areas of cognition are common, such as memory, executive function, language, psychomotor development and visuospatial function.<sup>5</sup> Mild cognitive impairment (MCI) refers to cognitive decline greater than expected for the individual's age and schooling but which does not significantly interfere with daily living activities, where it is related to difficulty in learning new information or retrieving stored information.<sup>6</sup> However, regular physical activity has been described as an excellent means of mitigating the degenerations caused by aging within the physical, psychological and social domains,<sup>7</sup> and the effects of regular physical activity include preventing or delaying the decline of cognitive functions and decreasing the risk of depression, stress, anxiety and drug use.<sup>8</sup>

Accordingly, strength training has been considered a promising intervention to prevent or reverse, at least in part, the losses resulting from aging.<sup>9</sup> For elderly people, the loads used generally range from 50 to 85% of one-repetition maximum (1RM) and one to three sets are used, with eight to twelve repetitions and 2 to 3 minutes of rest between sets and exercises. Resistance training with weights is capable of providing significant strength gains after 12 weeks,<sup>10</sup> in addition to providing important cardiovascular benefits to older individuals, as it reduces systolic (SBP) and diastolic (DBP) blood pressure.<sup>11</sup> Possibly, chronic control of blood pressure at rest is related to the acute effects of a single exercise session, in normotensive, prehypertensive and hypertensive individuals.<sup>12</sup> In addition, weight training generates beneficial results for cognitive performance in the elderly.<sup>13</sup>

Resistance training is a preventive mechanism against cognitive decline, and it reduces morbidities and prevents sarcopenia, acting through mechanisms that increase IGF-1, related to neuronal growth and improvement of cognitive performance.<sup>14</sup> In a study with 62 sedentary elderly, Cassilhas et al.<sup>15</sup> observed an increase in serum IGF-1 leading to improved memory, attention and executive function after 24 weeks of high (80% 1RM) and moderate (50% 1RM) training. Although resistance training has been linked to improvements in cognitive performance, the mechanisms involved are not yet fully understood.<sup>16</sup>

Intervention methods and strategies through a non-pharmacological approach have been sought in the prevention and improvement of cognition in the elderly with MCI. Since there are few studies that chronically evaluate resistance training related to this aspect,

the objective of the present study was to evaluate the effects of resistance training in elderly women with cognitive impairment. In addition, our aim was to assess the following parameters: body composition, muscle strength, hemodynamic variables, SBP, DBP, heart rate (HR), double product (DP) and cognitive capacity as well.

## Methods

This study was approved by the Research Ethics Committee of the University Hospital of the Federal University of Maranhão (HU-UFMA), under No. 15147719.0.0000.5086.

Participants were selected by convenience sampling from a database belonging to the Department of Physical Education at UFMA, for having previously participated in other research projects. All were informed about the objectives, protocol and procedures to be performed, as well as the risks and benefits of the study. All signed an informed consent form containing the necessary information.

The sample consisted of 31 elderly women divided into two groups: control (CG;  $n = 15$ ), who did not perform any type of physical exercise during the protocol, and resistance training (RTG;  $n = 16$ ), who participated in training sessions at an intensity of 50 to 80% 1RM for eight weeks. Assessments were performed in both groups before and after the interventions in RTG.

### Inclusion and exclusion criteria

Inclusion criteria were: women aged 60 years or older, with controlled hypertension, absence of other heart diseases, body mass index (BMI) below 30 kg/m<sup>2</sup> and MCI according to the Mini-Mental State Examination (MMSE).

Exclusion criteria were: being a smoker; having participated in a physical exercise program in the last three months; diagnosis of neurological disease; use of medication to treat depression and anxiety; orthopedic injuries that could prevent or hinder the performance of movements; visual and auditory difficulties that could hinder the identification of images and commands; refusal to participate in assessments and the training program; started using medication to treat depression and/or anxiety during the intervention period; and attendance of less than 75% of total sessions.

## Procedures

### Anamnesis

The study participants were presented with the informed consent form, and a physical evaluation was then scheduled, for which they were instructed not to consume alcoholic and/or caffeinated beverages and not to perform vigorous physical activity in the 24 hours preceding the physical evaluation. An anamnesis questionnaire was then applied, containing personal data, medications used, eating habits, past and/or current professional activities, clinical history, pathologies, past and/or current physical activities and clinical examinations.

### Anthropometric assessment and body composition

Anthropometric measurements were performed according to the International Society for the Advancement of Kinanthropometry.<sup>17</sup> The following anthropometric variables were determined: weight, height and ten skinfolds (pectoral, medial axillary, suprailiac, supraspinale, abdominal, subscapular, triceps, biceps, medial thigh and medial calf).<sup>17</sup> These measurements were performed in the pre- and post-intervention period by the same evaluator. The participants remained in an orthostatic position, wearing appropriate clothing for the evaluation while the evaluator performed the circumference and skinfold measurements.

Weight was measured using a digital balance with a capacity of 180 kg. Height was determined using a compact vertical stadiometer, with millimeter scale, Sanny model EST 23. Skinfolds were obtained on the right side, using a scientific adipometer, Terrazul model Opusmax, with 1-mm precision.

BMI was calculated as the ratio of body weight (kg) to height (m) squared (kg/m<sup>2</sup>) and classified according to the World Health Organization (WHO).<sup>18</sup> Body composition was determined using the body density (BD) prediction equation proposed by Petroski and Pires-Neto,<sup>19</sup> using four skinfolds for females, as follows: (BD = 1.02902361 - 0.00067159 \* (subscapular + triceps + suprailiac + calf skinfolds) + 0.00000242 \* (subscapular + triceps + suprailiac + calf skinfolds)<sup>2</sup> - 0.0002073 \* (age) - 0.00056009 \* (weight) + 0.00054649 \* (height)). Subsequently, BD was converted to percent body fat (%F) using the Siri equation: (%F = [(4.95/BD) - 4.50] x 100).<sup>20</sup>

### *Maximum strength assessment (1RM)*

The load used during training was determined through the 1RM. The objective of this test is to determine the maximum weight that the person can lift only once<sup>21</sup> and was applied to the main muscle groups that were required during training.

Prior to the 1RM test, there was a demonstration of the correct execution of the exercise to avoid errors during the test. The participants performed a specific warm-up (< 50% of the estimated maximum load) for elbow flexion (EF), elbow extension (EE) and bench press (BP) exercises for upper limbs, and extension chair (EC) and leg press (LP) for the lower limbs.<sup>22</sup> Three to five attempts were performed to determine the maximum load, with 3- to 5-minute intervals. The weight was increased from 2 to 5 kg, and then a new attempt was made. The weight recorded was the one prior to the unsuccessful attempt.<sup>22</sup>

### *Blood pressure and heart rate*

A Ma100 G-Tech automatic digital upper-arm pressure device was used to measure blood pressure and HR. DP was determined by multiplying SBP by HR. The women rested for at least 5 minutes in a calm environment and were instructed not to talk during the measurement. Possible doubts were clarified before or after the procedure. The examiners confirmed that the women did not have a full bladder and that they had not ingested alcoholic beverages, coffee or food in the previous 30 minutes. Regarding positioning, the women had to be in a sitting position, legs uncrossed, feet on the floor, back leaning on the chair and relaxed. The arm was at heart level, free of clothing, supported, with the palm facing up and the elbow slightly bent.<sup>23</sup>

### *Mini Mental State Examination (MMSE)*

MMSE is the most widely used cognitive screening test for adults and elderly people in the world, with versions translated and authorized for more than 35 countries.<sup>24</sup> The MMSE provides information on cognitive parameters, with questions grouped into seven categories. Each one aims to assess a specific cognitive function: temporal orientation (5 points), spatial orientation (5 points), registration of three words (3 points), attention and calculation (5 points), recall

of the three words (3 points), language (8 points) and visual constructive ability (1 point). Its score varies from 0 to 30 points and some cut-off points were established according to Brucki et al.,<sup>25</sup> who proposed that the cut-off points vary according to the person's years of study, that is: 20 points for illiterates, 25 for 1 to 4 years of schooling, 26 for 5 to 8 years, 28 for 9 to 11 years and 29 for those with higher education.

### *Resistance training protocol*

On the basis of the maximum load, the value of 50 to 80% 1RM was calculated and the intervention was through resistance training composed of five exercises: EF, EE, BP for upper limbs and EE and LP for the lower limbs.<sup>23</sup>

Participants performed three sets, with an interval of 60 seconds between each, performing 15 repetitions with moderate intensity (50% 1RM) to vigorous intensity (80% 1RM),<sup>22,26</sup> which occurred on alternate days, following the recommendations of the American College of Sports Medicine, which suggests that the strength training program be divided into two sessions: one with exercises for the lower limbs and the other with exercises for the upper limbs.<sup>27</sup>

### **Statistical analysis**

The GraphPad Prism 5® program was used to statistically evaluate the data, presented as mean and standard deviation. Data normality was checked with the Shapiro-Wilk test, followed by the independent t-test, adopting  $p < 0.05$  for a statistically significant difference.

### **Results**

At the end of the study, 31 elderly women (64.58  $\pm$  5.04 years) completed all experimental procedures. The sample characteristics are presented in Table 1 and demonstrated that there were no significant differences between the groups for any of the characteristics.

### **Muscle strength assessment**

Table 2 shows the results related to the exercises. It can be observed that there was a significant difference between the pre- and post-intervention moments in the

RTG in all exercises: BP ( $p < 0.0011$ ), EE ( $p < 0.0133$ ), EF ( $p < 0.0066$ ), LP ( $p < 0.0002$ ) and EC ( $p < 0.0231$ ). It was also possible to observe a significant difference in all exercises in the RTG after intervention when compared to the CG: BP ( $p < 0.0042$ ), EE ( $p < 0.0006$ ), EF ( $p < 0.0005$ ), LP ( $p < 0.0001$ ) and CE ( $p < 0.0014$ ). Therefore, resistance training proved to be effective in increasing muscle strength in all exercises performed.

**Table 1** - Characteristics of elderly

Variable	CG (n = 15)	RTG (n = 16)
Age (years)	66.00 ± 6.39	63.25 ± 2.96
Weight (kg)	67.20 ± 12.09	64.84 ± 8.03
Height (cm)	151.60 ± 7.72	154.50 ± 4.21
BMI (kg/m <sup>2</sup> )	29.10 ± 3.64	27.17 ± 3.60
Fat (%)*	46.01 ± 8.21	43.04 ± 8.75
Schooling (years)	10.93 ± 3.28	10.31 ± 2.75

Note: Values expressed as mean ± standard deviation. CG = control group; RTG = resistance training group; BMI= body mass index; \*Percent body fat.

### Hemodynamic assessments

Table 3 describes the behavior of the hemodynamic variables of the study participants. When comparing the GC and RTG groups, we were able to observe differences in SBP ( $p < 0.0001$ ), DBP ( $p < 0.0001$ ) and DP ( $p < 0.0110$ ), but there were no differences in HR ( $p < 0.8435$ ).

On the other hand, significant differences were observed in the pre- and post-intervention times in the RTG in the variables SBP ( $p < 0.0003$ ), DBP ( $p < 0.0004$ ) and DP ( $p < 0.0006$ ), showing that resistance training was effective in reducing hemodynamic variables. It is worth noting, however, that there was no difference in HR ( $p < 0.1265$ ).

### Cognitive capacity

Regarding cognitive ability (Table 4), there was a significant difference between pre- and post-intervention RTG ( $p < 0.0012$ ) and between the GC and RTG after an eight-week intervention ( $p < 0.0021$ ), demonstrating that resistance training increased the cognitive performance of the elderly.

**Table 2** - Assessment of muscle strength (1RM)

Variable (kg)	Control group (n = 15)		Resistance training group (n = 16)	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention*#
Bench press	24.40 ± 6.27	25.13 ± 6.36	25.25 ± 5.62	33.20 ± 7.95
Elbow extension	26.47 ± 5.76	27.40 ± 6.58	30.61 ± 10.39	37.94 ± 8.45
Elbow flexion	16.80 ± 3.14	16.07 ± 2.40	18.58 ± 5.75	20.89 ± 4.18
Leg press	72.07 ± 26.01	64.80 ± 11.85	80.75 ± 23.32	112.31 ± 25.64
Extension chair	47.07 ± 17.31	45.80 ± 18.94	54.94 ± 12.87	65.87 ± 12.24

Note: Values expressed as mean ± standard deviation. \* $p < 0.05$  vs pre-resistance training group; # $p < 0.05$  vs post-control group.

**Table 3** - Assessment of hemodynamic variables

Variable	Control group (n = 15)		Resistance training group (n = 16)	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Systolic blood pressure (mmHg)	125.07 ± 7.13	126.00 ± 9.72	124.13 ± 12.55	107.50 ± 11.97*#
Diastolic blood pressure (mmHg)	79.07 ± 6.13	81.73 ± 4.59	74.69 ± 6.87	68.50 ± 8.15*#
Heart rate (bpm)	72.00 ± 11.80	72.70 ± 11.00	74.94 ± 8.42	72.00 ± 7.40
Double product (bpm x mmHg)	9023 ± 1650	9172 ± 1664	9286 ± 1309	7746 ± 1244*#

Note: Values expressed as mean ± standard deviation. mmHg = millimeters mercury; bpm = beats per minute. \* $p < 0.05$  vs pre-resistance training group; # $p < 0.05$  vs post-control group.

**Table 4** - Cognitive capacity assessment before (pre) and after (post) intervention

Variable	GC (n = 15)		RTG (n = 16)	
	Pre	Post	Pre	Post*#
MMEE	22.52 ± 3.64	22.24 ± 3.82	24.06 ± 2.38	26.00 ± 2.13

Note: Values expressed as mean ± standard deviation. GC = control group; RTG = resistance training group; MMSE = Mini-Mental State Examination. \*p < 0.05 vs pre-RTG; #p < 0.05 vs post-GC.

## Discussion

This study aimed to evaluate the effects of resistance training in elderly women with cognitive impairment. Muscle strength, hemodynamic variables and MMSE showed statistically significant differences after eight weeks of a resistance training program. Therefore, this proved to be effective in increasing muscle strength, reducing blood pressure and improving cognitive function.

### Muscle strength assessment

After age 50, muscle mass decreases approximately 2% each year.<sup>28</sup> Similarly, there is an approximate decrease in muscle strength, which varies between 20 and 40% in elderly people aged between 70 and 80 years.<sup>28</sup> However, a decline in strength occurs slowly between 50 and 60 years of age, with a much faster decrease after 60.<sup>28</sup>

The results of this research revealed that the resistance training program promoted an increase in strength in all muscle groups evaluated. Likewise, Smolarek et al.,<sup>29</sup> when evaluating 37 elderly women after 12 weeks of intervention with strength training, found an increase in muscle strength both in the upper and lower parts. Queiroz and Munaro<sup>22</sup> reported that strength training showed significant results in increasing muscle strength in 17 elderly women after eight weeks of intervention with an intensity of 50 to 70% 1RM, in two weekly sessions. Similar results were found by Murlasits et al.,<sup>30</sup> who after eight weeks of a resistance training program, observed increases in muscle strength in elderly women.

Increase in muscle strength occurs in response to strength training through two factors, neural adaptations

and an increase in the cross-sectional area of the muscle (hypertrophy),<sup>31</sup> since the increase in strength in response to neural adaptations is a consequence of adaptations such as : recruitment of additional motor units acting synchronously; size of motor units recruited; reduction of neurological inhibition through the Golgi tendon organs; frequency coding, i.e. the frequency of trips or rate of discharge that the motor units receive; and co-activation of agonist and antagonist muscles.<sup>32</sup> From a structural point of view, hypertrophied fibers provide more cross-bridges for the production of force in a maximum contraction, thus increasing the capacity to generate force when compared to normal fibers.<sup>31</sup>

### Assessment of hemodynamic variables

In the present study, a reduction in SBP, DBP and DP was observed after eight weeks of resistance training, but no changes were found in HR. Locks et al.<sup>33</sup> observed a decrease in SBP and DBP at rest after four weeks of training. Terra et al.<sup>34</sup> found a reduction in SBP and DP at rest in hypertensive elderly women after 12 weeks of resistance training, not observing significant differences in DBP or HR. The reduction in DP, in turn, seemed to be mediated by the decrease in SBP.<sup>34</sup> The authors believed that blood pressure control after a resistance training program might have been the result of the sum of the acute effects of several sessions of strength exercises.<sup>34</sup> According to Gerage et al.,<sup>35</sup> the physiological mechanisms responsible for the decrease in blood pressure at rest after a resistance training program is a multifactorial phenomenon. Exposure to both moderate and high training loads in each resistance training session and, consequently, to the high blood pressure peaks obtained during exercise, may be the stimulus for a baroreflex adaptation, leading to a reduction in muscle sympathetic nerve activity.<sup>35</sup>

Other possible mechanisms involved in the decrease in blood pressure are related to the decrease in peripheral vascular resistance and cardiac output (CO),<sup>34</sup> in addition to the fact that after physical exertion there seems to be a more accentuated increase in vasodilating substances in the circulation, such as nitric oxide.<sup>36</sup> The reduction in cardiac output, in turn, is mediated by stroke volume and HR,<sup>34</sup> but in the present study, there was no decrease in HR, suggesting that the reduction in blood pressure induced by resistance training here was caused by other unclear mechanisms.



### Assessment of cognitive capacity

According to Liu-Ambrose et al.,<sup>37</sup> most studies on the intervention of physical exercise on cognition have focused on aerobic training, but other types of physical training such as resistance training may also have beneficial effects on cognition. The present study, as well as previous studies, reaffirms this hypothesis.

In the present study, a significant increase in cognitive performance was observed with eight weeks of resistance training in elderly women, which corroborates the findings of Smolarek et al.,<sup>29</sup> which strength training protocol defined by 12 exercises for upper and lower limbs combined in 3 × 10 repetitions, with an interval of 1 minute between repetitions and 2 minutes of rest between exercises (three times/week), with weight loads fixed between 60 and 75%, and applied for 12 weeks, increased cognitive performance in 29 elderly women. Cassilhas et al.,<sup>15</sup> in a study with 62 elderly people, showed that moderate- and high-intensity resistance exercises provided a significant improvement in cognitive performance in both working and episodic memory in approximately 24 weeks.

In a high-speed resistance training program (defined as a phase of contraction that is expected to be performed as quickly as possible), with the exercise session lasting 1 hour, consisting of 2-3 sets of 12-15 repetitions, performed 3 times a week for 16 weeks, participants were instructed to perform the training at a perceived exertion rate of 12-13 ("somewhat difficult"); it was observed that resistance training was able to significantly improve cognitive function.<sup>38</sup>

In addition, Antunes et al.<sup>39</sup> reported that among the reasons for this cognitive improvement, the increase in cerebral blood flow and, consequently, of oxygen and other energy substrates can be cited, due to better circulation and increase in neurotransmitter levels, as well as the substances released during physical activity that could improve memory consolidation, such as  $\beta$ -endorphin, catecholamines, vasopressin and adrenocorticotrophic hormone.

Gorelick et al.<sup>40</sup> reported that resistance exercises promote both chronic and acute vascularization throughout the body, inhibit the formation of atherosclerotic plaque and increase the supply of essential nutrients to the brain; therefore, regular resistance exercises represent a non-pharmacological

intervention to bring vascular, cognitive and neuromotor benefits to the elderly population.

Studies by such authors as Babaei et al.,<sup>41</sup> Goekint et al.,<sup>42</sup> Yarrow et al.<sup>43</sup> and Levinger et al.<sup>44</sup> investigated the neurobiological mechanisms involved in the improvement of cognition through resistance training in recent decades. Changes in blood viscosity, steroid hormone rebalance, increase in neurotransmitter levels, release of neurotrophic factors (linked to neuroplasticity) and mitochondrial functions in neurons are some of the main events currently under investigation.<sup>29</sup>

Therefore, this study is clinically relevant because it proposes an intervention capable of reproducibility in a non-laboratory environment, with the easy applicability of resistance training in elderly women, helping to reduce or prevent MCI, in addition to increasing muscle strength and reducing blood pressure.

It is worth noting that more studies are needed to clarify the mechanisms involved and the most appropriate in the relationship between strength training and positive cognitive responses in the elderly.

### Conclusion

Resistance training for only eight weeks with moderate to vigorous intensity improved muscle strength, hemodynamic variables and cognitive aspects in elderly women. Therefore, programs with this type of training can be recommended for this population to improve strength and cognition.

### Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

### Authors' contributions

BSF and DPS were responsible for the conception and design of the study and BSF, RDP, CM and JOB for the analysis and interpretation of the data. BSF and ACF wrote the manuscript, and ACF, CM and JOB reviewed it. All authors approved the final version.

## References

1. Suzman R, Beard JR, Boerma T, Chatterji S. Health in an ageing world: what do we know? *Lancet*. 2015;385(9967):484-6. DOI
2. Instituto Brasileiro de Geografia e Estatística (IBGE). Projeções da população do Brasil por sexo e idade: 2010-2060. Rio de Janeiro: IBGE; 2018. [Full text link](#)
3. Santiago LAM, Lima Neto LG, Santana PVA, Mendes PC, Lima WKR, Navarro F. Treinamento resistido reduz riscos cardiovasculares em idosas. *Rev Bras Med Esporte*. 2015;21(4):261-5. DOI
4. Argimon ILL, Stein LM. Habilidades cognitivas em indivíduos muito idosos: um estudo longitudinal. *Cad Saude Publica*. 2005;21(1):64-72. DOI
5. Bezerra PK, Rodrigues KA, Felix KD, Sotero RC, Ferreira AP. Déficit cognitivo: proposição de cartilha para atenção ao idoso. *Rev Bras Pesqui Cien Saude*. 2016;3(1):1-10. [Full text link](#)
6. Sanford AM. Mild cognitive impairment. *Clin Geriatr Med*. 2017;33(3):325-37. DOI
7. Tribess S, Virtuoso Jr JS. Prescrição de exercícios físicos para idosos. *Rev Saude Com*. 2005;1(2):163-72. [Full text link](#)
8. Matsudo SMM. Envelhecimento, atividade física e saúde. *Bol Inst Saude*. 2009;(47):76-9. [Full text link](#)
9. Oliveira DV, Bertolini SMMG, Martins Jr J. Qualidade de vida de idosas praticantes de diferentes modalidades de exercício físico. *ConScientiae Saude*. 2014;13(2):187-95. DOI
10. Gollie JM, Harris-Love MO, Patel SP, Argani S. Chronic kidney disease: considerations for monitoring skeletal muscle health and prescribing resistance exercise. *Clin Kidney J*. 2018;11(6):822-31. DOI
11. Queiroz ACC, Kanegusuku H, Forjaz CLM. Efeitos do treinamento resistido sobre a pressão arterial de idosos. *Arq Bras Cardiol*. 2010;95(1):135-40. DOI
12. Moraes MR, Bacurau RFP, Simões HG, Campbell CSG, Pudo MA, Wasinski F, et al. Effect of 12 weeks of resistance exercise on post-exercise hypotension in stage 1 hypertensive individuals. *J Hum Hypertens*. 2012;26(9):533-9. DOI
13. Vital TM. Efeitos do treinamento com pesos nos sintomas depressivos e variáveis metabólicas em pacientes com doença de Alzheimer [master's thesis]. Rio Claro: Universidade Estadual Paulista; 2011. 141 p. [Full text link](#)
14. Liu-Ambrose T, Donaldson MG. Exercise and cognition in older adults: is there a role for resistance training programs? *Br J Sports Med*. 2009;43(1):25-7. DOI
15. Cassilhas RC, Viana VAR, Grassmann V, Santos RT, Santos RF, Tufik S, et al. The impact of resistance exercise on the cognitive function of the elderly. *Med Sci Sports Exerc*. 2007;39(8):1401-7. DOI
16. Li Z, Peng X, Xiang W, Han J, Li K. The effect of resistance training on cognitive function in the older adults: a systematic review of randomized clinical trials. *Aging Clin Exp Res*. 2018;30(11):1259-73. DOI
17. Stewart M, Ryan BL, Bodea C. Is patient-centred care associated with lower diagnostic costs? *Healthc Policy*. 2011;6(4):7-31. [Full text link](#)
18. World Health Organization. Obesity: preventing and managing the global epidemic. Report on a WHO Consultation (WHO Technical Report Series 894); 2000 [cited 2020 Dec 14]. Available from: <https://apps.who.int/iris/handle/10665/42330>
19. Petroski EL, Pires Neto CS. Validação de equações antropométricas para a estimativa da densidade corporal em mulheres. *Rev Bras Ativ Fis Saude*. 1995;1(2):65-73. [Full text link](#)
20. Siri WE. Body composition from fluid space and density: analysis of methods. In: Brozek J, Henschel A. *Techniques for measuring body composition*. Washington: National Academy of Sciences; 1961.
21. Tritschler KA. Medida e avaliação em educação física e esportes de Barow & McGee. Barueri: Manole; 2003. 840 p.
22. Queiroz CO, Munaro HLR. Efeitos do treinamento resistido sobre a força muscular e a autopercepção de saúde em idosas. *Rev Bras Geriatr Gerontol*. 2012;15(3):547-53. DOI
23. Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Nefrologia. VI Diretrizes Brasileiras de Hipertensão. *Arq Bras Cardiol*. 2010;95(1 supl 1):1-51. [Full text link](#)



24. Nilsson FM. Mini mental state examination (MMSE) - probably one of the most cited papers in health science. *Acta Psychiatr Scand.* 2007;116(2):156-7. [DOI](#)
25. Brucki SMD, Nitrini R, Caramelli P, Bertolucci PHF, Okamoto IH. Sugestões para o uso do mini-exame do estado mental no Brasil. *Arq Neuropsiquiatr.* 2003;61(3-B):777-81. [DOI](#)
26. American College of Sports Medicine. Diretrizes do ACSM para os testes de esforço e sua prescrição. Rio de Janeiro: Guanabara Koogan; 2010.
27. American College of Sports Medicine. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc.* 2009;41(3):687-708. [DOI](#)
28. Pícoli TS, Figueiredo LL, Patrizzi LJ. Sarcopenia e envelhecimento. *Fisioter Mov.* 2011;24(3):455-62. [DOI](#)
29. Smolarek AC, Ferreira LHB, Mascarenhas LPG, McNulty SR, Varela KD, Dangui MC, et al. The effects of strength training on cognitive performance in elderly women. *Clin Interv Aging.* 2016;11:749-54. [DOI](#)
30. Murlasits Z, Reed J, Wells K. Effect of resistance training frequency on physiological adaptations in older adults. *J Exerc Sci Fit.* 2012;10(1):28-32. [DOI](#)
31. Fleck SJ, Kraemer WJ. Fundamentos do treinamento de força muscular. 4 ed. Porto Alegre: Artmed; 2017. 472 p.
32. Badillo JJG, Ayestaran EG. Fundamentos do treinamento de força. 2 ed. Porto Alegre: Artmed; 2004. 284 p.
33. Locks RR, Ribas DIR, Wachholz PA, Gomes ARS. Efeitos do treinamento aeróbio e resistido nas respostas cardiovasculares de idosos ativos. *Fisioter Mov.* 2012;25(3):541-50. [DOI](#)
34. Terra DF, Mota MR, Rabelo HT, Bezerra LMA, Lima RM, Ribeiro AG, et al. Redução da pressão arterial e do duplo produto de repouso após treinamento resistido em idosas hipertensas. *Arq Bras Cardiol.* 2008;91(5):299-305. [DOI](#)
35. Gerage AM, Forjaz CLM, Nascimento MA, Januário RSB, Polito MD, Cyrino ES. Cardiovascular adaptations to resistance training in elderly postmenopausal women. *Int J Sports Med.* 2013;34(9):806-13. [DOI](#)
36. Cunha ES, Miranda PA, Nogueira S, Costa EC, Silva, EP, Ferreira GMH. Intensidades de treinamento resistido e pressão arterial de idosas hipertensas - um estudo piloto. *Rev Bras Med Esporte.* 2012;18(6):373-6. [DOI](#)
37. Liu-Ambrose T, Nagamatsu LS, Graf P, Beattie BL, Ashe MC, Handy TC. Resistance training and executive functions 12-month randomized controlled trial. *Arch Intern Med.* 2010;170(2):170-8. [DOI](#)
38. Yoon DH, Lee JY, Song W. Effects of resistance exercise training on cognitive function and physical performance in cognitive frailty: a randomized controlled trial. *J Nutr Health Aging.* 2018;22(8):944-51. [DOI](#)
39. Antunes HKM, Santos RF, Cassilhas R, Santos RVT, Bueno OFA, Mello MT. Exercício físico e função cognitiva: uma revisão. *Rev Bras Med Esporte.* 2006;12(2): 108-14. [DOI](#)
40. Gorelick PB, Scuteri A, Black SE, Decarli C, Greenberg SM, Iadecola C, et al. Vascular contributions to cognitive impairment and dementia. *Stroke.* 2011;42(9):2672-713. [DOI](#)
41. Babaei P, Alamdari KA, Tehrani BS, Damirchi A. Effect of six weeks of endurance exercise and following detraining on serum brain derived neurotrophic factor and memory performance in middle aged males with metabolic syndrome. *J Sports Med Phys Fitness.* 2013;53(4):437-43. [Full text link](#)
42. Goekint M, De Pauw K, Roelands B, Njemini R, Bautmans I, Mets T, et al. Strength training does not influence serum brain-derived neurotrophic factor. *Eur J Appl Physiol.* 2010;110(2): 285-93. [DOI](#)
43. Yarrow JF, White LJ, McCoy SC, Borst SE. Training augments resistance exercise induced elevation of circulating brain derived neurotrophic factor (BDNF). *Neurosci Lett.* 2010;479(2):161-5. [DOI](#)
44. Levinger I, Goodman C, Matthews V, Hare DL, Jerums G, Garnham A, et al. BDNF, metabolic risk factors and resistance training in middle-aged individuals. *Med Sci Sports Exerc.* 2008;40(3):535-41. [DOI](#)