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Effects of augmented visual feedback during balance training in Parkinson's disease: A pilot randomized clinical trial

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ABSTRACT

Background: Balance training has been demonstrated to improve postural control in patients with Parkinson's disease (PD). The objective of this pilot randomized clinical trial was to investigate whether a balance training program using augmented visual feedback is feasible, safe, and more effective than conventional balance training in improving postural control in patients with PD.
Methods: Thirty-three patients with idiopathic PD participated in a five-week training program consisting of ten group treatment sessions of 60 min. Participants were randomly allocated to (1) an experimental group who trained on workstations consisting of interactive balance games with explicit augmented visual feedback (VFT), or (2) a control group receiving conventional training. Standing balance, gait, and health status were assessed at entry, at six weeks, and at twelve weeks follow-up.
Results: Sixteen patients were allocated to the control group and seventeen to the experimental group. The program was feasible to apply and took place without adverse events. Change scores for all balance measures favored VFT, but the change in the primary outcome measure, i.e. the Functional Reach test, did not differ between groups ($t(28) = -0.116$, $p = .908$). No other differences between groups were statistically significant.
Conclusions: VFT proved to be a feasible and safe approach to balance therapy for patients with PD. In this proof-of-concept study VFT was not superior over conventional balance training although observed trends mostly favored VFT. These trends approached clinical relevance only in few cases: increasing the training load and further optimization of VFT may strengthen this effect.
Trial registration: Controlled Trials, ISRCTN47046299.

1. Introduction

Individuals suffering from Parkinson's disease (PD) will, over time, typically be confronted with increasing difficulties with walking, balance, and making transfers [1]. This is important as mobility-related quality of life is closely linked to social participation [2] while impaired postural control contributes significantly to falls [3]. Balance and gait-related symptoms tend to be largely resistant to pharmacological treatment [4]. Allied health therapies such as exercise programs are therefore often implemented to improve mobility [5,6]. A recent meta-analysis suggests that balance-oriented training programs can address mobility-related deficits in patients with PD, but stresses that current evidence is inconclusive [6].

Biofeedback appears to be a promising means to deliver balance therapy [7]. Recent technological developments in the gaming industry have seen integration of players' own physical movements with virtual environments, furnishing new opportunities to provide explicit augmented visual feedback that engages the patient in cognitive and motor activities simultaneously [8]. For PD patients *serious games* may be particularly valuable

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considering the beneficial effects of external stimuli on motor function [9]. Commercially available game consoles with games that target balance control and other forms of physical capacity (e.g. Nintendo Wii™ Fit) are increasingly used in rehabilitation [10]. Pilot studies suggest that (home-based) exercise using Wii Fit is feasible in patients with mild PD and may improve measures of balance and gait, activities of daily living, and self-confidence [11,12]. However, a single randomized clinical trial (RCT) that compared Wii-based training with conventional balance therapy for PD patients found no additional benefits over control treatment in improving daily activities, balance, and cognitive performance [13]. A systematic review by Barry et al. concluded that the safety and clinical effectiveness of exercise-based computer games in general has not been established sufficiently [10]. In addition, the games and equipment may not be optimized for use with patients with PD, compromising user experience and safety [10]. The clinical utility of Wii Fit for instance, appears to be limited by the extent to which therapists can adjust parameters such as exercise complexity, speed, and workload [10]. Progressively modifying exercises in terms of dose and intensity is a key aspect of adequate physical training [14]. These shortcomings can be addressed by employing equipment that is designed for use in a clinical setting, with special attention for patients who experience severe mobility-related difficulties. This might improve effectiveness and applicability of visual feedback techniques in balance training.

In the present pilot RCT we investigated the feasibility of visual feedback-based balance training (VFT) specifically designed for clinical therapeutic settings in terms of applicability and safety. In addition, we compared the effects of the training program with conventional balance training in patients with PD. We hypothesized that VFT can be applied safely and more effectively than conventional training to improve standing balance performance.

2. Methods

2.1. Design

We compared two parallel treatment groups of PD patients. A detailed description of the study protocol was reported previously [15]. This study was registered as an International Standard Randomised Controlled Trial under ISRCTN47046299.

Assessments took place at entry prior to randomization (T0), at six weeks (T1), and at 12 weeks (T2) follow-up. A five-week training program was conducted between T0 and T1. All assessments and training sessions were performed in the ON-phase of levodopa medication.

2.2. Participants

A total of 33 patients with idiopathic PD were recruited from patient databases of the Department of Rehabilitation Medicine of VU University Medical Center (VUmc). Inclusion criteria were (i) a diagnosis of idiopathic PD according to the UK Brain Bank criteria [16], mild to moderate stage (i.e. Hoehn & Yahr stages II and III), (ii) able to participate in either training program, and (iii) written and verbal informed consent. Exclusion criteria were the (i) presence of (other) neurological, orthopedic, or cardiopulmonary problems that could impair participation, (ii) Mini Mental State Examination (MMSE) score below 24, (iii) a recent change in dopaminergic medication, and (iv) cognitive, visual, and/or language problems impeding participation. Participants did not receive other physical therapy treatments during the study period.

2.3. Intervention

Both groups received two treatment sessions per week for a period of five weeks in the outpatient clinic of VUmc. Each session lasted 60 min of which 45 min were dedicated to a series of workstations aimed to improve standing balance performance. In both intervention groups the dynamic balance exercises focused on controlling body posture in the forward, backward and sideward directions, exploring limits of stability, shifting weight from one foot to another, sit-to-stand movements, and included dual-task exercises. Patients worked in pairs, taking turns performing the exercise while the other person rested. Two senior therapists supervised training sessions, defined training goals, and monitored training intensity to ensure progressive overload throughout the training period. Participants kept a training log for the duration of the training program.

2.4. Visual feedback training

The experimental group received VFT, which was explicitly integrated in each workstation. Workstations consisted of a flat-panel LCD monitor connected to a PC containing a total of six, commercially available, interactive dynamic balance exercises (Motek Medical, Amsterdam, The Netherlands; see Fig. 1). Movement registration using a force plate (Forcelink, Culemborg, The Netherlands) or inertial sensors (Xsens, Enschede, The Netherlands) served to convert body movements to motion of an object ('avatar') displayed on the monitor, allowing patients to move within a virtual environment. Four exercises challenged control of body lean. They varied with respect to the coupling between lean and avatar motion. For instance, leaning forward would be associated with an increase in velocity of the avatar in some exercises, with downward movement in another, and with upward movement of the avatar in yet another exercise. The two remaining exercises were related to more functional tasks associated with standing balance, namely taking a step and performing a sit-to-stand movement. During the stepping exercise visual feedback referred to foot placement, whereas during the sit-to-stand movement feedback was related to upper body orientation while sitting, and related to upper leg orientation while coming to stance. Each game allowed a number of parameters to be adjusted so as to increase the difficulty (sensitivity to movement along each axis, speed, duration).

2.5. Conventional balance training

For the control group the workstations consisted of balance exercises recommended by the present Dutch guidelines for physical therapy in PD [14]. These workstations focused on training standing balance and included exercises while standing on one leg or with eyes closed, stepping exercises, dual-task exercises, sit-

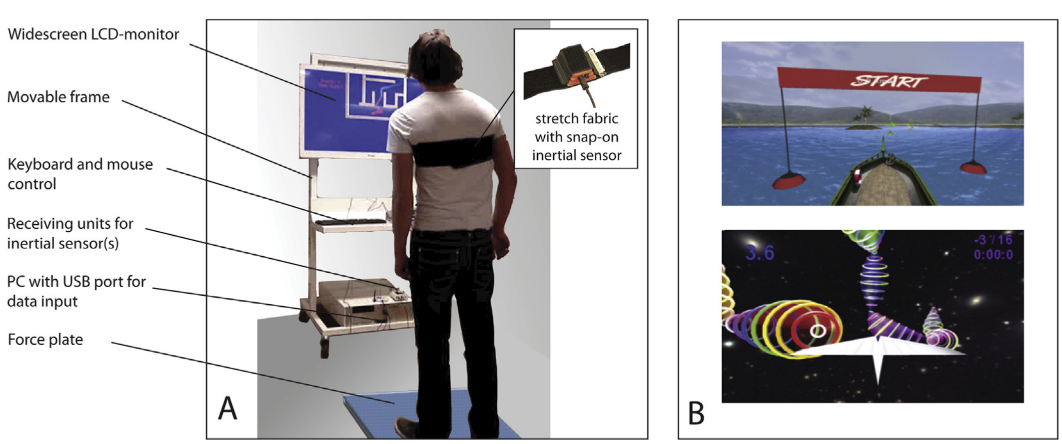

Fig. 1. Illustration of the intervention in the experimental group. A: Setup of mobile workstation with force plate and/or inertial sensor. B: Screenshots of examples of balance games. (Reproduced from Ref. [15]).

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