

Original Article

Effectiveness of force platform balance training with visual feedback in aged Chinese: a pilot study

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Abstract: Force platform technology was able to measure center of gravity and provide biofeedback during exercising. This study aimed to evaluate the effectiveness of force platform balance training with visual feedback in Chinese older adults. Eighty older adults were randomized to an intervention or control group. All participants received the one-leg standing balance exercise 2 min a day, and participants in the intervention group received additional force platform balance training 30 min a day. The balance training was provided 10 days a month for 3 months by physical therapists. Total path length, path length along the medial-lateral and anterior-posterior axes, and average center displacement deflection along the medial-lateral and anterior-posterior axes were assessed during eyes open and closed conditions at baseline and after intervention. Dynamic balance ability was evaluated by the Timed Up and Go test. Total path length, path length along the medial-lateral and anterior-posterior axes, average center displacement deflection along the medial-lateral and anterior-posterior axes, and Timed Up and Go test of both groups reduced after training. There was significant difference between the intervention and control group ($P < 0.05$). Force platform balance training with visual feedback improved balance control in Chinese older adults.

Keywords: Biofeedback, postural balance, elderly people

Introduction

Increased age results in some progressive physiological changes that can contribute to balance deficits [1]. In most cases, balance disorders result in a fall and consequently severe injuries [2]. Balance training is considered an important aspect of a fall prevention program [3]. Many exercise interventions have been designed for improving balance, such as walking, cycling, strengthening exercise, dance, Tai Chi, yoga, and whole body vibration. Some types of exercise may be moderately effective in improving clinical balance outcomes in older people [4].

Balance can be defined as the ability to keep the center of gravity within the base of support, and one goal of balance is to maintain control of the center of gravity [5]. The force platform with visual feedback system is designed to provide accurate visual representation and clues of a subject's real time center of gravity. During

the process of weight or posture shifting, the position and movement tracks of the center of gravity can be monitored; thus, a subject can recognize such information by visual feedback and adopt appropriate strategies to keep postural control as steady as possible [6]. Therefore, force platform balance training with visual feedback may be a promising approach to improve balance [7]. It has been shown to result in positive balance changes in patients with peripheral neuropathy and stroke [8, 9]. The purpose of this study was to evaluate the effectiveness of force platform balance training with visual feedback in Chinese older adults.

Material and methods

Subjects

The study was carried out in a geriatric population from March 2014 to January 2015. Patients aged over 60 years who were able to walk at least 20 m (with or without an assistive device)

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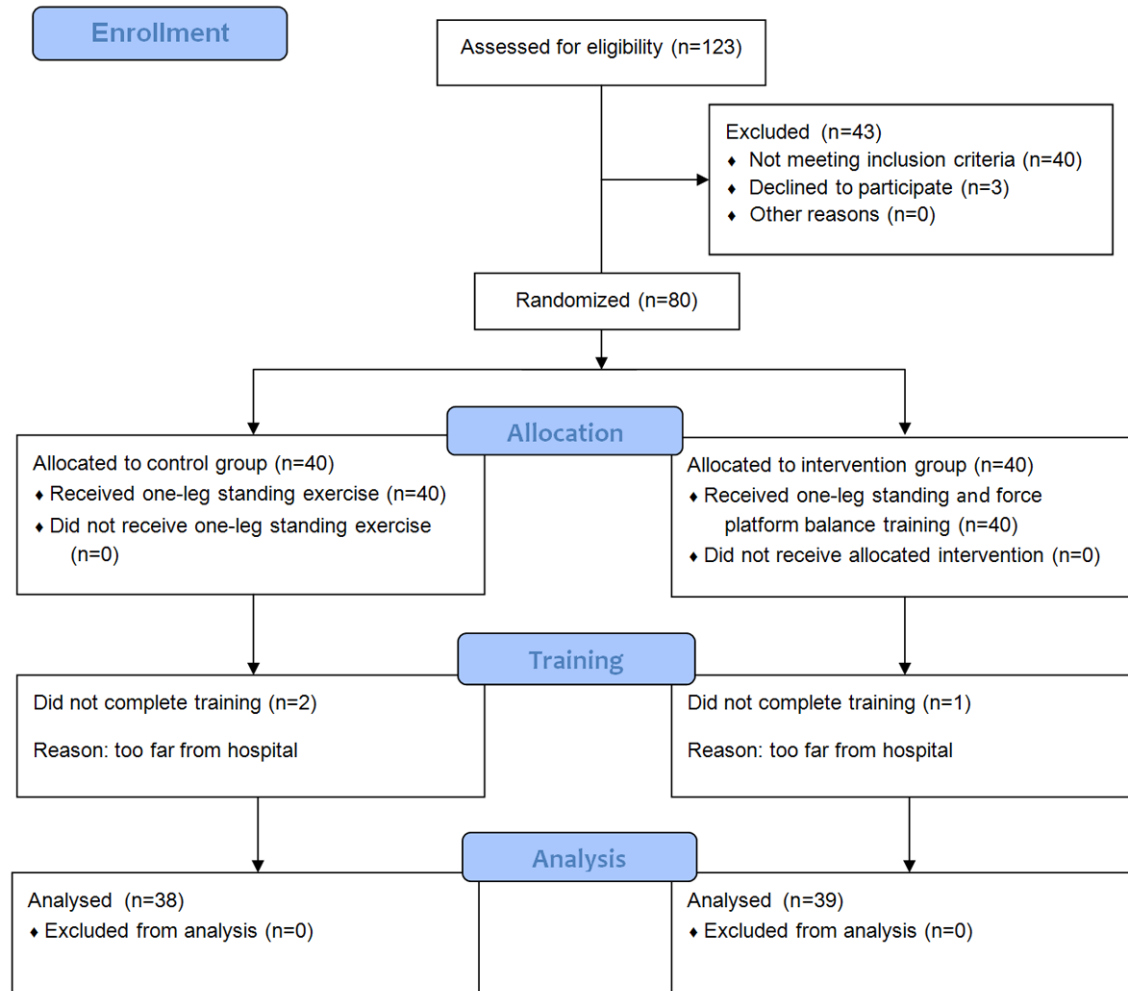


Figure 1. Flow chart for the study.

were included in the study. Exclusion criteria were as follows: cognitive impairment (Mini-Mental State Examination ≤ 23 points), severe visual impairment, and severe cardiovascular problems. After signing informed consent, all participants were randomly assigned to an intervention group (IG) or a control group (CG) using computer-generated random numbers. The Chinese Ethics Committee of Registering Clinical Trials approved the study protocol. The progress through the phases of screening, enrolment, allocation, training, and data analysis is illustrated in **Figure 1**.

Balance training

All subjects received the one-leg standing balance exercise. With their eyes open, subjects were instructed to stand on their right leg for 1

min and then their left leg for another minute, for a total of 2 min in a day [10]. In addition, the IG received force platform balance training with visual feedback. Participants in the IG stood barefoot on a force platform (Balance-A, NCC, Shanghai, China), keeping their feet 10 cm apart and their arms by their sides. They were instructed to fixate on a computer screen that provided the movement of their center of gravity. Participants were asked to adjust and maintain their movement in a specified visual boundary for 10 min a day. The balance training was provided 10 days a month for 3 months by physical therapists.

Outcome measures

Balance was assessed before and after the intervention. The Timed Up and Go test (TUG) was used to evaluate dynamic balance ability.

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Table 1. Baseline characteristics of the participants

Characteristic	Intervention group (n = 40)	Control group (n = 40)	P value
Age, years	68.2 ± 5.5	69.4 ± 6.2	0.362
Females, number	19 (47)	17 (42)	0.653
BMI, kg/m ²	23.2 ± 3.1	22.6 ± 3.6	0.427
MMSE, score	27.5 ± 2.1	27.2 ± 1.8	0.495

Data are mean ± standard deviation or number (%); MMSE, Mini-Mental State Examination.

The test records the time a person takes to stand up from a chair, walk three meters, turn around, walk back to the chair and sit down. High reliability (intraclass correlation coefficient = 0.99) has been demonstrated using this test in older adults [11].

Static balance ability was measured using the Balance-A, which assessed five center of gravity parameters as follows: total path length, path length along the medial-lateral axis, path length along the anterior-posterior axis, average center displacement deflection along the medial-lateral axis, and average center displacement deflection along the anterior-posterior axis. These parameters have been previously validated and published in the literature. Participants were asked to stand on the force platform with eyes open and eyes closed for 30 seconds. Sample size was calculated for difference in average center displacement deflections along the medial-lateral axis in the eyes closed condition between the two groups using results of our previous study. Assuming a power of 80%, significance level of 0.05, and a drop-out-rate of 10%, a sample size of 80 (40 per group) was needed to verify a significant effect.

Data analysis

Independent-sample t tests were used to compare the age, Body Mass Index, and Mini-Mental State Examination between the two groups before the intervention. Chi-square tests were used to compare sex distributions between the two groups. The differences in center of gravity parameters and TUG between two groups after intervention were analyzed by independent-sample t tests. Data were considered significant at $P < 0.05$. Data were analyzed using SPSS (version 21, IBM, New York, USA).

Results

A total of 80 inpatients were recruited in the study. Three patients dropped out during the

intervention period: 1 patient in the IG and 2 patients in the CG dropped out because of distance from the study center. No training-related adverse events occurred. Characteristics of the study participants are presented in **Table 1**. There were no significant differences in baseline characteristics between the IG (n = 40) and CG (n = 40). Results of pre-training and post-training balance assessment are reported in **Table 2**. No significant differences were noted in pre-training measures between the IG and CG. Total path length and path length along the medial-lateral and anterior-posterior axes in both eyes open and closed conditions and average center displacement deflection along the medial-lateral and anterior-posterior axes in eyes closed condition reduced significantly in the IG compared to CG ($P < 0.05$). The average center displacement deflection along the medial-lateral and anterior-posterior axes in eyes open condition reduced more significantly in IG than in CG, and there was significant difference between the two groups after training ($P < 0.01$). The TUG score in the IG reduced significantly more than CG after training ($P < 0.05$).

Discussion

The findings of the study revealed that force platform balance training with visual feedback could improve static and dynamic balance in older adults. The TUG score, path length, and average center displacement deflection reduced significantly in the IG than the CG after 3 months of training. To the best of our knowledge, the effectiveness of visual-feedback-based force platform balance training in combination with one-leg standing exercise has not been reported. Our findings showed that this training program was feasible to conduct. The training adherence was high and adverse events were none.

Our results are in line with those of previous studies on force platform balance training with visual feedback in older adults, even though studies used different balance measures. For example, a review including six studies reported that force platform balance training with visual feedback significantly reduced postural sway, decreased reaction time, improved weight-shifting ability, and increased the Berg Balance Scale score in older adults [12].

Some limitations in this study needed to be acknowledged. This study did not have a dou-

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Table 2. Effects of force platform balance training with visual feedback

Parameters	Intervention group (n = 39)			Control group (n = 38)			P value
	Pre-training	Post-training	Change	Pre-training	Post-training	Change	
TUG, s	10.3 ± 5.1	9.1 ± 4.1	-11.7%	11.2 ± 4.9	11.0 ± 4.2	-1.8%	0.048
Eyes open							
P, cm	14.1 ± 4.1	9.7 ± 1.9	-31.2%	13.2 ± 3.5	10.7 ± 2.1	-18.9%	0.032
P _{ML} , cm	8.5 ± 2.9	3.6 ± 0.7	-57.6%	7.6 ± 3.3	4.5 ± 2.5	-40.8%	0.034
P _{AP} , cm	6.3 ± 2.7	4.5 ± 0.9	-28.6%	6.5 ± 3.5	5.3 ± 2.3	-18.5%	0.047
D _{ML} , cm	1.1 ± 1.1	0.6 ± 0.5	-45.5%	1.3 ± 0.9	1.0 ± 0.7	-23.1%	0.005
D _{AP} , cm	0.6 ± 0.7	0.3 ± 0.2	-50.0%	0.7 ± 0.9	0.5 ± 0.4	-28.6%	0.007
Eyes closed							
P, cm	13.5 ± 4.5	9.8 ± 2.3	-27.4%	12.8 ± 4.9	11.3 ± 3.7	-11.7%	0.035
P _{ML} , cm	5.4 ± 2.4	2.9 ± 1.2	-46.3%	5.2 ± 2.8	3.7 ± 1.9	-28.8%	0.030
P _{AP} , cm	9.5 ± 2.9	8.2 ± 1.1	-13.7%	9.3 ± 2.3	8.9 ± 1.6	-4.3%	0.028
D _{ML} , cm	1.3 ± 0.9	0.7 ± 0.4	-46.2%	1.2 ± 1.1	0.9 ± 0.4	-25.0%	0.031
D _{AP} , cm	0.9 ± 0.6	0.4 ± 0.3	-55.5%	0.8 ± 0.7	0.6 ± 0.5	-25.0%	0.036

P values are given for difference between the intervention and control group after training; TUG, Timed up and go test; P, total path length; P_{ML}, medial-lateral path length; P_{AP}, anterior-posterior path length; D_{ML}, average center displacement deflection along the medial-lateral axis; D_{AP}, average center displacement deflection along the anterior-posterior axis.

ble blind design because of the nature of the intervention. However, all participants were randomly assigned to two groups, the one-leg standing exercise and force platform training were provided by two different physical therapists, and the balance ability was assessed by a specified person who was blinded to the grouping condition, so the data may not have been affected by the open-label nature of the design. The long-term effects of force platform balance training with visual feedback were not assessed in this study because of the limited time. Wolf et al. [13] studied the effect of force platform balance training in 72 older adults and found significant improvement in balance in favor of the training group at 4 months after the intervention.

Because of the extensive variation in the use of balance outcome measures and the absence of a gold standard method for evaluating balance, most results cannot be compared among different studies to determine which training program is more effective [14]. Sibley et al. [15] reviewed 56 existing balance measures validated in adult populations with evidence of use in the past five years and recommend the Berg Balance Scale as a core outcome set for measuring balance. Therefore, future research should include the Berg Balance Scale to access balance ability. A review that included nine studies reported that the medial-lateral

displacement and the medial-lateral sway might be predictors of falls among older adults [16]. These parameters were reported significant decrease in this study and previous studies. As poor balance is one of the major risk factors for falls among the elderly, perhaps the improvement of balance could reduce fall incidence in older adults. Therefore, future research should study the effect of force platform balance training with visual feedback on fall incidence in older adults.

This study shows that force platform balance training with visual feedback improves balance control in older adults. Visual-feedback-based force platform balance training in combination with one-leg standing exercise is a feasible training program to improve balance in Chinese older adults.

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Disclosure of conflict of interest

None.

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