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Research Article

Physical Exercises and Functional Mobility in Single and Dual-Task in the Elderly: Relationship with Cognitive Function

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Abstract

The aim of this study was to determine the effects of a 20 week program of multimodal physical exercises on functional performance in mobility considering single and dual-tasks conditions, as well as assessing the cognitive components that may affect this performance in the elderly. 49 elders (65.6 ± 2.8 years) participated in the study. The groups were distributed according to the participation in the proposed protocol: a) Trained Group (TG), composed of 21 participants who attended at least 75% of the total generalized exercise sessions; b) Control Group (CG), participants who were included in a group of social gathering with cognitive stimulation activities, but without any systematized physical activity. Functional mobility was assessed using the Timed-Up-and-Go (TUG) test. Participants performed a single-task and would later associate the test with a verbal fluency task (dual task condition). For analysis, we considered the time spent to perform the two conditions. Cognitive functions were measured by the Mini-Mental State Examination (MMSE). Results showed that the elderly in the TG showed better performance on the TUG for the conditions of single and dual-tasks after performing the 20-week of physical exercises proposed protocol. The cognitive status showed a significant association with the time spent to perform TUG test during the dual-task (r^2=46%, p = 0.01). Thus our results indicated that for twice a week doing physical exercises during 20 weeks, may promote functional performance benefits in the elderly, especially in situations that require performance of dual tasks.

Keywords: Aging; Exercise; Cognition; Functional mobility; Dual-task

Introduction

Elderly population frequently experience functional deficits during the ageing process. Their changes are common, mainly during they have to perform multiple tasks in which may demand the integration between cognitive and motor functions. Most of the daily instrumental activities require these abilities, such as walking, carrying a cup of water or count money to pay their expenses. The ability to perform dual-task activities is important to ensure the maintenance of a functional and independent lifestyle [1]. The ageing process is directly linked to impairments in information [2] and functional fitness [3,4], which become the performance on dual-tasks more complex for these people [5-8].

Voelcker-Rehage & Alberts [9] e Jamet et al. [10] verified that during the performance on motor tasks, elderly are able to maintain body balance when it is focused on achieving a specific activity, but they did not show the same pattern of performance when they need to perform multiple tasks simultaneously. While performing concurrent tasks, a primary and/or secondary task are assigned mainly by competition between the attentional demands. This competition is triggered by the decline in frontal lobe functions, particularly in executive functions, which are responsible for organizing, planning, scheduling and executing tasks [5, 11-13].

Thus, the need of attentional demand for accomplishment and monitoring the environment, might cause difficulties in motor performance [10] and increase the risk of falling when the subject is performing dual task activities [14-16], which is currently in activities of daily living.

Fallen reduce independence and consequently the quality of life of these individuals [15-18]; and is currently treated as a public health issue. In this sense, the practice of physical exercise has been widely recommended as a way to minimize the deficits in functional and cognitive systems [19-22] due to the aging process, as well as the important to the prevention of falls [23].

Some studies have been conducted with functional mobility and simultaneous cognitive tasks in elderly subjects [24,25], additionally to motor benefits, some investigations found a positive effect of an exercise program on the achievement of dual tasks. However, few researches linked this performance with the cognitive status of the elderly.

Thus, this study contributes to partial reduction in the gap of knowledge in the context presented above, analyzing the effects of a generalized program of physical exercises on dual and single tasks in the elderly, as well as the connection between performance and cognitive status. Therefore the objective of this study was to investigate the effects of a dual task exercise program in general for the functional mobility of older people, as well as the association of

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cognitive performance with the same status.

Methods

62 volunteer subjects participated in this study without prior history of neurodegenerative diseases or functional changes that could affect neither their motor function or the performance of the proposed training protocol (independent gait). Participants' age ranged between 63 to 75 years (mean age 65.6 ± 2.8 years).

The participants were distributed into two different groups as follows: a) experimental group: 28 individuals who taking part in a specific and generalized program of physical activity during 20 weeks. All participants included in our sample took part in at least 75% of all sessions of the proposed training; b) Control group: 34 subjects who participated in social gathering events. These participants did not perform any kind of systematic physical activity during the same period.

This prospective interventional study was approved by the Ethical Committee of the UNESP – São Paulo State University. All participants signed the consent term certifying that all procedures were planned according the ethical standards of the Committee on Human Experimentation of the institution and with the Helsinki Declaration of 1975.

Experimental group

Training protocol: In the present study, the experimental group underwent a multimodal training, with two weekly sessions on non-consecutive days, each session have a 60 minutes of duration. All sessions started with a 10 minute short warm-up and simple stretches, followed by the main activity aimed to work components of functional capacity (aerobic endurance, strength endurance, coordination and balance). The main part of the session has approximately 45 minutes. At the end of each session, it was suggested a five minutes cool-down activity. The workloads applied for the experimental group were calculated to ranges between 70 and 75% of the maximum heart rate.

Control group: The control group did not take part of any kind of systematic and regular motor intervention during the research period and on the six months before the beginning of the research. These individuals were participants in a project of social gathering with multidisciplinary activities (crafts, lectures, tours, etc.). This interventional project included two weekly meetings. All participants underwent the same evaluation protocol as the experimental group.

Evaluation protocol: The evaluations were conducted by "single-blind" instructors regarding the distribution of each group assessed. For the evaluation of functional mobility, participants were instructed to perform the Timed Up and Go test protocol [26]. The test begins with the participant sitting on a chair and at the signal of the evaluator, the participant should get up and walk as fast as they can, covering a distance of three meters in a straight line and returning around a cone that marked such away and returning to the starting position on the chair. The instructor marks the time taken for completing the task. High values of time and/or number of steps represent a higher risk of falls. After an attempt to ensure familiarization with the test, the tasks were performed under two different conditions: in the first condition, the elderly should focus exclusively on the attainment of motor action and at the second time, the test should be accompanied by a fluency verbal assessment (participants should nominate animals that begins with the letter "C" as many as possible he was able to recall). Verbal fluency task is often used for dual tasks in order to demand the attention under execution [13]. Each trial was performed with intervals of 2 minutes.

The adapted version of the Mini-Mental State Examination (MMSE) [27] was applied to assess cognitive deficits. This assessment tool consists of seven categories, each designed with the objective to evaluate specific cognitive functions. They are: orientation regarding time and place, registration of three words, attention and calculation, recall of three words, language and visual constructive praxis.

Data Analysis

The Outcomes of the variables are shown by descriptive statistics. The analysis to verify the normality of the data consisted of: a) A Two-Way ANOVA to verify the interaction between the balance/mobility conditions in single and dual-tasks between pre and post-motor intervention in the experimental and control group; b) Pearson correlation coefficient was calculated to investigate the association between functional mobility performance in dual-task condition and cognitive status and; c) Multiple Linear Regression, to analyze the relationship of the independent variables (age, sex, and cognitive status) as predictors of performance in mobility functional in dual task condition. For our statistical tests we adopted a significance level of 5% ($p < 0.05$). All analysis´ were performed using SPSS software version 10.0 for Windows.

Results

Sixty-two elderly were included for the data analysis. Twenty-eight of these elderly performed the proposed training protocol for a period of 20 weeks and had a frequency equal to or greater than 75% of the total meetings held during the development of the research. Seven of the total subjects who participate initially of the intervention, did not complete the participation in the study (2 withdrew, 3 did not achieve the minimum frequency and,2 did not attend the complete evaluation protocol). Regarding the 34 participants of the control group, only 28 completed the evaluation protocol and were included in the sample. Data regarding age, education, functional mobility and cognitive functions are presented in Table 1. Participants did not present significant differences between baseline characteristics evaluated.

The Two-way ANOVA indicated an interaction between groups on functional mobility in pre and post-motor intervention ($F_{1,47}$ = 13.625, p = 0.001). The analysis of variance has shown that the control

Table 1: Outcomes of evaluated groups (experimental and control) regarding main variables at baseline.

	Grupo Experimental N=21	Grupo Controle N=28
Age (years)	66.6 ± 2.6	69.3 ± 3.3
MMSE (score)	26.3 ± 2.9	27.3 ± 3.3
Schooling (years)	7.2 ± 3.8	6.3 ± 4.8
TUG (sec.) T	6.9 ± 1.2	7.2 ± 1.2
TUG (sec.) DT	7.2 ± 1.3	7.5 ± 1.1

MMSE: Mini-Mental State Examination; TUG-S: Time to perform the task proposed for the Timed Up and Go test; TUG-DT: Time spent to perform the Timed Up and Go test associated to the verbal fluency task (Dual-Task)

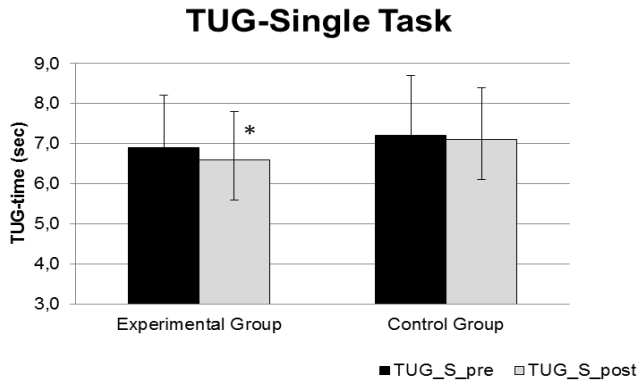

Figure 1: Timed Up and Go (TUG) for experimental (n=21) and control groups (n=29) between pre and post-research period (20-weeks). Experimental group showed improvements after the intervention period. Data presented by means; *=p<0.05.

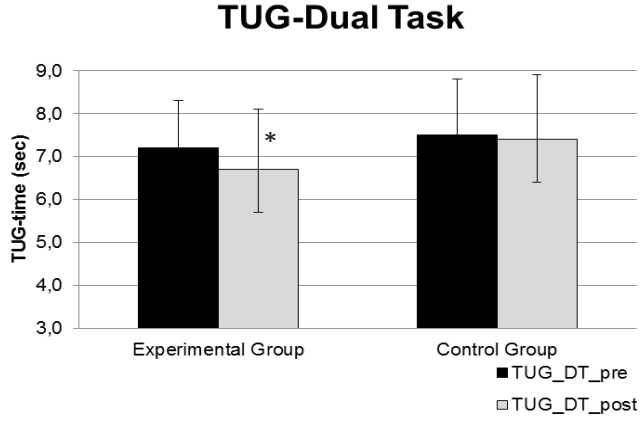

Figure 2: Timed Up and Go (TUG) test associated to verbal fluency task. Participants in the experimental groups (n=21) and control groups (n=29) in the pre and post-intervention program (20 weeks). The experimental group showed significant improvements after the period, compared to the control group. Data are presented by means; * = p <0.05.

group did not present significant changes between the pre and post-motor intervention period; however, significant improvements were shown by the trained group in reducing the time to perform the task that assessed functional mobility (Timed Up and Go). An analysis of variance was performed to determine whether the groups were homogeneous in relation to the characteristics evaluated for the participants during baseline. No significant differences were observed for age (p=0.27) and cognitive status (p=0.31), indicating that these variables were not potential covariates, influencing the results of interactions between the groups.

The interaction presented related to functional mobility for single and dual-tasks between pre and post intervention of the control and experimental groups are in the charts below:

Timed Up and Go (TUG) for experimental (n=21) and control groups (n=29) between pre and post-research period (20-weeks). Experimental group showed significant reductions in time spent to perform the single task after the intervention period. Data presented by means; *=p<0.05 (Figure 1).

Timed Up and Go (TUG) associated to verbal fluency task participants in the experimental groups (n = 21) and control (n = 29) in the pre and post-intervention program (20 weeks). Experimental group showed significant reductions in time spent to perform the dual task after the interventional period, compared to the control group. Data is presented by means; *= p <0.05 (Figure 2).

Pearson's' correlation coefficient for these variables showed a good level of association between global cognitive status expressed by scores on the MMSE and the time to perform the TUG in dual-task (R = 0.7; r2 = 0.46, p <0.001). An analysis of multiple linear regression for these variables showed that the performance of dual tasks is influenced by global cognitive status (β = - 0.66, p = 0.01). These associations are shown in (Figure 3).

Relationship between cognitive status (Mini-Mental State Examination score) and time spent to perform dual-task (functional mobility associated with verbal fluency) in elderly,

R=-0.7; r^2 0.46; β=-0.66; p=0.01.

Discussion

The present study has demonstrated, by the analysis of the variance, a significant improvement avoiding the risk of falls in the elderly, expressed through the assessment of functional mobility after the regular practice of a generalizated physical exercises program in comparison to the group control, which performed the same amount of sessions of social gathering without systematized physical stimulation. The analysis by regression allows us to infer that age and gender do not present a significant impact to hinder the accomplishment of a motor task in functional mobility associated with a test of verbal fluency for the evaluated sample. However, the cognitive status of the participants showed a significant association with this variable. An analysis for the prediction of falling risk is needed to structure clinical interventions. However, a non-pharmacological study showed significant improvements, which are crucial to expose the importance of preventive strategies during the aging process. Cress et al. [20], in a review study, indicated that multimodal programs of physical exercises seems to have positive effects on physical and mental health, as well as bringing significant benefits in reducing functional limitations.

Chenn et al. [28] indicated that elderly with history of recurrent falls had significantly lower MMSE scores. In spite of the risk of falls,

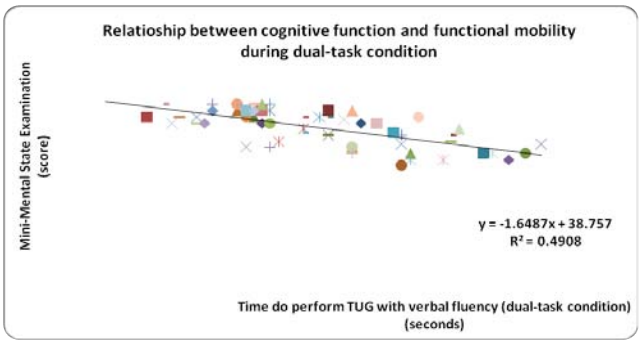

Figure 3: Relationship between cognitive status (Mini-Mental State Examination score) and time spent to perform dual-task (functional mobility associated to verbal fluency) in elderly.

these are a multifactorial variable for this reason; cognitive decline has proven to be a variable with significant interference as it has been confirmed in our results. Despite the results this study does not indicated that age could be potentially associated to reductions on functional mobility, gait abnormalities such as reduced speed and stride length, act as precautionary measures to increase stability and reduce the risk of falls, which are observed during the aging process [29,30]. Our results might have been swayed by the lack of variability on the ageing of the selected sample. The performance of gait patterns is influenced by cognitive function. Postural control during movement requires executive functions (frontal lobe) in order to plan and schedule the sequence of the motor function, which may represent the need of dual task condition. The cognitive impairment associated to functional motor deficits may result in the observed changes that reduces gait stability and disrupts postural control.

The performance on dual-tasks has frequently been used to elucidate the role of attention in gait control factors [31]. Lamoth et al. [32] investigated healthy individuals with cognitive impairment and found changes in the gait pattern in response to the dual tasks, reducing the walking speed and increasing the time from last place. This study also indicates that the associations between the dual task and the cognitive status were more pronounced in individuals with lower cognitive levels.

Beauchet et al. [8] did not found significant changes for gait patterns in young adults related to single and dual tasks. Later on, the same research group [33] found significant changes to the performances of motor tasks that are associated to verbal fluency in individuals with cognitive impairment, indicating that aging process associated to the selective neuronal loss may impair the ability to appropriately focus the attention during the performance of dual-tasks.

The explanation for these results that shows the relationship between motor performance under single and dual-task conditions is based on the assumption of limitations when using attentional resources [34]. This hypothesis suggests that an overload of the additional central resources is associated to an inability to properly adapt the attentional demands to perform multiple tasks that simultaneously determine the changes observed in that condition. Thus, the load of attention is shared with the execution priority of the tasks that the system considers most important.

A study of Ullman & Williams [35], also found significant differences in the time it took to accomplish the same test (Timed Up and Go) in elderly patients when single and dual tasks are compared. Review studies have indicated that the effects of systematic and regular physical activity are an important alternative to prevent and reduce risk of falls in the elderly [36-38].

Regular exercise can help to prevent functional losses and may reduce the perform simple tasks and, in some cases, both conditions as in the present study. In the same field of our findings, Melzer et al. [39], presented significant improvements on the performance on simple tasks in physically active individuals, but these results did not allows to infer the dual-tasks conditions. This fact can be justified by the lack of specificity of the proposed training for this research (lack of generalized exercises that may require the implementation of dual-tasks most of the time) during the intervention period. Thus, these results allows to suggest that interventions, especially for the elderly population, may address challenging conditions involving the integration of cognitive circuits to the motor performance, in order to improve this kind of practice for this population.

Despite the current guidelines on exercise emphasize the importance of a generalized exercise program for the elderly [20,40], it is not defined to consolidate the dose-response (frequency and appropriate intensity) for significant functional improvements. Overall, Baker et al. [23] in a systematic review have suggested that a program of multimodal exercises has a positive effect on the prevention of falls compared to specific training, which is exclusively related to stimulation of a functional component. In this study, the authors suggests, that it is required at least three weekly training sessions for significant improvements in order to calculate the Effect Size and the comparisons in the intervention and control groups. However, the present study found positive changes for the performance on functional mobility under single and dual-task conditions with the completion of a multimodal protocol of exercises that was performed in twice a week, during 20 weeks (40 sessions).

Evidences showed that the regular practice of a systematic exercise program (general or specific) can be a benefit improving mobility; reducing the risk of falls and slowing the aging deficits that may lead to functional losses [41-45] with some physiological changes that seems protect brain even under neurodegenerative conditions [46]. In this field, it is important to highlight the role of physical exercises under these conditions, especially considering the growing of ageing population, and the high prevalence of the main neurological conditions in these people as Parkinson's and Alzheimer's disease. Considering the loss of functionality since the beginning of these conditions, physical activity has been regarded as a useful non-pharmacological strategy in the treatment of AD and PD. Indeed, several studies have confirmed the usefulness of motor interventions for improving both motor and non-motor variables [47-49]. Furthermore, physical exercise has been shown to have beneficial effects on reducing falls in these populations with positive reflexes under frontal function [50], although in this regard, more research is required.

Conclusion

The changes in the performance of functional mobility under multiple tasks conditions, in example with a verbal fluency task, allow us to infer that there is a relative selectivity for attentional demands when performing dual-tasks. These findings are justified, partially, because of the significant connection observed between the results of the performance of the mobility test in dual-tasks and cognitive status in elderly individuals.

A generalized physical exercise program seems to be effective to improve dual task performances and functional mobility in the elderly during gait, which may reduce the risk of falls and, witch consequently could impact on the reduction of morbidity rates. These results allow us to suggest that the generalized and structured physical exercise programs seem to be an important alternative to promote protection, rehabilitation and prevent progressive common losses during the ageing process. Therefore, such programs should

associate motor activity to cognitive stimulation. Future studies are suggested to check the effects of an exercise program, specifically when analyzing the variables of gait and postural control and the relationship between this performance and the cognitive status in elderly individuals.

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