ORIGINAL ARTICLE

Effects of resistance training exercise on cognitive performance in elderly individuals with memory impairment: results of a controlled trial

Efeitos dos exercícios resistidos no desempenho cognitivo de idosos com comprometimento da memória: resultados de um estudo controlado

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ABSTRACT

Objective: To detect the effects of a resistance training program on cognitive performance and muscle strength in sedentary elderly individuals with memory impairment. **Methods**: Thirty-one sedentary elderly persons with no dementia or depression were randomly distributed into two groups: Physical Activity Group and Control Group. The resistance training exercise program lasted nine months and consisted of three series of six exercises per session, carried out on lever-type equipment for approximately one hour, twice a week. Every three months, both groups were submitted to the following cognitive tests: Rivermead Behavioral Memory Test (RBMT), Wechsler Adult Intelligence Scale (WAIS) Direct and Indirect Digit Span, Memory Complaints Scale, and Cambridge Cognitive Test (CAMCOG). **Results**: After nine months, the group that did resistance exercises showed a significant increase in the standardized RBMT score ($p = 0.021$) and in muscle strength ($p < 0.001$), with no significant difference in the other parameters evaluated. **Conclusions**: These results indicate that supervised resistance exercises can improve memory performance in sedentary elderly individuals with prior memory compromise, besides increasing muscle strength.

Keywords: Aging; Health of the elderly; Dementia; Cognition disorders; Motor activity

RESUMO

Objetivo: Detectar os efeitos de um programa de exercícios resistidos no desempenho cognitivo e na força muscular de idosos sedentários com comprometimento da memória. **Métodos**: Trinta e um idosos sedentários sem demência ou depressão foram distribuídos aleatoriamente em dois grupos: Grupo Atividade Física e Grupo Controle. O programa de exercícios resistidos durou nove meses e consistiu de três séries de seis exercícios por sessão, realizados em aparelhos com sistema de alavancas, por aproximadamente uma hora, duas vezes por semana. Ambos os grupos foram submetidos aos seguintes testes cognitivos a cada três meses: Teste Comportamental de Memória de Rivermead (RBMT), Amplitude de Dígitos Diretos e Indiretos do Wechsler Adult Intelligence Scale (WAIS), Escala de Queixas de Memória e Teste Cognitivo de Cambridge (CAMCOG). **Resultados**: Após nove meses, o grupo que realizou os exercícios resistidos teve um aumento significativo do escore padronizado do RBMT ($p = 0,021$) e da força muscular ($p < 0,001$), sem diferença significativa dos demais parâmetros avaliados. **Conclusões**: Estes resultados indicam que os exercícios resistidos supervisionados podem melhorar o desempenho da memória em idosos sedentários com prévio comprometimento, além de determinar o aumento da força muscular.

Descritores: Envelhecimento; Saúde do idoso; Demência; Transtornos cognitivos; Atividade motora

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INTRODUCTION

Aging of the population is a worldwide phenomenon that has been increasing due to a marked decrease in fecundity and increase in life expectancy[1-2]. One of the consequences of this is the increase in prevalence of dementia that is clinically characterized by a compromise in fixation or evocation memory and impairment of at least one other cognitive dominion (language, praxis, and executive functions)[3].

However, the complaint of memory difficulty is one of the most frequent in the elderly. One study performed in a metropolitan Brazilian region demonstrated that 54% of elderly individuals interviewed had memory complaints[4]. There are medications that can be beneficial in cases of dementia, but there was no benefit in elderly subjects who presented only with memory impairment[5-6].

Therefore, memory rehabilitation by non-pharmacological means has been intensely sought. Recently, a correlation between the preservation or even improvement of cognitive performance and physical exercises, especially aerobic exercises, has been particularly researched. A systematic review which included 18 longitudinal studies (1966 to 2001) concluded that aerobic exercises may provide a consistent advantage in cognitive performance of sedentary elderly individuals[7]. Another systematic review including 30 studies (1970 to 2003) demonstrated a decrease in occurrence of dementia[8].

One particular type of physical exercise has shown great benefit in the elderly: strength training, also called resistance exercises[9]. Nevertheless, the effects of these on cognition have not been studied very often.

OBJETIVE

Therefore, the objectives of this study were to evaluate the effects of a supervised resistance exercise program on cognition in sedentary elderly subjects with memory impairment; to compare the performance of the subjects in cognition tests and the progression of muscle strength as to gender.

METHODS

The study was conducted at the Memory of the Elderly Outpatient´s Clinic (AMI) of the Geriatric Service of Hospital das Clínicas of Faculdade de Medicina da Universidade de São Paulo (HC-FMUSP), site for patient selection, clinical follow-up and cognitive assessments.

Inclusion criteria were: elderly of both genders aged 60 years or more who had not performed programmed physical exercises in the six-month period prior to the selection process; subjective memory complaints reported by the patient or by an informant; geriatric depression scale (GDS)[10] within normal limits; mini-mental state examination (MMSE)[11] within limits of normal corrected by schooling[12]; changes in the objective memory test: a screening Rivermead test score equal to or less than nine[13]; preserved function in instrumental and basic activities of daily life[14-15].

Exclusion criteria were: dementia, depression and anxiety disorders as per Diagnostic and Statistical Manual of Mental Disorders of the American Psychiatric Association (DSM – IV) criteria[3]; head trauma or stroke in the previous year; recent use of substances that contribute to memory loss (alcohol, antidepressants, anxiolytics, neuroleptics, anticonvulsants, hypnotics, opioid analgesics); alterations in laboratory tests (glucose, hepatic transaminases, thyroid hormones, creatinine, urea, sodium, potassium, calcium, erythrocyte sedimentation rate, serology for syphilis, levels of vitamin B12 and folic acid), and unstable cardiovascular disease.

Once the selection criteria were met, patients signed an informed consent form approved by the Commission for Research Project Analysis (CAPPesq) of HC-FMUSP and names were drawn by a person independent of the research using papers taken from an opaque envelope, with two possibilities: Intervention Group or Control Group. Both groups were evaluated as per a cognitive assessment protocol at baseline, and after three, six, and nine months[13].

Cognitive assessment

- Cambridge cognitive test (CAMCOG) is a cognitive test (with 67 items) that evaluates orientation, language, memory, praxis, attention, abstract thinking, perception, and calculation. The score varies from 0 to 107[16-17].
- Rivermead Behavioral Memory Test (RBMT) is a memory test consisting of a battery of practical tasks which seeks to simulate daily situations, in order to decrease the interference of cultural factors. The standardized score varies from 0 to 24 and screening scores vary from 0 to 12[13].
- Direct and Indirect Digit Span of the Wechsler Adult Intelligence Scale (WAIS) measures the capacity for concentration and working memory, respectively. It consists of a repetition of a sequence of numbers and both scores vary from 0 to 14[18].
- Memory Complaints Scale (MCS) is a questionnaire derived from "The Cambridge examination for mental disorders of the elderly" (CAMDEX) and was designed so that the greater the number of complaints, and the greater their interference in the

subject's life, the greater the score that varies from 0 to 21 is[19].

Statistical analysis

In order to compare the means of the groups, the t-Student test was used for continuous variables. In categorical variables, χ^2 test or proportion analysis of two samples was used, and, in reduced samples, the Fischer's exact test was applied. To analyze the effect of group and time and the effect of group and gender regarding the results of the cognitive tests, the analysis of variance (ANOVA) was used for repeat measurements. A value of $\alpha < 0.05$ was adopted, and the analysis was carried out using the MINITAB 14 statistics program.

Intervention

The resistance exercises were performed at the Experimental Therapeutic Gymnasium as per the training protocol used by Centro de Estudos em Ciências da Atividade Física (CECAFI) of the Department of Geriatrics of FMUSP. The protocol carried out at the CECAFI was based on scientific evidence on the use of resistance exercises with safety and efficacy to increase muscle strength in the elderly[9].

The program consisted of six exercises per training session, lasting for approximately one hour each time, twice a week. In each exercise, loads were progressively increased in series of 12, 10, and 8 repetitions. Each repetition was made slowly, with approximately three seconds during the concentric contraction phase and six seconds in the eccentric contraction phase. The series of eight repetitions was performed with the highest load, which was increased in subsequent sessions by the supervising physical therapist or physical education professional, always attentive to not allowing a tendency towards isometry in apnea.

As cardiovascular safety measures, arterial blood pressure was measured before and after the sessions, with a resting period of one to two minutes between the series, avoiding maximal muscle contraction in apnea during the repetitions. The protocol was directed towards training of the large muscle groups (chest press, rowing, leg press, calves, abdominal, and lumbar). The exercises were carried out on six equipment pieces with system of levers and weights (Biodelta® Maxiflex line)

RESULTS

Subject characteristics

Thirty-one elderly individuals were selected (8 men and 23 women) and distributed by drawing of names: 17 to the Resistance Training Group and 14 to the Control Group. The mean age among the participants was 72.2 ± 5.4 years (varying from 62 to 86 years). There was no statistical difference in the means of age, level of schooling, and chronic diseases between the groups. A statistical difference was identified (p = 0.049) as to gender between the groups. Four participants, two from the Resistance Exercise Group and two from the Control Group abandoned the study before its conclusion, but all data obtained during follow-up of these individuals were included in the statistical analysis. The subject characteristics in the initial phase are presented in Table 1.

Table 1. Baseline sample characteristics

Variables	Control Group (n = 17)	Physical Activity Group (n = 14)	p value
Age: mean ± sd (years)	73.3 (± 6.4)	70.4 (± 3.6)	0.13*
Women/men	15 / 2	8 / 6	0.049**
Schooling: mean ± sd (years)	4. 3 (± 4.6)	6. 3 (± 3.8)	0.24*
CAMCOG: mean ± sd	81.3 (± 8.1)	82.9 (± 8.9)	0.62*
Rivermead test: mean ± sd	16.1 (± 3.2)	15.5 (± 3.2)	0.61*
Arterial hypertension	10 (58.8%)	7 (50%)	0.78***
Diabetes mellitus	3 (17.6%)	4 (28.6%)	0.66**
Coronary artery disease	1 (5.9%)	1 (7.1%)	1.0**
Arterial fibrillation	1 (5.9%)	1 (7.1%)	1.0**
Dyslipidemia	5 (29.4%)	7 (50%)	0.16***
Stroke	1 (5.9%)	0 (0%)	1.0**
Hypoacusis	1 (5.9%)	1 (7.1%)	1.0**
Osteoporosis	4 (23.5%)	2 (14.3%)	0.67**

* t-Student test; ** Fisher's exact test; *** proportion analysis of two samples

Cognition results

The results of the cognitive assessment may be evaluated by data in Table 2. The physical activity group showed an increase with statistical significance in the RBMT mean detected during the fourth assessment, after nine months of resistance training (Figure 1). An effect of interaction between the group and time was detected (p = 0.021). The initial means in both genders are not the same (p = 0.003), since the mean in males is greater than that in females, regardless of the group. In the Physical Activity Group (PA), men showed a mean variation (final minus initial values) of 0.8 (95%CI= -2.1-3.7), and for women it was 4.7 (95%CI = 2.3-7.1). In the Control Group, men showed a mean variation of -4 (95%CI = -8.6-0.6) and women of -0.2 (95%CI = -2.0-1.6). Thus, the mean variation in RBMT also depends on the gender (p = 0.045), since the variation in the women of AF was greater than in the men.

Table 2. Results of cognitive assessment in both groups

Cognitive assessment	Baseline	3rd month	6th month	9th month	p value*
CAMCOG (C)	81.3	82.1	83.4	84.5	0.32
CAMCOG (PA)	82.9	84.4	88.1	89.2	
Rivermead test (C)	16.1	16.7	14.9	15.33	0.021
Rivermead test (PA)	15	17.1	17.6	18.9	
MCS (C)	7.6	7.5	8.1	8.2	0.36
MCS (PA)	8.9	8.9	8.7	8.2	
Direct digit span (C)	4.6	4.6	4.5	4.9	0.66
Direct digit span (PA)	4.9	4.5	4.6	4.6	
Indirect digit span (C)	4.2	3.8	4.3	4.2	0.13
Indirect digit span (PA)	3.7	4	4.2	4.5	

C = Control Group; PA = Physical Activity Group; *analysis of variance (group/time); MCS = memory complaint scale

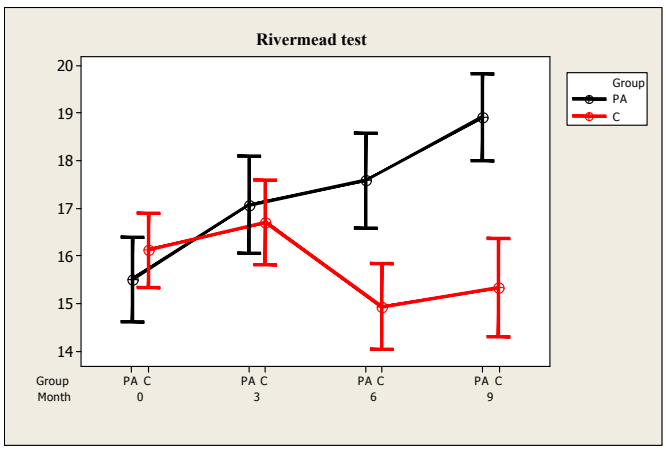

Figure 1. Mean variation (± sd) in the Physical Activity Group (PA) and in the Control group (C) in the Rivermead test during the nine-month period of study (p= 0.021)

The CAMCOG means increased significantly in both groups over the course of the study ($p < 0.001$), but there was no difference with statistical significance between the groups. No group effect was identified at any of the timepoints (p= 0.322). In other words, the means coincided, but at the end they were greater than in the beginning, both in group physical activity and in Control Group. No interaction effect was detected between time and gender in the CAMCOG mean ($p = 0.71$).

Muscle strength results

With the objective of estimating the variation in muscle strength of the resistance training participants, the means of the loads used in the series of eight repetitions were compared, as of the end of the first month for adaptation. There was an increase with statistical significance in the means of the loads (Table 3). No interaction effect was detected between gender and progression of muscle strength by the Kruskal-Wallis test: rowing ($p = 0.16$); leg press ($p = 0.45$); lumbar extension ($p = 0.80$); abdominal ($p = 0.25$); pectoral ($p = 0.06$), and calves ($p = 0.74$).

Table 3. Progression of mean (± sd) resistance training load (kg)

Exercises	1st month	3rd month	6th month	9th month	p*
Lumbar extension	13.2 ± 7.94	27.5 ± 21.1	37.1 ± 22.8	47.1 ± 24.1	p < 0.001
Leg press	16.1 ± 8.94	25.4 ± 19.56	37.3 ± 24.39	45 ± 23.4	p < 0.001
Calves	10.3 ± 5.4	17.8 ± 15.6	22 ± 17.6	28.13 ± 20.9	p = 0.004
Rowing	10.1 ± 7.9	16.9 ± 7.6	20.4 ± 6.8	26.59 ± 11.7	p = 0.001
Abdominal	9.7 ± 5.2	15.3 ± 12.1	19 ± 13.1	22.7 ± 10.2	p = 0.001
Pectoral	5 ± 4	10.4 ± 9.1	11.7 ± 2.7	13.3 ± 2.8	p = 0.001

*Analysis of variance (ANOVA)

DISCUSSION

Even though the evidence that aerobic exercise benefits cognition in the elderly is consistent, few studies have been conducted to assess the effect of resistance exercises on the cognition of elderly individuals. The study by Perrig-Chiello et al.[20] was the first with this purpose, but it only demonstrated an improvement in general well-being.

In the present study, the RBMT mean increased significantly in the Intervention Group in comparison with the Control Group. We point out that RBMT was developed to measure memory loss and monitor the effects of rehabilitation. It is not affected by level of schooling, age, or gender, and since it is a behavioral test, it shows a good correlation with memory difficulties in situations of daily life. However, there was no statistically significant difference between the means of the Memory Complaints Scale (MCS) of both groups.

In the study performed by Lachman et al.[21], with 210 elderly subjects, there was an improvement in working memory only in the subgroup with the greatest progression of loads during training. In the study by Cassilhas et al.[22], with 62 elderly individuals, there was a significant improvement, both in working memory and episodic memory. However, in these two studies, with six-month duration, there was no selection of the elderly according to memory complaints or by prior performance on cognitive tests.

In this study, in the PA, there was improved performance on the RBMT in both genders, but the improvement in females was significantly superior. In some prior studies it had been observed that the female gender showed superior benefits than the male gender, especially with aerobic exercises. Nevertheless, it still is not clear by which mechanisms gender influences the modulation of the effects of physical exercises on cognition[23].

The significant increase in CAMCOG, both in the Control Group and the Intervention roup can be explained by the test learning effect, since there is only one version applied every three months. The learning effect did not occur with the RBMT, possibly because there are four versions of it and a different version was used at each assessment. Performance on CAMCOG was statistically the same for both genders.

There was no statistically significant difference between the means of the direct and indirect digit span in both groups**.** Therefore, this is different from the study performed by Lachman et al.[21] and the study by Cassilhas et al.[22], in which a significant improvement was noted in these tests.

Muscle strength was measured indirectly, i.e., by progression of loads in the resistance training program. There was a significant increase in loads in the six-piece equipment used, between the end of the first month and the end of the ninth month of training, which was similar in both genders. The mean increase estimated in muscle strength was 178%, similar to the results obtained in studies carried out in our region with a similar exercise protocol[24-25].

Increased sociability is, no doubt, one of the objectives of the prescription of physical exercises to promote health for any age bracket. It is possible, then, that the greater social interaction afforded by the practice of resistance exercises contributed towards an improved performance in memory in the Intervention Group. However, it has been noted in various studies that the greater the intensity of the exercise, the better the progression of cognitive performance, demonstrating that increased sociability, in itself, is not sufficient[26].

This study presents relevant contributions to scientific knowledge, but there are some limitations that may be adjusted in future research projects. The number of participants was small, which led to a significant difference in distribution of the genders between the groups during the random distribution. A more expressive sample size would certainly lend greater reliability to the results found, and would eventually show other benefits that were not significant in this study. The results of cognitive assessment could also be more reliable if the raters had no prior knowledge of which group the subjects belonged to.

CONCLUSIONS

The results indicate that nine months of supervised resistance exercises may be effective in improving the memory performance of sedentary individuals with memory impairment. In the Intervention Group, there was a significant improvement in performance of the RBMT in both genders, but the improvement in the female gender was more expressive. The CAMCOG may be affected by learning the test if it is applied repeatedly, with intervals of three months. The increase in muscle strength in the Intervention Group was very significant in all muscle groups covered in the resistance exercise protocol. There was no difference in proportion of muscle gain between genders.

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