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ORIGINAL RESEARCH

Effectiveness of Conventional Versus Virtual Reality–Based Balance Exercises in Vestibular Rehabilitation for Unilateral Peripheral Vestibular Loss: Results of a Randomized Controlled Trial

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Abstract

Objective: To compare the effectiveness of virtual reality–based balance exercises to conventional balance exercises during vestibular rehabilitation in patients with unilateral peripheral vestibular loss (UVL).

Design: Assessor-blind, randomized controlled trial.

Setting: Two acute care university teaching hospitals.

Participants: Patients with UVL (N=71) who had dizziness/vertigo, and gait and balance impairment.

Interventions: Patients with UVL were randomly assigned to receive 6 weeks of either conventional (n=36) or virtual reality–based (n=35) balance exercises during vestibular rehabilitation. The virtual reality-based group received an off-the-shelf virtual reality gaming system for home exercise, and the conventional group received a foam balance mat. Treatment comprised weekly visits to a physiotherapist and a daily home exercise program.

Main Outcome Measures: The primary outcome was self-preferred gait speed. Secondary outcomes included other gait parameters and tasks, Sensory Organization Test (SOT), dynamic visual acuity, Hospital Anxiety and Depression Scale, Vestibular Rehabilitation Benefits Questionnaire, and Activities Balance Confidence Questionnaire. The subjective experience of vestibular rehabilitation was measured with a questionnaire.

Results: Both groups improved, but there were no significant differences in gait speed between the groups postintervention (mean difference, −.03m/s; 95% confidence interval [CI], −.09 to .02m/s). There were also no significant differences between the groups in SOT scores (mean difference, .82%; 95% CI, −5.00% to 6.63%) or on any of the other secondary outcomes ($P>.05$). In both groups, adherence to exercise was high (~77%), but the virtual reality–based group reported significantly more enjoyment ($P=.001$), less difficulty with ($P=.009$) and less tiredness after ($P=.03$) balance exercises. At 6 months, there were no significant between-group differences in physical outcomes.

Conclusions: Virtual reality–based balance exercises performed during vestibular rehabilitation were not superior to conventional balance exercises during vestibular rehabilitation but may provide a more enjoyable method of retraining balance after unilateral peripheral vestibular loss.

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Unilateral peripheral vestibular loss (UVL) results in vertigo, dizziness, anxiety, gaze instability during head movement, and gait and balance impairment.[1-5] Vestibular rehabilitation is a safe and effective intervention for UVL.[6-8] Fundamentally, vestibular rehabilitation programs are motor learning programs requiring practice and feedback. The increasing prevalence of technology has produced opportunities for improving rehabilitation. Virtual reality, defined as computer simulation that combines computer graphics to create a realistic-looking world that can respond in real-time to a user's input (verbal commands or gestures) and modify the virtual world instantaneously, is one such technology.[9]

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In addition, forceplate technology has been used in the clinical setting to provide visual and auditory feedback of the center of pressure and has shown some promising results.[10,11] Developments in the gaming industry have resulted in a low-cost virtual reality system, an off-the-shelf virtual reality gaming system, the Nintendo Wii Fit Plus,[a] which incorporates a force platform. It provides accurate visual and auditory feedback of the body's center of pressure during virtual reality exercises and games.[12] It perturbs balance in order to retrain it. In a previous study,[13] we reported that patients with vestibular disease found the system highly usable, enjoyable, and motivating and were in favor of using it in balance rehabilitation. Recently, Sparrer et al[14] found evidence that the Wii Fit Plus used in the first 2 weeks after acute vestibular neuritis was effective in improving balance when compared with placebo, but to date, no randomized controlled trial has investigated the superiority of the system to conventional vestibular rehabilitation, nor its application in the home exercise environment. The aim of this study therefore was to investigate whether the Wii Fit Plus as a form of virtual reality presented a superior method of rehabilitation of balance during vestibular rehabilitation when compared with conventional balance exercises during vestibular rehabilitation, in adults with UVL.

Methods

The trial was an assessor-blinded, randomized controlled, parallel trial with a 1:1 allocation. Two university teaching hospitals were involved in the study, and ethical approval was obtained from each of the sites' research ethics committees. Patients attending the otolaryngology or neurology outpatient clinics were invited to participate. Inclusion criteria were a clinical diagnosis of unilateral peripheral vestibular hypofunction confirmed, where possible, with bithermal caloric irrigation and a canal paresis >20%. Where caloric testing was not available, the presence of a positive head thrust test, or head shaking after nystagmus, or direction-fixed spontaneous nystagmus (assessed with an infrared oculomotor recording system) was required. Participants also had 1 or more of the following subjective complaints for longer than 6 weeks: dysequilibrium, gait instability, vertigo/dizziness, or motion sensitivity. Participants were excluded if they reported previous vestibular rehabilitation, had bilateral vestibular pathology, central nervous system involvement, fluctuating disease (active Meniere's disease, migrainous vertigo), active benign paroxysmal positional vertigo, or other medical conditions in the acute phase. A pacemaker or epilepsy also excluded participation (as per Nintendo Wii safety guidelines). Written informed consent was obtained. The trial protocol was published.[15]

Randomization

A permuted, blocked randomization procedure was used to randomly assign participants at an individual level to 1 of 2 treatment arms: conventional vestibular rehabilitation or virtual reality-based vestibular rehabilitation (VR). A third party, who was not involved in the day-to-day running of the trial, used an online randomization program (www.randomization.com) to assign individual patients in advance of recruitment. Block size was 6, chosen randomly from a block size of 4, 6, or 8. Allocation was notified to the treating therapist by the randomizer using e-mail or phone, after participants provided informed consent and underwent baseline assessments.

List of abbreviations:

DVA	**dynamic visual acuity**
LogMAR	**logarithm of the minimum angle of resolution**
SOT	**Sensory Organization Test**
UVL	**unilateral peripheral vestibular loss**
VR	**virtual reality-based**

Interventions

Both groups underwent 6 weeks of vestibular rehabilitation. The interventions were tripartite consisting of gaze stabilization exercises, balance exercises, and a graded walking program (supplemental appendix S1, available online only at http://www.archives-pmr.org/). The gaze stabilization exercises and the walking program were similar for both groups. The balance exercises were the differentiating feature. Balance training in the conventional group was based on a progression of conventional exercises derived from the literature and the authors' clinical practice,[16-19] and patients were provided with a foam balance mat for their home exercise program.[b] Balance training in the VR group was developed during pilot work.[13] Participants in the VR group were loaned a Wii Fit Plus for use at home and were loaned a rocker board that transforms the Wii Board from a stable to an unstable surface (Frii Board, Swiit Game Gear) (see supplemental fig S1, available online only at http://www.archives-pmr.org/). Both balance programs were designed to conform to the known neurophysiological principles underpinning balance dysfunction in UVL and its subsequent recovery,[20-23] and incorporating motor learning principles.[24] Both balance programs lasted 15min/d for 5 days a week and were progressive. Initial training in all exercises was provided in the clinic during weekly treatment sessions. Participants received weekly exercise booklets, designed to look the same, which incorporated an exercise diary (see supplemental appendix S1). A minimum of 4 sessions at the clinic (and a maximum of 7) was stipulated for those participants who lived geographically far away from the treatment site or who started the program at a higher level, or both. This was left to the discretion of the individual treating therapists and was deemed to reflect customary clinical practice. Interventions were provided by senior physiotherapists at the sites. All therapists had completed postgraduate training in vestibular rehabilitation and had an average of 6 years of experience in the rehabilitation of vestibular disorders.

Outcome measures

Outcome measures were administered by the blinded assessor at baseline, 8 weeks, and 6 months. The primary outcome measure was self-preferred gait speed (m/s) at 8 weeks. Gait speed was measured with a computerized 3-dimensional gait analysis system,[c] described elsewhere.[25] This is considered the criterion standard method of gait analysis.[26] The secondary endpoint was at 6 months. Secondary outcome measures were as follows:

Gait parameters: Gait parameters measured included speed, step length, step width, and percentage of gait cycle spent in double support during (1) self-preferred gait speed, (2) walking with head turns (as per the Dynamic Gait Index task[27]), and (3) walking with eyes closed (distance, 3.75m). For the eyes closed task, the amplitude of displacement (cm) over 3.75m.was also measured. The Dynamic Gait Index, a validated and reliable measure of gait function in patients with UVL, was also assessed.[27]