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Effects of physical activity on cognitive functions, balance and risk of falls in elderly patients with Alzheimer's dementia

Efeitos de um programa de atividade física nas funções cognitivas, equilíbrio e risco de quedas em idosos com demência de Alzheimer

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Abstract

Objective: To analyze the effects of regular, systematic and supervised activity on the cognitive functions, balance and risk of falls of elderly patients with Alzheimer's Dementia (AD). **Methods:** Sixteen elderly patients (mean age 78.5±6.8 years) were divided into two groups: intervention group (IG; n=9) and routine group (RG; n=7). The IG exercised systematically for six months, and both groups were submitted to the following tests: Mini-Mental State Examination (MMSE), Berg Balance Scale (BBS), Timed Up-and-Go (TUG) and the agility/dynamic balance (AGIBAL) item of the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) test battery. **Results:** There was a statistically significant interaction (two-way ANOVA; $F_{1,14}$=32.07; p=0.01) between groups and moments for the AGIBAL. The Mann Whitney U test indicated significant differences between groups (p=0.03), only at the post-intervention moment for the TUG measured in steps and for BBS. Therefore, no significant intergroup differences were found for the TUG, BBS and MMSE at the pre-intervention moment or at post-intervention moment for the TUG measured in seconds and MMSE. The intragroup analysis by means of the Wilcoxon test showed a significant decline in the TUG, BBS and MMSE for the RG, but not for the IG. Spearman's coefficient showed a significant correlation between the results of the MMSE and AGIBAL. **Conclusions:** Physical activity may be an important non-pharmacological approach that can benefit cognitive functions and balance and reduce the risk of falls. Moreover, agility and balance are associated with cognitive functions in elderly patients with AD.

Key words: physical activity; cognitive function; balance; risk of falls; Alzheimer.

Resumo

Objetivo: Analisar os efeitos de um programa de atividade física regular, sistematizado e supervisionado sobre as funções cognitivas, equilíbrio e risco de quedas de idosos com demência de Alzheimer (DA). **Métodos:** Dezesseis idosos com idade média de 78,5±6,8 anos foram alocados em dois grupos: grupo intervenção (GI; n=9) e grupo rotina (GR; n=7). O GI praticou seis meses de atividade física sistematizada, e ambos os grupos foram avaliados por meio dos seguintes testes: Mini Exame do Estado Mental (MEEM), Escala de Equilíbrio Funcional de Berg (EEFB), *Timed Up and Go* (TUG) e de Agilidade e Equilíbrio Dinâmico (AGILEQ) da bateria da American Alliance for Health Recreation and Dance (AAHPERD). **Resultados:** Houve interação estatisticamente significativa (ANOVA *two way*; $F_{1,14}$=32,07; p=0,01) entre grupos e momentos para o teste AGILEQ. O teste U *Mann Whitney* apontou diferenças significantes intergrupos (p=0,03) apenas no momento pós-intervenção para o TUG avaliado em passos e para a EEFB; portanto sem mostrar diferença significante no TUG, EEFB e MEEM no momento pré intervenção, bem como no momento pós-intervenção para o TUG em segundos e para o MEEM. Na análise intragrupo, o teste de *Wilcoxon* mostrou piora significativa no MEEM, TUG e EEFB do GR, mas não do GI. O coeficiente de *Spearman* mostrou correlação significativa entre os resultados do MEEM e AGILEQ. **Conclusões:** A atividade física parece representar uma importante abordagem não farmacológica, beneficiando as funções cognitivas e o equilíbrio com diminuição do risco de quedas. Além disto, a agilidade e o equilíbrio estão associados com funções cognitivas em idosos com DA.

Palavras-chave: exercício físico; cognição; equilíbrio; quedas; Alzheimer.

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Introduction

The literature describes many types of dementia, among which Alzheimer's Dementia (AD) stands out and currently represents over 50% of cases[1]. AD is a neurodegenerative disease characterized by the accumulation of extraneuronal amyloid plaques and intraneuronal neurofibrillary tangles in regions of the temporal lobe that lead to progressive cognitive decline[2]. In the initial phase, the patient has short-term memory loss and, with the progression of the disease, semantic memory disorders, difficulty recalling names and communicating[3], attention deficits, impairment of visual and spatial skills and executive functions[4].

During the natural aging process, there is a decline in the somatosensory (proprioceptive), visual and vestibular systems that control balance. The central nervous system (CNS) may undergo several changes that affect postural control and balance, including neuron loss, dendritic loss and reduced branching, lower metabolism and cerebral perfusion and modified neurotransmitter synthesis[5]. In addition, muscle strength, especially in the lower limbs, is also impaired with advancing age, leading to a decrease in the recruitment and activation of motor units. The same occurs in the elderly patient with dementia, reflecting an increase in the risk of falls[6]. Furthermore, cognitive decline increases the risk of falls because 65.5% of these episodes occur in elderly people with cognitive deficit[7]. In elderly patients with AD, falls are three times more frequent than in healthy elderly people due to the damage to the frontal lobe, which causes a decline in executive functions and attention control[8].

In their study, Rolland et al.[9] submitted elderly patients with AD to a physical activity program consisting of walking, stretching, balance and flexibility, held twice a week for one hour. The authors concluded that the elderly patients who took part in the program had a smaller decline in the performance of activities of daily living (ADLs) and better performance in the walking and balance tasks compared to those not participating in the program.

Falls in elderly people are a major clinical problem due to high incidence, subsequent complications, high care costs and early institutionalization. The consequences of falls for elderly people may represent losses in the levels of components of functional capacity and reduced ADLs, and may also trigger a depressive state[10-12].

Some studies have shown beneficial results regarding cognitive functions and functional capacity in elderly patients with dementia who were submitted to regular physical activity[13]. In a review article, Yu, Evans and Sullivan-Marx[14] concluded that physical activity may slow cognitive decline. Arcoverde et al.[15] also found that physical and cognitive stimulation in elderly patients with AD may contribute to the attenuation of cognitive and functional decline.

Considering the gravity and high prevalence of AD and the current lack of treatment, it is necessary to develop strategies to mitigate the cognitive and functional decline in these patients. Thus, this study aimed to analyze the effect of a regular, systematic and supervised program of physical activity on cognitive functions, balance and risk of falls in patients with AD.

The present study may contribute to the discussion on the degree of effectiveness of non-pharmacological procedures for patients with AD. It should be noted that AD is a progressive degenerative disorder with no definitive solution at present. Procedures that assist in stabilizing, even if temporarily, the clinical decline of the patient are most likely to represent a relevant gain in quality of life. Thus, health professionals who deal with Alzheimer's could combine systematic motor activity with conventional psychopharmacological treatment.

Methods

Participants

Initially 20 elderly patients took part in this study. All of them had been diagnosed with AD according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)[16]. The selected participants volunteered for the study or were referred by physicians and caregivers. The patients' guardians signed an informed consent form approved with the research project by the Research Ethics Committee (protocol no. 2448).

The sample consisted of community-dwelling elderly people from the city of Rio Claro, SP. The sample was divided into two groups, the intervention group (IG) and the routine group (RG), according to the availability of caregivers and patients for transport to the place of physical activity. However, there was sample loss of four elderly patients due to health problems, followed by hospitalization. Thus, the study was completed with 16 elderly patients with AD (IG; n=9 and RG; n=7) with a mean age of 78.5 ± 6.8 years, schooling of 5.2 ± 3.0 years and disease duration of 3.0 ± 1.0 years. Patients were classified into mild and moderate stages of disease according to the Clinical Dementia Rating[17]. The IG consisted only of mild cases of the disease, and the RG contained three elderly patients in the moderate stage and the remainder (four elderly patients) in the mild stage.

Although there were no significant differences between groups regarding age, schooling and disease duration, the IG was slightly younger and had higher schooling compared with the RG. In contrast, the RG had long disease duration. Both groups were evaluated before and after six months of physical activity. Furthermore, they maintained their pharmacological assistance and medical routine without changes. However, the RG did not follow the exercise protocol described later in this study.

Instruments

To following tests were used to measure balance: the Berg Balance Scale (BBS), the Timed Up-and-Go test (TUG) measured in seconds (TUGs) and steps (TUGp), and the agility/dynamic balance test (AGIBAL) of the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) test battery. The BBS[18] is a scale consisting of 14 items involving specific functional tasks in different situations and on different bases of support. The total score ranges from 0 to 56 points, and the lower the score, the greater the risk of falls. The TUG is an important tool to evaluate balance, and it records the time taken to rise from an armchair, walk a distance of 3 meters and return to the chair, as well as the number of steps. Higher values of time and number of steps represent a higher risk of falls[19]. The AGIBAL[20] involves total body activity with forward movement and changes in direction and position. The participant begins the test sitting on a chair with feet flat on the ground. At the signal, the participant walks to the right and goes around a cone placed 1.50 m behind and 1.80 m to the side of the chair, returning to the chair and sitting down. Immediately, the participant gets up again, moves to the left and goes around the second cone, returns to the chair and sits down again, completing a circuit. The participant must complete two full circuits. Two trials are conducted (two circuits each), and the best time (the shortest) is recorded, in seconds, as the final result.

For cognitive evaluation, we used the Mini-Mental State Exam (MMSE)[21], an instrument consisting of questions grouped into seven categories: orientation to time, orientation to place, registration, attention and calculation, recall, language and visuoconstructive capacity. The MMSE score ranges from 0 to 30 points and lower values indicate possible cognitive impairment. As the MMSE is influenced by schooling, reference values were proposed in order to distinguish participants with possible cognitive deficits. Brucki et al.[22] analyzed a Brazilian sample and suggested the following values for studies evaluating cognition: illiterates=20 points; 1 to 4 years of schooling=25; 5 to 8 years=26.5; 9 to 11 years=28; and more than 11 years=29 points.

Intervention or exercise protocol

The 60-minute sessions of the systematic and supervised program of regular physical activity were performed three times a week on nonconsecutive days for six months. The sessions were performed in groups with the help of trainees. This program was prescribed according to the functional and cognitive capacity of the elderly participants, aimed at maintaining independence and reducing the risk of falls.

The exercises were structured with the aim of promoting the motor and cognitive stimulation of the participants, simultaneously or separately. For motor development, stretching activities, weight training, circuits, pre-sport games, dance sequences, recreational activities and relaxation were prescribed. Auxiliary apparatuses were used, e.g. weights, ankle weights, sticks, medicine ball, thera-band and gymnastics ball, to develop components of the functional capacity of coordination, agility, balance, flexibility, strength and aerobic capacity. During the sessions, the participants' heart rate was measured with a Polar A4 heart rate monitor, therefore the training was adapted so as to require an effort equivalent to 60 to 80% of the maximum heart rate[23].

Statistical analysis

Given the confounding variables (age, schooling, disease duration), the Mann Whitney U test was used to determine whether there was any difference between the RG and the IG in the pre-intervention moment. Furthermore, descriptive data analysis (mean and standard deviation) were carried out, as well as verification of the data distribution by Shapiro Wilk test. As the result of the AGIBAL is a continuous variable and the hypothesis of normal distribution was not rejected, two-way ANOVA was used. For TUGs, the hypothesis of normal distribution was rejected, therefore the Mann Whitney U test was used for intergroup comparison and the Wilcoxon test for the intra-group comparison. These tests were also used for the BBS, TUGp and MMSE test because they are discrete variables. Spearman's correlation was applied to verify the relationship between the MMSE and the other tests. In all cases, the significance level was set at 5% ($p<0.05$).

Results

The Mann Whitney U test showed no statistically significant differences between groups in any of the confounding variables and MMSE in the pre-intervention moment (Table 1). Psychopharmacological assistance was also maintained without any change in dosage and type of medication during the study for both groups.

In the AGIBAL test, statistical analysis (two-way ANOVA) showed statistically significant differences ($p=0.01$) for the group x moment interaction and for the main effect of time

($F_{1,14}$=32.07). The main effect of group was marginally significant ($F_{1,14}$ =3.76; p=0.07).

Regarding the TUG, the Mann Whitney U test showed: a) no significant difference between groups in pre- and post-intervention moments in the TUGs; b) significant difference between groups in the post-intervention moment (p=0.03), but not in the pre-intervention moment in the TUGp. The Wilcoxon test showed: a) significant worsening for the RG and maintenance for the IG in the TUGs; b) significant worsening for the RG and significant improvement for the IG in the TUGp.

The Mann Whitney U test showed: a) significant difference between groups (p=0.03) in the post-intervention moment, but not in the pre-intervention moment, in the BBS; b) no significant difference between groups both in the pre- and post-intervention moments in the MMSE. The Wilcoxon test showed: a) that the RG had significant damage between moments, while the IG did not change significantly in the BBS; b) significant worsening for the RG between moments, while the IG did not change significantly in the MMSE. Table 2 shows the pre- and post-intervention results for the groups on the AGIBAL, TUGs and TUGp, BBS and MMSE tests.

To verify possible correlations in the post-intervention moment between the MMSE and the other variables, Spearman's correlation was used, and it was observed that in the RG, there was a strong correlation (r=-0.85 and p=0.01) between cognitive function and agility and dynamic balance.

Discussion

The interpretation of the results shows a positive influence of physical activity program in the maintenance of cognitive functions, agility and balance, without increasing the risk of falls in elderly people with AD. Regarding the elderly participants with AD who did not take part in the physical activity program, there was a significant decline in all variables.

While it was not within the scope of this study to verify neurotrophic and psychosocial mechanisms that explain the benefits cited, the scientific literature gives possible explanations for the maintenance of the cognitive functions found in the IG, such as: a) stimulation of biological mechanisms, including changes in encephalic metabolism[24] and an increase in neurotrophic factor[25], provided by brain plasticity[25]; b) psychological benefits that reduce symptoms of anxiety and depression[26]; c) hypothesis of social networks that act in conjunction with neurophysiological changes, enhancing the improvement of symptoms and physical, cognitive and behavioral signs in elderly patients with dementia[27].

The control of confounding variables is extremely important for the observation of the effects of the implemented physical activity program[13]. No significant difference was found between the groups for these variables (age, schooling and disease duration), however the analysis of descriptive statistics showed that the RG had longer disease duration, higher level of disease severity, and higher mean age when compared with the IG. Such results can lead to limitations in the present study because the RG may have worsened compared to its initial characteristics in relation to the confounding variables. It is worth noting that there was no change in the pharmacological treatment of both groups during the study or in the period prior to the study.

After six months of physical activity, the elderly participants of the IG had a significant improvement in the performance of the TUGp, i.e. significantly decreased number of steps, while in the TUGs, they maintained the same time. This fact may be linked to improvement in stride length, walking speed and balance. In contrast, the RG worsened significantly in the TUGp and the TUGs.

A study conducted with 30 participants with AD, vascular dementia (VD) and cognitively preserved elderly people showed a significant decrease in stride length and speed when compared to a control group[28]. The authors concluded that stride length was a more important predictor of the walking pattern than cadence and speed and that this finding may be directly related to changes in blood flow in the frontal region of

Table 1. Mean, standard deviation and alpha value (p) of confounding variables (age, schooling and disease duration) and Mini-Mental State Exam in elderly patients with Alzheimer's dementia for the intervention group (IG; n=9) and the routine group (RG; n=7) at the pre-intervention moment.

Pre-intervention moment	IG	RG	p
Age (years)	77.7±7.6 years	84.0±6.1 years	0.63
Schooling (years)	5.6±3.3 years	4.5±3.0 years	0.21
Disease duration (years)	2.5±1.0	3.5±1.3	0.32
Mini-Mental State Exam (points)	16.4±6.7	14.2±5.1	0.59

Table 2. Mean, standard deviation and intra- and intergroup comparison for the intervention group (IG; n=9) and the routine group (RG; n=7) at the pre- and post-intervention moments of physical activity in the tests of agility/dynamic balance (AGIBAL), Timed Up-and-Go in seconds (TUGs) and steps (TUGp), Berg Balance Scale (BBS) and Mini-Mental State Exam (MMSE).

Groups	IG		RG	
	PRE	POST	PRE	POST
AGIBAL[a]	39.1±10.2	38.3±8.2	45.6±16.7	59.9±22.0
TUGs	9.8±2.5	9.5±3.3	10.6±4.5	14.7±7.3[b]
TUGp	16.7±4.9	15.1±4.4[b,c]	18.1±4.6	21.8±8.3[b]
BBS	46.8±8.1	47.5±8.4[c]	43.5±7.5	38.0±8.8[b]
MMSE	16.4±6.7	15.8±6.6	14.2±5.1	11.4±7.0[b]

[a]=significant interaction between groups and moments; [b]=significant difference compared to the pre-intervention moment; [c]=significant difference between groups at the post-intervention moment.

cerebral cortex. This study showed better performance in the gait pattern (fewer number of steps in the same task), which may be associated with improvement and/or maintenance of attention and executive function in the elderly participants, a function primarily processed by the frontal region.

Comparatively, Oliveira, Goretti and Pereira[29] found that the cognitive impairments detected by the MMSE were not associated with the performance of the elderly patients in the TUG test. However, these authors found a significant association between the performance of the elderly patients in the mobility test obtained by the TUG and in the performance of activities of bathing, dressing and transferring. The present study showed that the elderly patients from the IG maintained cognitive function, as shown by the MMSE, indicating the positive influence of physical activity because the RG had a significant worsening of the analyzed variable.

Regarding the BBS, the elderly participants from the RG worsened significantly and the IG maintained its score and therefore its balance, being protected against an increased risk of falls. For Tinetti, Speechley and Ginter[11], Myers et al.[30] and Buchner and Larson[31], falls can be associated with an increase in fractures, loss of mobility, being bedridden, early institutionalization and increased use of medication by the elderly patients. Weller and Schatzker[32] compared elderly patients with AD to cognitively-preserved elderly people and reported that the occurrence of falls in elderly patients with AD was of 36%, while in cognitively-preserved elderly people it was 11%. The same authors found no correlation between the increase in falls in the elderly patients with AD with the advancement of the disease or with the use of psychotropic drugs and concluded that the loss of functional independence caused a higher risk of falls.

According to Nutt, Marsden and Thompson[33], the concept of gait dysfunction may be a persistent characteristic of AD. In this study, 55 elderly patients with AD were divided into groups according to the stage of disease (mild, moderate and advanced), and the prevalence of gait disorders increased at every stage. The present study found a negative correlation between cognitive function (MMSE) and balance (AGIBAL) in the RG, reinforcing important aspects mentioned in earlier studies. This negative correlation is due to the low score obtained on the MMSE test, which indicates cognitive impairment, and to the high score on the AGIBAL test, which indicates poor balance and agility; hence both studies found a worsening of functional and cognitive variables. Thus, the decline in cognitive function observed in the RG may be directly associated with the decline in agility and balance. This finding corroborates the study by Nutt, Marsden and Thompson[33], in which the decline in cognitive function may be proportionally increasing gait dysfunction and consequently increasing the risk of falls.

An important aspect to be discussed is the fact that the only significant correlation was between cognitive functions and the AGIBAL test in the GR. The performance of more complex motor tests may place a higher cognitive demand on patients with AD. This data suggests that the motor test performance could be directly associated with the patient's level of cognitive function. The AGIBAL test is one of the tests that require good reasoning, attention and visual and spatial orientation, with sudden changes of direction. Because the RG had a decrease in cognitive function, the cognitive reserves became insufficient for the demand placed by the AGIBAL and the correlation was revealed.

Regarding the motor tests used to evaluate patients with AD, the stimulation and instruction during the tests are extremely important. However, the literature does not elucidate this kind of stimulation, highlighting the need to develop and adapt techniques to instruct elderly patients with AD in these tests so that the quality of their performance is not affected during the tests. Therefore, during the intervention protocol, clear, objective and repetitive instructions were designed to guide the participants in performing the exercises.

Although the present study found positive results for physical activity and AD, it is important to emphasize the difficulty in controlling variables such as recruitment, sample loss and intervention period. Regarding the participants, there are still several barriers that hinder the recruitment of elderly patients with AD for regular physical activity, particularly the fact that medical specialists who diagnose AD often do not refer patients to physical activity programs. Another barrier is transportation and the availability of caregivers to take the patient to the programs, which are rare for this population. The long period of intervention also contributes to the high rate of sample loss. However, it is important to note that six months of motor activity are sufficient to yield noticeable improvements in balance and to decrease the risk of falls among the intervention program participants.

In the literature, there is still no consensus on non-pharmacological approaches, such as physical activity, for the treatment of DA[34]. The present study, although not original, aimed to contribute to the development of the methodology and the effectiveness of these approaches, and to promote a deeper understanding of the subject. Such approaches may be identified as adjunct treatments to drug treatment and will contribute to the study of physical therapy and rehabilitation sciences.

Given these findings, we conclude that patients with AD who participated in the program of systematic physical activity improved maintenance of cognitive functions, and performance in balance and decreased risk of falls. In contrast, patients with AD who did not take part in the physical activity program showed a greater decline in cognitive function, reduction in balance and increased risk of falls. Physical activity may represent an important non-pharmacological contribution to diminish the rate of cognitive and motor decline due to the progression of the disease.

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