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Original Article

Effects of a multicomponent exercise on dual-task performance and executive function among older adults

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SUMMARY

Background: Previous studies showed that multicomponent exercise enhanced physical and cognitive functions. This study aimed to investigate the effects of a multicomponent exercise on dual-task performance and executive function and to demonstrate the relationship between improvement in dual-task performance and enhancement in executive function among the elderly.

Methods: A total of 27 people completed the intervention, with 16 in the experimental group and 11 in the control group. The 12-week multicomponent exercise lasted 1 h per day and 3 days per week. Participants' gait performance was assessed in dual-task conditions and executive function was examined at both pre- and post-intervention.

Results: Results showed significant interaction effects of time x group on all selected gait parameters in both dual-task conditions and the Executive Interview. Compared with the control group, the experimental group showed greater improvements in most measures following intervention. Improved dual-task performance was correlated with enhanced executive function ($r = 0.46–0.75$).

Conclusion: Our results suggested that a multicomponent exercise positively affects dual-task performance and executive function in the elderly.

1. Introduction

The ability to perform multiple tasks simultaneously is a common requirement for carrying out activities of daily living. Performing dual-tasks while walking has been shown to affect older adults' gait performance.[1] Hollman et al. reported that healthy older adults decreased gait velocity and increased gait variability when spelling words backwards or when counting backwards.[2] Dual-task decrements in gait indicated an increasing need for directing attentional resources to walking.[3]

Dual-task ability relies on executive function.[4] In turn, executive function is particularly affected by aging.[5] Executive function is defined as a set of cognitive skills necessary for planning, monitoring, and executing a sequence of goal-directed complex actions. Executive function plays a key role in dual-task coordination and is sensitive to dual-task interference in older adults.[6] Age-related declines in executive function may contribute to increased dual-task deficits in older adults.

Exercise is an evidence-based strategy for improving motor functions in older adults.[7] Previous meta-analytic and systematic reviews also reported that exercise is associated with improvements in executive function and attention in older adults.[8,9] Conversely, a moderate-dose physical activity program was found to not result in improved executive function among sedentary older adults; however, the authors suggested that physical activity may benefit executive function.[10] This inference was derived from their results of subgroup analyses showing that a physical activity program improved executive function in participants with lower baseline physical performance and those aged ≥80 years. Older adults have also been recommended to regularly engage in multicomponent physical activity programs that target endurance,

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strength, flexibility, and balance in accordance with advice from the American College of Sports Medicine and other documents.[11,12] Improved motor and cognitive functioning have been shown to be facilitated by multicomponent exercise training.[7,9,13–15]

Some studies have measured the effects of multicomponent exercise on dual-task performance. One such study showed that multicomponent exercise might improve dual-task performance,[16] while another study failed to prove a positive effect of multicomponent exercise on dual-task performance.[17] Both studies did not include a control group. Moreover, investigations into the effect of multicomponent exercise on both dual-task performance and executive function within the same study are scarce. Therefore, the aim of the present study was to evaluate the effects of a multicomponent exercise on dual-task performance during gait and on executive function, and to clarify the relationship between improved dual-task performance and enhanced executive function among older adults.

2. Methods

2.1. Participants

Participants were recruited from local public health centers in Taiwan. All 30 participants met the following inclusion criteria: (1) ≥65 years old; and (2) ability to walk outdoors independently without assistive devices. The exclusion criteria were as follows: (1) presence of a neurological disease known to impair mobility (e.g., stroke and Parkinson's disease); (2) presence of musculoskeletal problems limiting safe participation in an exercise program; and (3) a diagnosis of cardiovascular diseases, dementia, psychosis, or depression. Information on age, gender, and medical history were obtained through participant interviews.

2.2. Procedure

The study protocol was approved by the Taipei City Hospital Institutional Review Board and registered in a clinical trial registry (ClinicalTrials.gov NCT02102308). The purpose, nature, and potential risks of the experiments were fully explained to the participants. All participants gave written, informed consent before study participation. To increase attendance and compliance, participants were placed into either an experimental or control group depending on their preference. The experimental group received a multicomponent exercise three times a week for 12 weeks, while the control group attended six health education classes during the 12-week period. Outcome measures were obtained pre and post-intervention. Measures included gait performance in dual-tasks and interviews on executive function.

2.3. Intervention

Participants in the experimental group received multicomponent exercise for 1 h per day and 3 days every week over 12 weeks. The exercise program was based on the recommendations for the elderly population from the American College of Sports Medicine, including 20-min resistance training, 20-min endurance training, and 20-min balance training. The sequence of intervention was endurance, resistance, and then balance training. During the exercise period, a physical therapist provided guidance and assistance for each participant. Resistance training focused on major muscles of the hip, knee, and ankle joints. Training dose started from 50% maximal voluntary contraction for 10 repetitions, and then increased to 75%–80% maximal voluntary contraction progressively. A 5-min stretching exercise was conducted before and after resistance training to prevent muscle soreness and injury. The endurance training program was a sequence of whole body activity including 5-min warm-up, 20-min endurance training and a 5-min cool-down exercise. Stepping, brisk walking and hula hoop with upper limb movement were protocols for endurance exercise. The training dose was set at 70–75% maximal heart rate (220−age). The rate of perceived exertion between 12 and 14 was also considered during the training period. The balance exercise program involved static and dynamic balance training. Static balance training included the participant standing on the floor or a foam mat and changing their base of support by both forward reaching and from a single stance with their eyes opened or closed. Dynamic balance training included straight walking, sideway walking, backward walking and figure-8 walking.

Participants in the control group attended six education classes regarding health for 1 h per day and 1 day every 2 weeks over 12 weeks. The class provided information regarding common exercises for the elderly, with an individualized exercise program and teaching on prevention of injury during exercise.

2.4. Measures

2.4.1. Gait performance

The GAITRite system (GAITRite, CIR Systems Inc., USA) was used to evaluate gait performance. The validity and reliability of gait parameters as measured by the GAITRite system in the elderly is well established.[18,19]

Gait was evaluated while walking under two dual-task conditions, serial seven subtractions and naming animals. Serial sevens, counting down from a random three-digit number, is a clinical test that evaluates one's ability to maintain attention with distraction. Naming animals, i.e., generating as many examples of animals as possible, is a clinical test used to assess abstract thinking and word generation. Participants were asked to walk three trials under each condition. Trial interval lasted 1 min. Data were averaged from the three trials. No instruction was provided for prioritization of one of the tasks (walking or cognitive task) during the dual-task trials. To minimize the learning effect and fatigue, the order of the dual-tasks was randomized. Gait parameters of interest were velocity (cm/s), stride time (ms), stride length (cm), stride time variability (%) and stride length variability (%). The coefficient of variation (CV) was used to assess the variability of gait. Lower values reflect a more consistent gait pattern. The formula of CV given as a percentage is as follows: standard deviation/mean × 100%.

2.4.2. Executive function

The 25-item Executive Interview (EXIT 25) is a quick screening tool for assessing of executive function.[20] The Chinese version (C-EXIT 25) was uses in this study.[21] The C-EXIT 25 had high internal consistency and good reliability.[21] The test consisted of a 25-item rating for executive function on tasks. Scores ranged from 0 to 2 for each item, and higher scores indicated worse performance.[20]

2.5. Sample size

The primary outcome was gait velocity. The sample size was determined using G*power based on an effect size f of 0.25, an alpha level of 5%, 80% power, and an ANOVA model.[22] A minimum sample size of 28 participants was indicated.

2.6. Statistical analysis

All analyses were performed using the SPSS 20.0 statistical package (SPSS Inc., Chicago, IL, USA). Descriptive statistics were generated for all variables, and distributions of variables were expressed as mean ± standard deviation. Intergroup differences

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