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Multi-dimensional balance training programme improves balance and gait performance in people with Parkinson's disease: A pragmatic randomized controlled trial with 12-month follow-up

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ABSTRACT

Introduction: Previous studies have demonstrated that exercise interventions can improve balance and gait performance in people with Parkinson's disease (PD), but most training did not target all balance domains and was conducted mainly indoors.
Objectives: To investigate the short- and long-term effects of a multi-dimensional indoor and outdoor exercise programme on balance, balance confidence and gait performance in people with PD.
Methods: Eligible subjects with PD were randomly assigned to an eight-week indoor and outdoor balance training (EXP, N = 41) group or upper limb exercise (CON, N = 43) group. Outcome measures included BESTest total and subsection scores, gait speed, dual-task timed-up-and-go (dual-task TUG) time and Activities-specific Balance Confidence (ABC) score. All outcomes were assessed before training (Pre), immediately after intervention (Post) and at six-month (FU_{6m}) and twelve-month (FU_{12m}) follow-ups.
Results: Immediately after training, EXP group showed more significant improvements than CON group in BESTest total and subsection scores, gait speed and dual-task TUG time ($p < 0.05$). At both FU_{6m} and FU_{12m}, EXP group showed significantly greater gains than CON group in BESTest total and subsection scores and dual-task TUG time ($p < 0.05$). EXP group also showed significantly greater increase in the gait speed than CON group at FU_{6m} ($p < 0.05$).
Conclusion: The positive findings of this study provide evidence that this multi-dimensional balance training programme can enhance balance and dual-task gait performance up to 12-month follow-up in people with PD.

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1. Introduction

Falls are a very common and serious problem for people with Parkinson's disease (PD). A systematic review has reported high proportion of fall and recurrent falls in participants ranging from 35–90% and 18–65% respectively [1]. Falls can lead to devastating outcomes including physical injuries and fractures, fear of falling, functional restriction and increased risk of nursing home admission [2]. As fall history is the most significant predictor of future falls, it is essential to prevent the first fall in non-fallers and subsequent falls in those who had fallen [3]. We found that PD fallers had worse balance performance than healthy subjects, but alarmingly PD non-fallers also had worse balance and functional performance than healthy controls. Moreover, PD patients were more likely to sustain their first fall outdoors [4].

Early identification and reduction the risk of falling is an urgent priority [3]. The intervention should target PD non-fallers and those who had 1 fall to improve their postural stability to ambulate safely in both indoor and outdoor environments. Patients with PD have been found to have six impaired postural control systems, including biomechanical constraints, limits of stability and perception of verticality, anticipatory postural adjustments, postural responses, sensori-motor integration, as well as dynamic control of gait based on the Balance Evaluation Systems Test (BESTest) framework [5]. Practicing challenging balance tasks and gait activities has been reported to enhance postural stability in PD patients [6,7]. However, most of these balance training programmes only addressed some dimensions of postural control system using mainly indoor training [8–10]. The

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use of task-specific balance training that addresses all postural control domains and the inclusion of context-specific outdoor exercises could be effective to enhance postural stability of PD patients.

In this study, we designed an eight-week multi-dimensional blended indoor and outdoor (BIO) balance training intervention for PD non-fallers and those who had 1 fall in previous 6 months. We aimed to examine its short- and long-term effects on balance and gait performance and balance confidence in PD patients. We hypothesized that this novel balance training programme would be effective in improving the balance and gait performance and balance confidence of PD patients at treatment completion, and at six- and twelve-month follow-ups.

2. Methods

2.1. Study design and participants

This is a single-blinded, pragmatic, randomized control trial with group allocation concealed and masked to the principal assessor. Subjects were recruited from the Hong Kong PD Association, a patient self-help group and movement disorder clinics at three public hospitals. All subjects were aged 30 years or over, were diagnosed with PD by a neurologist, had no falls or only one fall in the past six months, were stable on anti-PD medications and could walk independently for 30 m with or without an assistive device. Subjects were excluded if they had neurological conditions other than PD, any history of neurosurgery, significant musculoskeletal or cardiopulmonary diseases, disorders that might affect balance or locomotion, communication or cognitive deficits with mini-mental state examination, (MMSE) < 24 [11], or had joined any structured exercise programme in the previous three months (Fig. 1). Ethics approvals were obtained from The Hong Kong Polytechnic University and respective clinics. Informed written consent was obtained from each participant in accordance with the 1964 Declaration of Helsinki. The ClinicalTrials.gov identifier is NCT01799681.

2.2. Sample size calculation

Using the web-based G*power 3.1.9 software [12] and based on the effect size obtained in our pilot study for BESTest total score, gait speed and dual-task TUG time (f = 0.781, 0.196 and 0.188) [13], and assuming a 5% type I error (α value) and 90% power, the sample sizes computed were 4, 56 and 48 respectively. By adopting the maximum sample size value (56) to extend generalizability and anticipating a 15% attrition rate, the total sample size required to ensure adequate statistical power was 65. Eligible subjects were randomly assigned into either experimental (EXP) or the active control (CON) group before baseline assessment, by a research team member who was not otherwise involved in the study, using the web-based computer software Research Randomizer [14]. Group allocation was masked to the assessor and subjects' performance at each assessment interval was masked to the therapists who conducted the training. The masking was further maintained by instructing the subjects not to reveal their group assignment to the assessor at all times.

2.3. Outcome measures

Baseline demographic information such as gender, age, PD duration, body mass index, daily levodopa equivalent dosage (LED), fall history and number of falls in past 6 months, modified Hoehn and Yahr stage, Movement Disorder Society-Unified Parkinson's Disease Rating Scale (MDS-UPDRS) III [15], and Physical Activity Scale

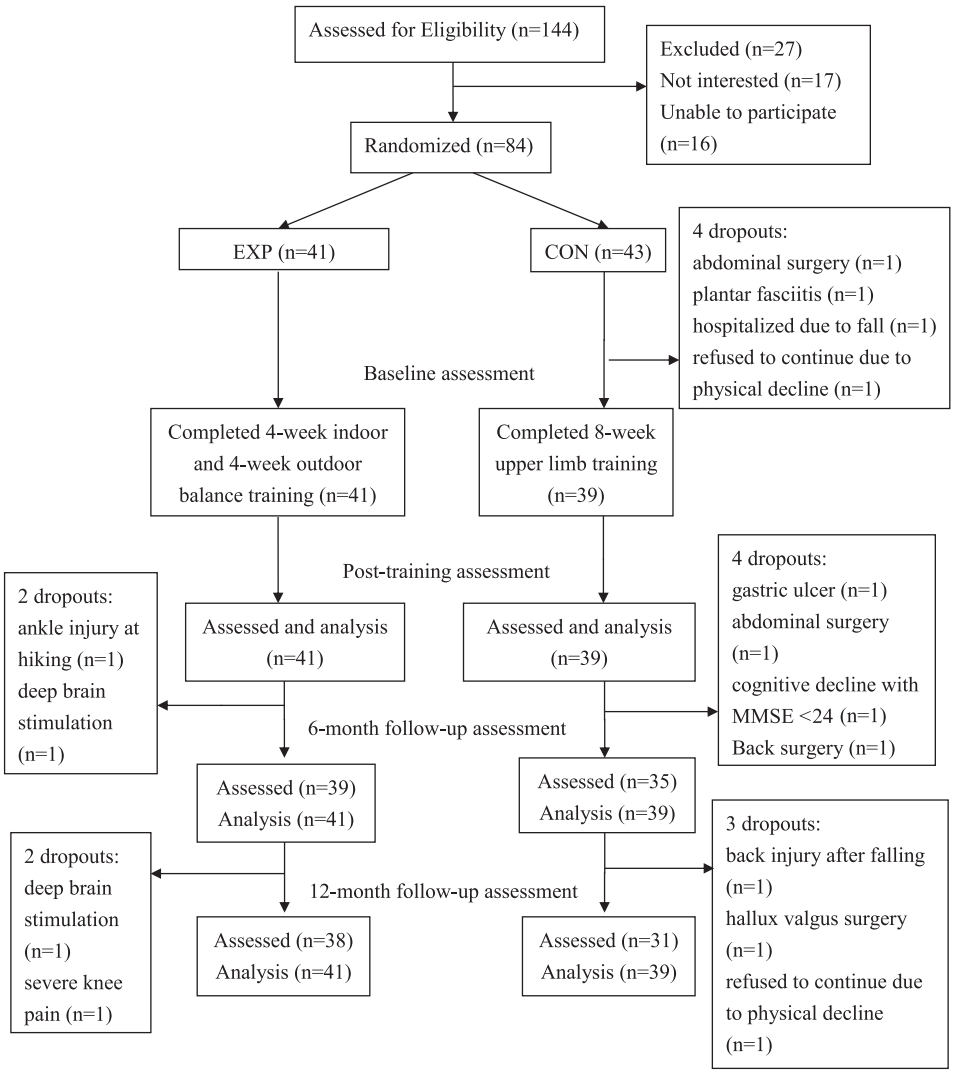

Fig. 1. Consort flow diagram showing the course of the study.

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