RESEARCH

Can two multimodal psychomotor exercise programs improve attention, a□ordance perception, and balance in community dwellings at risk of falling? A randomized controlled trial

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Abstract

Background: Falls are associated with cognitive and physical function deterioration. Attention decline, inaccurate a□ordance perception, and balance impairment are considered to be risk factors for falls. Furthermore, few studies have reported psychomotor intervention as a fall prevention program. This study aimed to investigate the e□ects of two multimodal programs on attention, perceptual and stepping-forward boundaries, and balance in community-dwelling older adults at risk of falling.

Methods: Fifty-one community-dwelling older adults were recruited to participate in a 24-week randomized controlled trial. Participants (75.4 ± 5.6 years) were randomly assigned to one of three groups: the 1) multimodal psychomotor program [EG1], 2) combined program (multimodal psychomotor program + whole-body vibration program) [EG2], and 3) control group. Participants were assessed at baseline, at post-intervention, and after a 12-week no-intervention follow-up period.

Results: The within-group comparisons showed significant improvements in attention and balance in EG1 and EG2 after the intervention (

Background

According to the United Nations, the number of older adults aged 65 years or over is increasing faster than all other age groups [1]. Following this trend, the aging process is related to an increase in falls, such that one-third of community-dwelling older adults aged 65 years or more, experience at least one fall each year, resulting in substantial economic costs [2]. This evidence highlights the importance of developing effective strategies and programs to prevent fall occurrences and manage fall risk factors to maintain independence and quality of life [2, 3].

Related to the aging process, a link has been established between cognitive decline and fall risk since cognitive function and motor maintenance share restricted neural resources [4]. Within cognitive function abilities, attention is a specific element of executive functions (EF) [5]. Evidence from neuroimaging studies focusing on structural or physiological changes (e.g., cerebral white matter and brain volume) suggests that a decline in EF is related to an increased fall risk [5, 6]. According to O'Halloran et al. [7], brain changes promote a larger variability in sustained attention, which is strongly associated with fall risks. Additionally, the selective attention described as a fundamental EF has also been related to falls [6].

Similarly, age-associated locomotor skills deterioration can lead to inaccurate perceived action limits, whereby it is essential to recognize the respective action boundary (e.g., perceptual and stepping-forward boundary), especially in community-dwelling older adults [8]. Accordingly, a ordances, that is, possibilities for action, are a concept involving the relationship between the action possibilities of the individual (e.g., maximum stepping-forward length) under a particular set in an environment [9, 10]. However, recent literature has shown that older adults frequently overestimate their motor abilities, specifically their action boundary as a step length [8]. is is particularly relevant and especially true for fallers because those who overestimate their step length reveal more signs of motor deterioration, which can lead to an increase in fall risk [8, 11]. Moreover, perceptual overestimation can also potentially induce balance impairment and consequent falls [11]. Despite the previous findings, no experimental studies on fall prevention programs were found focusing on a ordance perception, particu

risk and incidence of falls [19, 20]. is method may also lead to an enhancement of EF [21]. However, to our knowledge, an intervention program that combines both methods has not yet been studied, particularly on fall prevention programs. us, the objective of this study was to investigate the e ects of two multimodal programs on attention, perceptual and stepping-forward boundaries, and balance in community-dwelling older adults at risk of falling.

Methods

Trial design

e present study was designed as a 24-week randomized controlled trial (RCT), single-blinded, with a three-arm parallel assignment. Community-dwelling older adults from Évora (Portugal) were allocated into three groups (allocation ratio 1:1:1): experimental group 1 (EG1) was assigned a multimodal psychomotor program; experimental group 2 (EG2) was assigned a combined program (multimodal psychomotor program + WBV); and the control group (CG) was asked to maintain their daily life activities. After the study finished, those in the CG were o ered an identical fall prevention program. is trial was conducted between March 2018 and January 2019, and it was previously registered at ClinicalTrials.gov (NCT03446352). Also, this study was reported in accordance with the CONSORT guidelines for RCTs (http://www.consort-statement.org).

Participants

Participants were male and female community-dwelling older adults recruited in community settings as the local senior university and recreational centers via pamphlets. In each community setting, verbal communication was used to present our study and for answers to any possible doubts. e older adults who expressed interest to participate were scheduled for the baseline evaluation.

A minimum sample size of 45 participants was required (15 participants per group) to detect a treatment di erence, calculated by the online G*Power software, under the following parameters: $\alpha = 0.05$ and power $= 0.95$. Accounting for an expected dropout rate of 20%, a minimum of 60 participants were recruited for this study.

e inclusion criteria comprised the following: a) age ≥ 65 years old; b) classified with moderate or high physical independence according to the Composite Physical Function (CPF) scale ($\geq$ 18 points) [22]; c) participants who had experienced at least one fall in the previous 6 months or were identified with a high risk of falling according to the result in the Fullerton Advanced Balance (FAB) scale ($\leq$ 25 points) [23]. Exclusion criteria comprised: a) the presence of cognitive impairment ($\leq$ 22 points in the Mini-Mental State Examination - MMSE) [24]; b) walking dependently (e.g., with mobility aids); c) musculoskeletal, cardiovascular, and neurological conditions [25]; and d) attending physical and/or cognitive structured exercise programs preceding 6 months [26].

Initially, sixty-one older adults were assessed for eligibility and agreed to participate in the study as described in Fig. 1. Five participants did not fulfill the inclusion criteria, which remained a total of fifty-six participants (47 women and 9 men). For participants who were enrolled in this study, simple randomization was performed according to the "Random Team Generator" (https://www.randomlists.com/team-generator) into EG1 ($n = 18$), EG2 ($n = 19$), and CG (n = 19). An investigator with no clinical involvement in the trial performed the randomization.

All the study participants were volunteers and gave their written informed consent. is study was approved by the University of Évora Ethics Committee - Health and Well Being (reference number 16012) and conducted in accordance with the Declaration of Helsinki.

Procedures

A trained evaluator in the rehabilitation sciences field individually assessed all participants at baseline, at post-intervention (24 weeks), and after a 12-week no-intervention follow-up. e evaluator was blinded to participants' allocation. Cognitive and other measures assessed by questionnaires were performed in a laboratory silent room. A ordance perception, physical function and body composition assessments were performed in a laboratory hall. All assessments were preceded by the protocoled explanation and/or demonstration performed by the evaluator.

Data collection was performed at the University of Évora laboratories.

Outcome measures

Attention

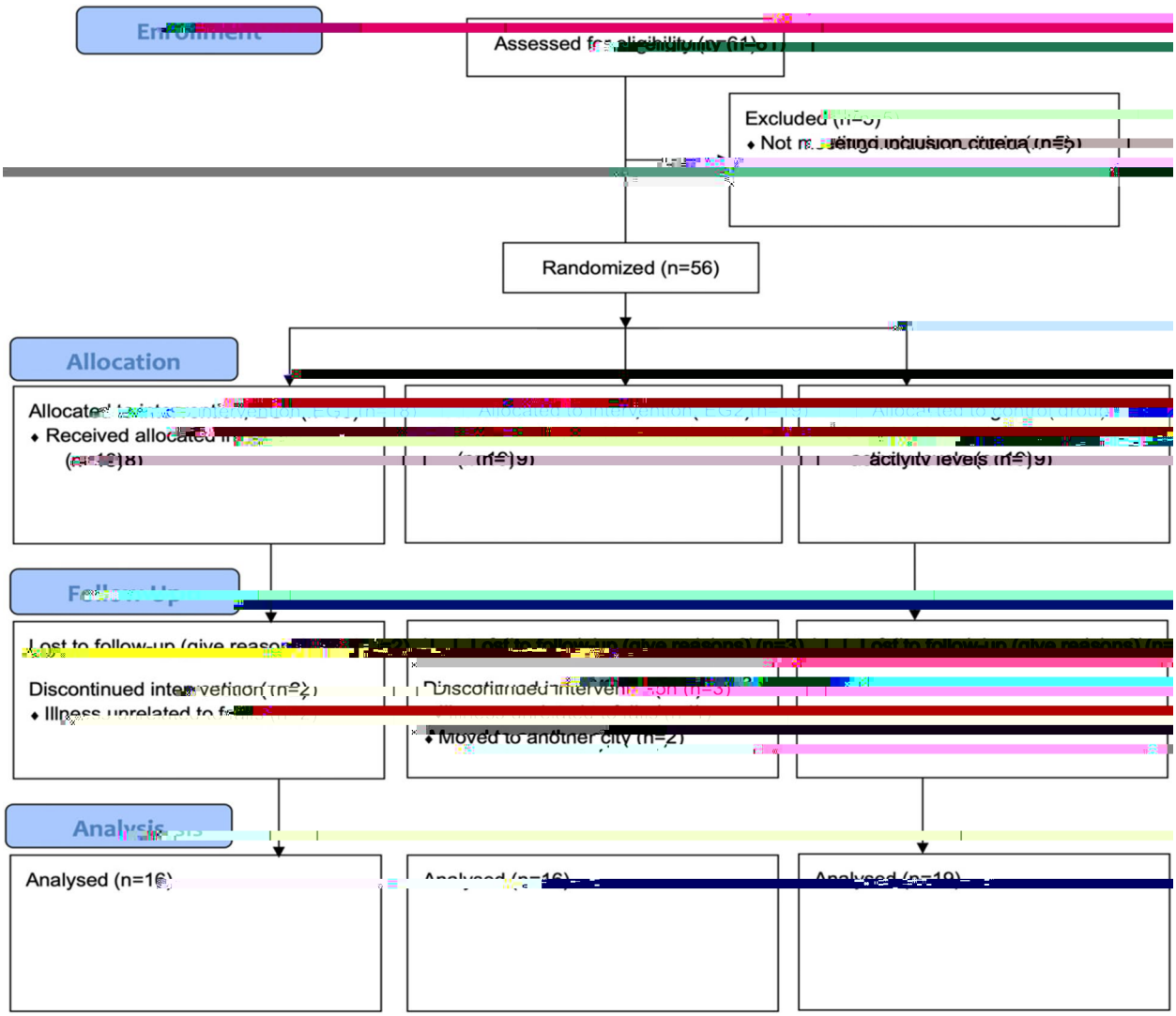

Fig. 1 Flow Diagram

concentrate; fluctuation rate (n), which indicates the consistency in the task execution; and percentage of errors (%).

A ordance perception

e perceptual and stepping-forward boundary was assessed by the stepping-forward a ordance perception test, established as a valid, accurate, and reliable tool for fall risk assessment in community-dwelling older adults [8]. e estimated stepping-forward and real stepping-forward distances were collected as described by Almeida et al. [8]. In addition, the absolute error (|real-estimated distances|) and the error tendency measuring the magnitude and direction error (overestimation: real < estimated distances; or underestimation: real > estimated distances), (over- or underestimation) were also computed.

Balance

Multidimensional balance was assessed by the FAB scale, which is considered a valid and reliable instrument designed to assess independently living older adults. is scale comprises 10 individual tests, such that each one ranged from 0 (worst) to 4 points (best), and the "Total FAB scale" (sum of the test scores) ranged from 0 (worst) to 40 points (best) [23].

Falls

e occurrence of falls, respective circumstances (e.g., type/place of fall), and consequent injuries were assessed by means of an interview following a 13-item script, although only the occurrence of falls was used in this manuscript. A fall was defined in accordance with the definition proposed by the World Health Organization

e Kolmogorov-Smirnov test and Levene homogeneity of variances test were used to evaluate the normality of the data distribution. Since much of the data were not normally distributed, non-parametric tests were performed, namely, the Friedman test for comparisons within groups followed by the related pairwise post hoc test and the Kruskal-Wallis test for comparisons between groups followed by the independent pairwise post hoc test. In the case of two related samples, the Wilcoxon test was carried out for within-group comparisons. Additionally, to perform comparisons regarding qualitative variables (error tendency variables), Cochran's Q test was used for within-group comparisons, and the chi-squared test was used for between-group comparisons.

e magnitude of the treatment e ect was determined following the instructions for non-parametric tests [32] and according to Cohen's method, in which the e ect size (ES) was computed as $r = (Z/\sqrt{N})$. Standardized classification for small (0.10), medium (0.30), and large (0.50) e ects was used [33].

Results

Table 1 provides the participants' characteristics at baseline and no significant di erences between groups were found.

A total of fifty-one participants completed this RCT study. ose who dropped out of the study ($n = 5$) had similar characteristics compared to participants who completed the multimodal exercise programs. Regard-

Regarding the ES within-groups between the baseline and the post-intervention evaluations, from the previous variables, it ranged from 0.47 (medium) to 0.54 (large), in EG1, and from 0.48 (medium) to 0.51 (large), in EG2, while between the baseline and the follow-up evaluation ranged from 0.43 (medium) to 0.52 (large), in EG1 and was medium (0.48), in EG2.

Table 3 shows the results for the a ordance perception and physical function - multidimensional balance - variables. At baseline, all groups presented similar results, and no statistically significant di erences were found between groups on the perceptual and stepping-forward boundary variables or on multidimensional balance. On post-intervention evaluation and on follow-up evaluation, between-group comparison did not detect significant di erences between the three study groups in these variables.

As seen in Table 3, the within-group comparison showed no significant di erences between the three evaluation data on perceptual and stepping-forward boundary variables, except in the variable “Error tendency”. Cochran's Q test revealed significant di erences in the

variable “Error tendency” in both EGs at the follow-up evaluation, in which an increase in the number of participants overestimating the perceived stepping-forward boundary was observed.

e within-group multidimensional balance variable comparison showed significant improvements between

significant di erences were found between groups in the number of falls. e within-group comparison analysis indicated significant improvements by reducing the number of falls between the baseline and post-intervention evaluations (fall number EG1: 1.13 ± 0.8 vs. 0.63 ± 0.7, $p = 0.021$; fall number EG2: 1.19 ± 1.0 vs. 0.44 ± 0.7, $p = 0.008$). In turn, no di erences were observed in the CG (1.11 ± 0.3 vs. 0.95 ± 1.0, $p = 0.405$).

Discussion

e present study aimed to investigate the e ects of two multimodal exercise programs on attention, a ordance perception, and balance in community-dwelling older adults at risk of falling. First, both the multimodal psychomotor program and the combined program (multimodal psychomotor program + WBV program) were demonstrated to be e ective for fall prevention and were

fall prevention program (e.g., 12 months) focusing even more on a ordances and perception-action ability and motor imagery training. In this line, a recent systematic review suggested that the use of motor imagery training, which appeals to the imagination of an action without the respective motor execution, may improve risk factors for falls, such as balance and mobility in older adults [38].

For physical function, both multimodal exercise programs induced improvements in multidimensional balance, with a large ES. Although both EGs presented a similar ES, the combined exercise program presented a slightly larger ES. Few studies have reported the e ects of a WBV program in addition to an exercise program in community-dwelling older adults. e present study findings are in line with the 8-week study of Pollock et al. [39], although the setting was designed for frail older adults. In the Pollock et al. study [39], the addition of a WBV program to balance and strength training resulted in similar enhancements in balance in both groups (exercise alone vs. exercise + WBV). A recent 4-week study also detected significant improvements in balance in a combined program (WBV + unstable shoes) compared to a CG that received WBV with standard shoes [40]. ese improvements in balance were found in both groups at post-intervention for the FAB scale score (combined program: 30.7 vs 35.2 points; CG: 31.9 vs. 35.6 points) and were maintained after a 4-week follow-up, only in the combined program (35.2 vs. 35.1 points) [40]. Contrary to the follow-up results of previous studies, in which the balance results remained unchanged after a 4-week follow-up [40] or a 24-week follow-up [39], the improvements in balance in the present study were no longer evident in

26. Focht BC, Knapp DJ, Gavin TP, Raedeke TD, Hickner RC. A□ective and self-e□cacy responses to acute aerobic exercise in sedentary older and younger adults. J Aging Phys Act. 2007;15(2):123–38.
27. Brickenkamp: d2 Test of attention. Lisboa: CEGOC-TEA; 2007.
28. World Health Organization: Falls. 2018. https://www.who.int/news-room/fact-sheets/detail/falls. Accessed 15 Jun 2020.
29. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377–81.
30. Yoshihara S, Kanno N, Fukuda H, Arisaka O, Arita M, Sekine K, et al. Caregiver treatment satisfaction is improved together with children's asthma control: prospective study for budesonide monotherapy in school-aged children with uncontrolled asthma symptoms. Allergol Int. 2015;64(4):371–6.
31. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE, et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exerc. 2003;35(8):1381–95.
32. Fritz CO, Morris PE, Richler JJ. E□ect size estimates: current use, calculations, and interpretation. J Exp Psychol Gen. 2012;141(1):2–18.
33. Cohen J. Statistical power analysis for the behavioral sciences. Hillsdale: Lawrence Erlbaum Associates, Publishers; 1988.
34. Linde K, Alfermann D. Single versus combined cognitive and physical activity e□ects on fluid cognitive abilities of healthy older adults: a 4-month randomized controlled trial with follow-up. J Aging Phys Act. 2014;22(3):302–13.
35. Fraser SA, Li KZH, Berryman N, Desjardins-Crepeau L, Lussier M, Vadaga K, et al. Does combined physical and cognitive training improve dual-task balance and gait outcomes in sedentary older adults? Front Hum Neurosci. 2017;10:688.
36. Jehu DAM, Paquet N, Lajoie Y. Balance and mobility training with or without simultaneous cognitive training reduces attention demand but does not improve obstacle clearance in older adults. Mot Control. 2018;22(3):275–94.
37. Berchicci M, Lucci G, Pesce C, Spinelli D, Di Russo F. Prefrontal hyperactivity in older people during motor planning. Neuroimage. 2012;62(3):1750–60.
38. Nicholson V, Watts N, Chani Y, Keogh JW. Motor imagery training improves balance and mobility outcomes in older adults: a systematic review. J Physiother. 2019;65(4):200–7.
39. Pollock RD, Martin FC, Newham DJ. Whole-body vibration in addition to strength and balance exercise for falls-related functional mobility of frail older adults: a single-blind randomized controlled trial. Clin Rehabil. 2012;26(10):915–23.
40. Sobhani S, Sinaei E, Motealleh A, Hooshyar F, Kashkooli NS, Yoosefinejad AK. Combined e□ects of whole body vibration and unstable shoes on balance measures in older adults: a randomized clinical trial. Arch Gerontol Geriatr. 2018;78:30–7.
41. Tseng SY, Hsu PS, Lai CL, Liao WC, Lee MC, Wang CH. E□ect of two frequencies of whole-body vibration training on balance and flexibility of the elderly: a randomized controlled trial. Am J Phys Med Rehabil. 2016;95(10):730–7.
42. Yang F, King GA, Dillon L, Su X. Controlled whole-body vibration training reduces risk of falls among community-dwelling older adults. J Biomech. 2015;48(12):3206–12.

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