Influence of the level of education in older women on gains in executive function after dual task training

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Abstract

Objective: Investigate the influence of education levels on gains in executive function after dual-task (DT) training. *Method:* Exploratory study carried-out with 31 old women, who had ≥3 years of education and without cognitive deficits, as screened by the Mini-Mental State (MMS). The participants were distributed in two groups: group 1: 3 to 7 years of education (n=17) and group 2: ≥8 years of education (n=14). Measures of executive function (*Stroop, Addenbrooke's Cognitive Examination* - Revised (*ACE-R*), and Trail Making Test – B (B-Trails)) were obtained before and after training. The intervention protocol consisted of three weekly sessions of 50 minutes each and included cognitive and motor DT training, associated with walking, over 12 weeks. *Results:* ANOVA indicates that DT training improved the performance of Stroop (F=5.95; p=0.02) and ACE-R (F=18.33; p<0.0001) tests, regardless of the education level. The effect of the ACE-R test group (F=14.65; p<0.001) and B-Trails (F=18.74; p<0.001) was verified. In none of the investigated tests, the interaction effects between groups and time (0.04<F<2.14; 0.15<p<0.95) was observed. *Conclusion:* DT training has the potential to generate effects and can positively improve the executive function of older women, regardless of educational level and may be used within clinical practice, aiming at improving executive function.

Keywords: Dual task training. Executive Function. Health of the Elderly. Educational Status.

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INTRODUCTION

The aging process occurs in a dynamic, irreversible and natural way, which can generate cognitive, motor and functional losses. The way in which the individual will age and go through this process of change depends on the basic skills acquired during the years and also on the environment in which he is inserted[1], thus relating to the cognitive reserve acquired throughout life. Such reserve consists of the junction of innate intelligence with the aspects acquired through the educational and occupational processes, generating functionally more efficient cognitive networks[2].

The educational level can be related to the level of cognitive decline considered normal from the aging process, so that the higher the individual's education, the slower the cognitive aging, due to his greater cognitive reserve[3]. Therefore, the cognitive reserve seems to have a neuroprotective function to age-related cognitive decline[3]. In addition to the educational level, individuals with a pre-morbid intelligence coefficient, more challenging occupational activity and leisure activities in old age have a lower risk of developing dementia and may also mitigate cognitive decline related to increasing age[2].

The activities of spatial and working memory, sustained visual attention, episodic memory and learning, reaction time, and processing speed, which are most affected by aging, can be stimulated and thus protected by greater education, making the processing of executive functions more effective[2,3]. The lower level of education can be associated with lower performance in tasks of sustained visual attention, learning, episodic memory, reaction time and working memory demonstrated in a study with older Brazilians[4]. Therefore, it is expected that individuals with a higher level of education obtain better test scores compared to those with less level of education.

Executive functions include a series of cognitive processes, such as planning, self-monitoring, flexibility, inhibitory control and sequencing of actions, favoring a good performance of activities of daily living (ADL), whether simple or complex[5]. Executive functions are made up of more complex cognitive functions that are directly related to goal-directed behavior and the solution of new problems, in addition to time-scale planning, cost and benefit analysis in the decision-making process and behavioral self-regulation[6]. Furthermore, they depend on the existing connections between the prefrontal cortex and subcortical structures, and the main circuits[7] involved are: the dorsolateral prefrontal cortex, responsible for planning, problem solving, self-regulation, cognitive flexibility and operational memory; the anterior cingulate cortex, responsible for controlled attentional processes, selection of responses and motivation; and the frontal orbit cortex that is directly linked to social behaviors[7,8]. The cognitive aging process can generate a progressive decline in the efficiency of these circuits and, consequently, in the ability to perform tasks related to executive functions, causing, in some cases, functional impairment[9].

The sedentary lifestyle in conjunction with cognitive inactivity has been associated with an increased risk of aging-related cognitive decline[10]. Therefore, regular physical activity and active lifestyle are considered neuroprotective and important for reducing or slowing cognitive decline, since they generate biochemical and structural changes in the brain through brain neuroplasticity[11].

Among the intervention possibilities to be adopted in clinical practice, the Dual Task (DT) training, which consists of the simultaneous performance of two tasks, one of which may be cognitive and the other motor or two motor tasks[12], can be an interesting and beneficial approach for old people[13]. Training studies using DT have shown a relationship with mechanisms for improving gait characteristics that can lead to falls, such as gait variability in activities with divided attention and balance, and in preventing falls[9,13]. In addition, there are studies that show the influence of this training in cases related to mild cognitive decline, cases of moderate dementia, neurological conditions such as Parkinson's and Stroke, osteoarthritis and depression[13-15]. DT is normally used in the evaluation and training of executive and gait functions in the old people population[13]. However, the literature is still scarce when relating DT training to executive function in older women. Cognitive training has positive effects on issues related to memory and measures of quality of life, being transferable and beneficial for ADL[16]. The systematic review by Kahya et al.[17] supports the fact that neurodegenerative changes resulting from normal aging or those with disease are associated with changes in the activation of the neural network that result in increased brain activity specifically in the prefrontal cortex. These activation changes were demonstrated in DT and balance activities[17]. This fact demonstrates that it may be through this stimulation route, through the use of DT, the optimization of rehabilitation interventions for cases of normal and pathological cognitive decline, along with changes in gait and balance.

Given the above, through this study, we sought to investigate the influence of education on executive function gains after training with DT. The hypothesis was that different levels of schooling could influence executive function gains after an intervention using DT training. The observation of executive function in older women, in the two levels of education analyzed (high and low), can contribute to the assessment of whether a gain in these functions would be identified in both groups and whether any of them would show better results after DT training. This would imply the most appropriate use of this intervention, identifying the public that would benefit from this training, in addition to presenting the validity of DT in improving executive functions, minimizing cognitive decline related to aging.

METHOD

This is an exploratory study of secondary data from a prospective randomized clinical trial, entitled Effects of aerobic and dual-task training on mobility, gait, balance and cognition in older women in the community: a controlled clinical trial[18]. This was approved in October 2011 by the UFMG Ethics and Research Committee (ETIC0448.203.000-11), and protocol registered with the National Clinical Trials (registration number: NCT02185157; available at: www.clinicaltrials.gov). All research participants read and signed the Free and Informed Consent Form. The research was conducted at the Physiotherapy Department of the School of Physical Education, Physiotherapy and Occupational Therapy (EEFFTO) of the Federal University of Minas Gerais, in the period between October 2011 and October 2013.

The inclusion criteria of the study were old age (female), between 69 and 79 years, with the aim of addressing individuals with a higher probability of physiological neurodegeneration, education equal to or greater than three years and without alterations in the cognitive functions tracked by the Mini Mental State Examination(MMSE), considering the scores: ≥23 for older women with 3 years of education, ≥25 for the educational stratum of 4 to 7 years and ≥26 for participants with 8 years or more of education[19].

The sample consisted of 31 older women, members of the intervention group of the clinical trial that gave rise to this study, recruited from the community through advertisements on public transport and lists of participants in previous works carried out at the Physiotherapy Department. Considering that this study is a secondary analysis, an analysis of the power reached for each of the analyzes presented was performed. We chose not to include male participants, since they tend to show less interest and adherence to group activity programs. Participants were divided into two groups based on the educational criteria, with group 1 having low education (3-7 years; n=17), and group 2 with high education (≥8 years; n=14). The cutoff range chosen for schooling was eight years from the Brazilian average for this age group, according to IBGE data in 2016[20].

The old women who presented involvement of the musculoskeletal system, to the point of interfering in the performance of physical activities; uncorrected auditory and visual changes, which prevented the identification of commands; factors that could compromise the functioning of the central nervous system, such as administration of medications with action on the central nervous system that interfere with memory and motor performance, such as benzodiazepines, hypnotics and anticonvulsants, or that were diagnosed with chronic-degenerative neurological diseases, were excluded from the study.

Clinical, demographic and functional characteristics were collected by the physiotherapy and psychology team through a semi-structured questionnaire, with open questions, prepared by the authors, observing social aspects (age in years, address, education, marital status, number of children, occupation, income, who lives with), use of regular medications in the last 3 months, comorbidities present, supervised physical activity (which type of activity and how many hours per week), occurrence of falls in the last 6 months (number of falls, need to seek a health service and be hospitalized, occurrence or not of fractures, in addition to functional disability after the fall), subjective perception of memory (difficulty remembering recent facts), aspects related to sleep (makes use of medication to sleep, wake up in the middle of the night and do not sleep anymore, stay awake most of the night, delay to sleep, sleep poorly at night and if it is necessary to sleep during the day to recover, in cases of positive response it was asked how many hours of sleep) and subjective perception of the current state of health (excellent, very good, good, fair, very poor or none of the above).

In order to characterize the sample, the Falls Efficacy Scale - International (FES-I-BRAZIL)[21] instruments were also used, related to self-efficacy related to falls, with the cut-off point ≥23 points and the Geriatric Depression Scale (GDS)[22], to track mood changes in the last week, with the cutoff point for mood changes equal to or greater than six[22]. Older women were assessed at baseline (pre-intervention) and between days 1 and 7 after the 12th week of intervention (post-intervention). The 12-week interval enabled the learning effect not to occur, as recommended by the literature[23]. The instruments used in the study to identify executive functions in older women were the Stroop, the Addenbrooke Cognitive Exam - Revised (ACE-R), and the Trail Making Test – B (B-Trails). Each of these tests, validated for the Brazilian older population[24-27], evaluate different components of the executive function. These instruments were applied in printed form and the tests were not familiarized. Each evaluator was responsible for accompanying an older woman, delivering the printed tests, providing guidance on how each test should be performed, also timing the total time spent for each block within the test and the accuracy of the responses.

The Stroop test assesses executive function through inhibitory control and memory processes, in addition to fluency in reading and naming colors. The participants were instructed to speak, as quickly as possible, the colors observed, while the evaluator timed and evaluated the answers, as correct or wrong. This instrument, formed by three stages, consists of three printed cards that have 100 items arranged in five columns. The first card is called Word, and consists of reading the words red, blue and green written at random. The second is named Color, and the word colors must be nominated. The third is called Color and Word and consists of speaking the color that the word is printed on (font color)[24]. The final score is obtained from the time spent to perform each phase of the test, applying the formula: Final score= Color and Word Time - [(Word Time+ Color Time) / 2]. The total time for each phase of the test was timed regardless of the accuracy of the response. However, in the event of wrong answers, the older women were asked to reconsider their answers until the correct answer was provided. That way, the less time it takes to perform the test, the better the performance (e.g., faster responses and/or less errors)[24].

ACE-R is a global cognitive assessment tool responsible for identifying changes in the performance of executive functions, related to memory, verbal fluency, orientation, attention, visual-spatial ability and language. The test was translated and adapted for the Brazilian population and can be applied in an average time of 15 minutes, together with the MMSE[25]. The total ACE-R score is 100 points, 30 of which are related to MMSE, 26 to memory, 14 to verbal fluency, 18 to attention and orientation, 16 to visual-spatial ability and 26 to language. The higher score at the end of the test, the better the performance in the analyzed domains[25].

The B-Trails assesses the components of sequencing and inhibitory control, present in the executive function, since it is necessary to alternate the numerical and alphabetic sequence. Each participant was instructed, after the command, to connect the numbers from 1 to 12 and letters from A to L in ascending and alphabetical order alternately, such as 1A-2B-3C, while the time was measured by the evaluator. This part is considered more complex and is more directly related to executive function and cognitive flexibility[26]. The total score is determined from the time taken to perform the test, and the shorter the time, the better the performance[27].

An intervention protocol composed of 18 sessions, with 15 exercises each, of cognitive DT (motor-cognitive) and 12 sessions, with 35 exercises each, of motor DT (motor-motor) was developed. The number of sessions was elaborated in an attempt to minimize the effect of learning the exercises, since throughout the training, 36 sessions, each session of motor-cognitive exercise was only repeated once and the sessions of motor-motor activities were repeated only twice.

The protocol with the cognitive DT exercises was developed with the objective of training cognitive abilities such as immediate, recent, episodic, spatial, semantic memories, in addition to mathematical, logical reasoning and chaining of actions. As examples of proposed activities: tell me about your day yesterday; walking two steps to one side and two steps to the other, saying names of people; what number is formed with the number of months that have a year plus the days of the week plus the number of days of the months. The examiners participated in the reasoning and response process of the cognitive task, showing interest and, if necessary, making the necessary corrections, thus forcing the reasoning and the elaboration of appropriate responses. It was not allowed to stop to reason, understand the questions better or respond to the command requested.

The motor DT protocol covered exercises of laterality, reasoning, execution of the motor act, memorization of consecutive acts, coordination and balance. Some instruments, such as sticks, rubber and Styrofoam balls, were used for the participant to perform exercises with the upper limbs while walking. Examples of proposed activities: zigzag on the sticks walking sideways; throw the ball up high and at the same time bring the tip of your right foot forward, side and back; walk bouncing the ball once on the floor and pick it up again.

36 training sessions were held, which took place three times a week, for 12 weeks, being held in free external areas of EEFFTO. Each session lasted 50 minutes, divided into three moments: a) 10 minutes of fast walking in pairs; b) 10 minutes of activities related to cognitive DT, with each participant being accompanied by an applicator; c) 30 minutes of motor DT, being carried out in groups of a maximum of four participants. The command of each exercise was repeated twice for a better understanding. The cognitive and motor DT activities were performed in a way associated with walking and the applicators were responsible for giving the command for the old women to change the walking speed to fast, slow or usual speed, at least three times between exercises and in a random way. The order of the session was not determined, varying according to the number of participants and applicators at the time of training. The training had at least three applicators for up to eight participants per hour, with six applicators in total. However, all participants performed 50 minutes of exercise and went through the three proposed moments.

Descriptive analysis of the data was performed, using mean and standard deviation, and absolute and relative frequency. The normality of data distribution for continuous variables was verified using the Shapiro-Wilk test. The t test for independent groups and the Chi-square test were used to verify differences in clinical and demographic measurements between groups with different educational levels in the pre-intervention phase.

The analysis of homogeneity of variances was performed using the Levene test. Two-way analysis of variance (ANOVA) 2x2 with repeated measures was used to evaluate the effect of the intervention on performance in the Stroop, ACE-R and B-Track test. The comparison factor between groups was time (pre vs. post) and the group (high vs. low education). Bonferroni's post hoc was used for paired comparisons. To evaluate the effect size, the partial eta-square ($\eta^2 p$) will be presented, the effect size being considered small (0.0099), medium (0.0588) and large (0.1379). In addition, the power, related to the power reached in each analysis, will be presented. The sphericity of the data was verified using the Mauchly test. All analyzes were performed using the SPSS program (version 21) with a significance level of 5%.

RESULTS

Among the 31 study participants, 17 had 3 to 7 years of education (4±1.2) and 14 had education of 8 years or more (12±4.2; p<0.0001). There were no significant adverse effects associated with participation in the program, such as cardiovascular problems, tendon or musculoskeletal system injuries. Adherence to the program was 100% of sessions in both groups, and all the old women completed all 36 weeks of training. At the baseline (pre-intervention), the groups were similar in terms of clinical and functional characteristics, with the exception of education and salary income (Table 1).

Table 2 presents the results of ANOVA for the three measures of executive function evaluated. Regarding the Stroop test, main effects were observed before and after intervention (η^2p=0.17, power=0.66), with no significant effects from the interaction group (pre and post and groups) (F=2.14, p=0.15), demonstrating that the groups had a similar behavior, that is, improvements were observed in the Stroop test for both groups after the DT. Similar results were found for ACE-R. Main effects were observed (η^2p=0.39; power=0.99), with effect of the group and without significant interaction effects, demonstrating that the groups had similar behavior, that is, improvements were observed in the ACE-R test for the two groups. For the B-Trails test, no significant main effects were found (η^2p=0.30; power=0.15), but an effect of the group was identified, without interaction.

Table 1. Initial clinical characteristics of the participants and comparison between the low (1) and high (2) education groups. Belo Horizonte, MG, 2013.

Variable	Group 1 (n=17)	Group 2 (n=14)	Statistical test and p
Age (years), mean (SD)	72.4 (±3.4)	73.5 (±3.5)	t=1.47; *p*=0.388
Years of study, mean (SD)	4.0 (±1.2)	12.1 (±4.2)	t=-6.0; *p* <0.0001
Income (minimum wage), average (SD)	1.5 (±0.7)	12.1 (±4.2)	t=-3.92; *p* <0.0001
Medicines (n), mean (SD)	3.0 (±2.5)	3.8 (±2.6)	t=1.33; *p*=0.405
Comorbidities (n), mean (SD)	2.2 (±1.5)	1.9 (±1.0)	t=1.38; *p*=0.466
Physical activity (weekly hours), mean (SD)	2.3 (±1.6)	1.9 (±1.6)	t=0.35; *p*=0.169
Falls (n), mean (SD)	0.4 (±0.8)	0.3 (±0.5)	t=0.55; *p*=0.781
FES-I-BRASIL (score), mean (SD)	23.9 (±4.6)	23.0 (±8.3)	t=5.57; *p*=0.692
GDS (score), mean (SD)	5.1 (±2.1)	3.9 (±1.6)	t=2.54; *p*=0.116
MMSE (score), mean (SD)	25.5 (±2.1)	27.1 (±1.9)	t=-2.10; *p*=0.530
Perception of subjective memory (yes), n (%)	12.0 (70.6)	8.0 (57.1)	χ^2=0.60; *p*=0.477
Sleeps poorly (yes), n (%)	5.0 (29.4)	2.0 (14.2)	χ^2=1.00; *p*=0.412

FES-I-BRASIL=Self-efficacy scale for falls; GDS=Geriatric depression scale; MMSE=Mini-Mental State Examination, t=t test; χ^2=Chi-square test.

Table 2. Cognitive performance in older women with low (G1) and high (G2) education before and after dual task training. Belo Horizonte, MG, 2013.

Variables	Group 1[#]			Group 2[#]			ΔG1-G2[$]	ANOVA: F (*p*)		
	Pre	Post	ΔG1	Pre	Post	ΔG2		Effects of time	Effects of group	Effects of interaction
Stroop (s)	23,4±15,8	18,8±12,6	-10,7±14,8	12,7±7,7[a]	16,3±7,12[a]	-2,6±15,7	-8,1 (-19 a 3)	5,95* (0,02**)	0,023 (0,881)	2,14 (0,15)
ACE-R (points)	74,5±12,1	86,0±6,91	5,0±7,9	79,5±8,5[a]	91,1±6,73[a]	5,1±4,4	-0,1 (-5 a 5)	18.33* (<0.0001**)	14,65* (<0,001**)	0,04 (0,95)
B-Trails (s)	5,1±2,2	2,0±0,9	-0,9±1,6	4,2±1,8[a]	2,4±1,6	-0,4±1,1	-0,5 (-2 a -0,1)	0,88* (0,36*)	18,74 (<0,001**)	5,37 (0,28)

Note: ACE-R=Addenbrooke's Cognitive Exam - Revised; [a] Difference between pre and post intragroup moments; * Result of the Bonferroni post hoc test; ** Significant results of the Bonferroni post hoc test; [#] mean ± standard deviation; [$] average (95% CI); Δ=post - pre; ΔG1-G2=(post - pre G1) - (post - pre G2).

DISCUSSION

The present study aimed to evaluate the influence of education on the gains in executive function of older women after DT training. The sample showed homogeneity between the groups with low and high education, presenting clinical characteristics without statistical difference in factors that could influence the test results. Education and income were the factors that showed significant differences between groups. However, these differences were expected since education was one of the variables selected for the selection of groups and that this influence directly on income, that is, a higher education enables a higher income[28]. The performance in the executive function after DT training showed improvement when analyzing the pre and post intervention moments, in the Stroop and ACE-R tests, in both groups. However, in the B-Trail test, no significant gain was identified after training in any of the groups. In the Stroop test, DT training reduced the time for the test, consequently demonstrating a better performance in inhibitory control, memory, reading fluency and color naming at both educational levels. This result may be related to training, since the test is specific to assess executive function[29]. The level of education influences the results of the Stroop test since education acts directly on the ability to read, to name colors, as well as to act in the inhibition and flexibility necessary to perform the test[30]. In view of this, it was expected that the subjects of both groups presented a reduction in the test execution time in the pre and post-intervention, a hypothesis that was confirmed from the results found, being important to evaluate the magnitude of the gain. The improvement identified in both groups can be explained by the DT training that was sufficient to generate a greater stimulus related to the executive function.

It is important to point out that both in the Stroop test and in the ACE-R it was possible to notice that the training with DT had a positive effect in older women from both groups, and this can be justified, probably, by the greater cognitive and motor stimulus offered to them in the training period. When carrying out specific DT training, the older women have a greater challenge to fulfill the tasks and, therefore, are more stimulated and, consequently, present important gains in the performance of executive functions[31]. Thus, this was a relevant finding of the present study that demonstrates that, when challenged, the brain of older women responded positively to the challenge, improving the result in a more challenging test.

All old women were stimulated both in cognitive tasks, associated with walking, and motor, associated with cognitive activities, which may also have contributed to the findings of the present study. The level of activity that the old women practiced, per week, did not present a significant difference in the study, which eliminates a possible confounding factor related to other extra activities to that performed in training. Therefore, since the older women were stimulated in an equivalent way during training, it is believed that the results found in the tests corroborate the fact that DT training may have generated beneficial effects on the executive function of these women.

DT training is effective for the global cognition of healthy old people[32], and the combination of physical exercise, sensorimotor stimulation and cognitive involvement can facilitate neurophysiological changes responsible for the process of cognitive improvement[33]. These improvements in executive function were identified through the test results in the pre and post-intervention moments, thus corroborating the findings of the present study. In the B-Trail test, no significant difference was found between the moments before and after DT training. This result may be due to the simplicity of the test, which does not allow significant changes to be observed after the intervention[31]. Education is a variable that influences the results of the B-Trail[34] test and this can be seen in the time spent to perform the test, considering the two groups, in which the group with the highest level of education had less time spent completing the test when compared to the group with less education in the initial assessment. We believe that the old women already had high results at the beginning of the training, showing a ceiling effect on the test. It was observed, in the ACE-R and B-Trail tests, a significant effect on the groups. Therefore, regardless of the time, the groups presented different values, therefore, the education influenced the performance of these tests, but not the gains with DT training.

No interaction effect between education and test results was observed in any of the tests. Therefore, the effects of DT training do not depend on the different levels of education analyzed. The training was effective in improving executive function in both groups, regardless of education. Being an important contribution of the present study, since the literature shows the effects of education on the performance of executive functions, but they did not assess whether such gains with certain interventions could be influenced by education.

The absence of a control group, which has not performed any other type of activity, and the sample composed only of the older female population can be considered limitations of the present study. The control group, without performing another activity that could influence the results of the executive function, would be a way to minimize the potential confounding factors of the results, ensuring that the effects found were related only to the training performed. In addition, the sample analyzed does not allow generalization of the results for the older male population. Considering the results found, which indicate that DT training is beneficial for the better performance of executive functions in the older and female population, it is necessary to investigate whether in the male population the results are similar. In addition, new studies will be interesting to investigate whether people with different cognitive deficits will have benefits in executive function with DT training and whether education will interfere in this population.

CONCLUSION

Dual task training (DT) resulted in improved performance of executive functions regardless of education in most tests used in this study. In only one test, B Trails, no significant difference was found after DT training in any of the groups, probably because it is a very simple test with low requisition of executive functions. These results suggest that interventions that use DT can be used in clinical practice, aiming at improving the performance of executive functions in old women, regardless of education, expanding its use.

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