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ORIGINAL RESEARCH

Task- and Context-Specific Balance Training Program Enhances Dynamic Balance and Functional Performance in Parkinsonian Nonfallers: A Randomized Controlled Trial With Six-Month Follow-Up

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Abstract

Objectives: To investigate the short- and long-term effects of a task- and context-specific balance training program on dynamic balance and functional performance, and to explore the effects on preventing total and injurious falls in parkinsonian nonfallers.

Design: A randomized controlled trial with group allocation single-blinded to the assessor.

Setting: Community centers, malls, and outdoor parks.

Participants: Nonfallers with Parkinson disease (PD) (N=70; mean age ± SD, 61.2±8.8y) randomly assigned to either a balance (BAL) group (n=32) or a control (CON) group (n=38).

Interventions: The BAL group received 4 weeks of indoor and 4 weeks of outdoor balance training (with a 2-h session per week). The CON group received 8 weeks of upper limb training at the same dosage. Both groups were instructed to perform 3 hours of home exercise weekly posttraining.

Main Outcome Measures: (1) Dynamic balance performance: Mini-Balance Evaluation Systems Test (Mini-BESTest); (2) Functional performance: functional reach (FR), 5 times sit-to-stand (FTSTS), 1-leg-stance (OLS), Timed Up and Go (TUG), and dual-task TUG tests; (3) Fall-related outcomes: ratios of total nonfallers to fallers and noninjurious fallers to injurious fallers, total and injurious fall rates, times to first falls and injurious falls.

Results: Sixty-eight participants completed training. A total of 7 patients (10%) withdrew before the 6-month follow-up, but not because of any adverse effects. At immediate and 6 months posttraining, the BAL group showed significantly greater improvements (from baseline) than the CON group in Mini-BESTest total scores, FR distances, and OLS times, together with greater time reductions in FTSTS, TUG, and dual-task TUG tests (all $P<.05$). The number of injurious fallers was significantly lower in the BAL group at 6-month follow-up.

Conclusions: This task- and context-specific balance training program improved the dynamic balance and fall-prone functional performance of PD nonfallers for up to 6 months after training. The BAL group showed a reduction in injurious fallers.

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Falls are frequent in patients with Parkinson disease (PD), and the proportion of fallers ranges from 35% to 90%.[1] These falls cause immobility and fear of falling,[2,3] and between 25% and 65% of them result in injuries or fractures.[4,5] Fall history is a significant predictor of future falls in patients with PD.[5-7] However, even patients without prior falls have a fall rate of 21% at 3 months' follow-up.[7] Clearly, PD nonfallers show worse balance performance than healthy subjects.[6] Therefore, early intervention is essential for improving postural stability, preventing first falls, and avoiding injuries.

To date, 1 study[8] has reported the immediate effects of repetitive step training to enhance parameters of stability and develop

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postural and gait skills in PD nonfallers. We designed a comprehensive program to train multidimensional postural control systems[9] for biomechanical constraint,[10] postural reactions,[11,12] sensory integration,[13] and dynamic control of gait.[14,15] This program also included practice for fall-prone functional and dual-task activities.

We investigated the short- and long-term effects of a task- and context-specific balance training program on dynamic balance and fall-prone functional performance, and explored its effects for preventing or mitigating falls and fall-related injuries. We hypothesized that the program would improve dynamic balance and performance of fall-prone activities at immediate and 6-month posttraining.

Methods

Study design and participants

This study was a single-blinded, randomized controlled trial with group assignment concealed to the assessors, and the subjects' performances masked to the trainers. The participants were recruited from the Hong Kong PD Association, a patient self-help group, and movement disorder clinics. Ethics approval was granted by The Hong Kong Polytechnic University and hospital ethical committees. The subjects included individuals with diagnosed PD according to the United Kingdom Brain Bank Criteria[16] who were at least 30 years of age, stable on anti-PD medications, had no fall history in the previous 6 months, and could walk 30m with or without a cane. Subjects were excluded if they had musculoskeletal or cardiopulmonary disorders, had undergone neurosurgery, had neurologic conditions other than PD, showed cognitive deficits on the Mini-Mental State Examination[17] (<24), or had joined another exercise program in the previous 3 months (fig 1). Informed written consent was obtained in accordance with the 1975 Declaration of Helsinki. This study involved PD nonfaller participants from our previous study.[18]

Sample size calculation

Based on the findings of the Mini-Balance Evaluation Systems Test (Mini-BESTest) and Timed Up and Go (TUG) test (effect sizes, .56 and .16) in our pilot study,[19] the sample sizes computed (with G*power 3.1.9 software[a]) were 8 and 60, respectively (5% type I error and 80% power). Therefore, the sample size required for adequate statistical power was 69, assuming a 15% attrition rate. Before the baseline assessment, a team member not involved in this study used the Research Randomizer[b] to make a randomized assignment of eligible participants into either a balance (BAL) or an active control (CON) group.

List of abbreviations:

BAL	**balance**
CON	**control**
FR	**functional reach**
FTSTS	**5 times sit-to-stand**
FU_{6m}	**6-month follow-up**
Mini-BESTest	**Mini-Balance Evaluation Systems Test**
OLS	**1-leg stance**
PD	**Parkinson disease**
TUG	**Timed Up and Go**

Outcome measures

Baseline demographic data including age, sex, PD duration, body mass index, and use of cane were collected. Assessments were made using the modified Hoehn and Yahr scale[20] (1−5, higher stages indicating a higher PD severity), the Movement Disorder Society Unified Parkinson's Disease Rating Scale Part III[21] (0−132, higher scores representing more severe motor symptoms), and the Physical Activity Scale for the Elderly[22] (0−500, higher scores indicating higher self-reported physical activity levels). The participants' daily levodopa equivalent dosages[23] were collected at each interval. All outcome measures were assessed during the on-medication cycle and at 3 intervals: at 1-week pretraining, immediately posttraining, and at the 6-month posttraining follow-up (FU_{6m}).

The primary outcome measure was the Mini-BESTest total score for assessing dynamic balance performance.[24] The subjects were evaluated in 4 domains: anticipatory postural adjustments, postural responses, sensory orientation, and stability in gait. Each item was rated from 0 to 2, and the total score ranged from 0 to 28, with higher scores indicating better dynamic balance. The Mini-BESTest demonstrated excellent test-retest and interrater reliabilities.[25] Before the main study, a pilot study was conducted on the test-retest reliability of the Mini-BESTest in 5 subjects with PD (mean age ± SD, 56.4±4.9y) at a 3-day interval. It showed that the Mini-BESTest had good test-retest reliability (intraclass correlation coefficient, .866), indicating the learning effect was minimal at baseline.

Secondary outcome measures included performance of fall-prone activities such as functional reach (FR) distance,[26] 5 times sit-to-stand (FTSTS) time,[27] 1-leg stance (OLS) time,[28] TUG time,[29] and dual-task TUG time.[30] The FR test measured the distance a subject could reach forward while standing. The FTSTS test recorded the time required to perform 5 cycles of standing up and sitting down. The OLS test involved timing how long the subjects could stand on their nondominant leg (up to a maximum of 30s). The TUG test measured the time the subjects took to rise from a chair, walk 3m, walk back, and sit down. For the dual-task TUG, the subjects were first instructed to count backward in 3s from a number between 90 and 100. After a few counts they were asked to perform the TUG while continuing the serial subtraction. One practice trial was allowed for each test, followed by 1 test trial for the Mini-BESTest and dual-task TUG, or 2 test trials for the FR, FTSTS and TUG. Sufficient rest was allowed between trials.

Other measures included fall-related outcomes such as ratios of total and injurious nonfallers to fallers, total and injurious fall rates, and times to first falls and injurious falls.[31] Fall diaries[32] were provided, and subjects were instructed to complete a standard form on the date and location of the fall, fall activities, landing body parts, perceived causes, and related injuries, as soon as possible after each fall event. A fall was defined as "an event that results in a person coming to rest unintentionally on the ground or other lower level, not as the result of a major intrinsic event or overwhelming hazard."[32(p60)] Injurious falls were classified according to severity of symptoms, types of injuries, and health care required.[33]

Interventions

Both BAL and CON subjects received a 2-hour training session per week for 8 weeks. The groups took treatments at different