Virtual Reality Rehabilitation for Vestibular Dysfunction

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ABSTRACT

Background: People with chronic vestibular dysfunction can be treated with balance rehablitation. Virtual reality (VR) technology may serve as a useful therapeutic tool to facilitate rehabilitation. The aim of this pilot study was to investigate the clinical applicability of VR technology in treating patients with vestibular dysfunction.

Methods: Eleven patients with chronic vestibular dysfunction were recruited for this uncontrolled clinical study. The rehabilitation protocol (modified Cawthorne-Cooksey exercises, MCCE) was adapted into a VR-based training system. Patients followed the instructions of MCCE to complete 20 sessions of vestibular rehabilitation within a 4-week period.

Results: A VR-based rehabilitation system was developed with various latest technologies, including Kinect Xbox for full-body interaction, 3D-ready projector with shutter-glasses for stereo imaging, Wii Fit pressure pad for tracing the center of gravity and Unity game engine for leveled-difficulty design. Five VR tasks were built and more than 100 training trials were designed. Subjectively, all patients experienced the improvement of balance function performing daily activities and were overall positive to the training protocol. After intervention the fast component of postural sway ($p < 0.05$) was reduced. The follow-up interview showed decreased disability and increased general health.

Conclusions: VR has many advantages over traditional rehabilitation techniques in improving the testing or training environment of human performance. This study demonstrates that VR technology offers great promise in the field of vestibular rehabilitation.

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INTRODUCTION

- People with chronic vestibular dysfunction can be treated with balance rehabilitation.
- Virtual reality (VR) technology may serve as a useful therapeutic tool to facilitate rehabilitation.

Objective

- Using the latest motion sensor and 3-dimensional technologies, the aims of this pilot study are to investigate the clinical applicability of VR rehabilitation in treating patients with vestibular dysfunction.

MATERIALS AND METHODS

- Eleven patients with chronic vestibular dysfunction were consecutively recruited for this prospective, longitudinal pilot study.
- The postugraphy, Romberg's and stepping tests data were collected at baseline and 1 month after intervention.
- The rehabilitation protocol (modified Cawthorne-Cooksey exercises, MCCE) was adapted into a 5-scenario, VR-based training program (ball tracking, ball picking, ball catching, ball pitching, and body-limb movement scenarios). (Figure1)
- The VR-based rehabilitation system was developed with various latest technologies, including Kinect Xbox for full-body interaction, 3D-ready projector with shutter-glasses for stereo imaging, Wii Fit pressure pad for tracing the center of gravity and Unity game engine for leveled-difficulty design. (Figure2)
- The 5 VR scenarios provide more than 100 training trials.
- Patients followed the instructions of MCCE to complete 20 sessions of VR-based vestibular rehabilitation within a 4-week period.
- Each rehabilitation sessions would comprise of the eye, head, shoulder, body, limb exercises during sitting, standing, and moving.
- The VR program would gradually increase speed and difficulty (level 1-4) in a cyclic pattern for all 5 scenarios, starting from slow minimal to fast maximal motions.
- Patients' performance were recorded into an embedded scoring system.
- We also use the Technology Acceptance Model (TAM) to evaluate the usefulness, ease to use, and willing to use of this system.
- Wilcoxon sign rank test was used to evaluate the effectiveness of the VR-based MCCE intervention .

Results

- There are 6 male and 5 female with mean age of 54±20 years (7 with Meneire's disease, 1 with cervicogenic dizziness, and 3 with other vertiginous diseases).(Table 1)
- For pateint aged more than 60 years, the average score of MCCE increased from 64.4 to 70.2 points and the length of time of ball picking and pitching sessions decreased from 7.4 to 7.0 sec. (Table 2)
- There is significant improvement in scenario performances between the first two weeks and the last two weeks following VR rehabilitation.
- The center of gravity sway (postugraphy evaluated using Wii Fit pressure pad) improves significantly after intervention for all patients (121.2 mm vs. 112.3 mm, p=0.032). (Figure3)

- Subjectively, all patients experienced improvement of balance function in performing daily activities and were overall positive (usefulness, ease to use, and willing to use) toward the training protocol.
- The follow-up interview showed decreased disability and increased general health.

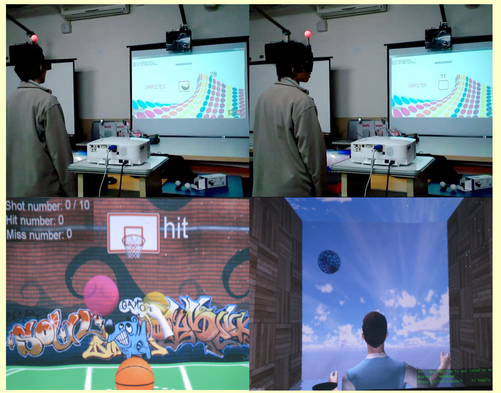

Figure 1. Ball tracking, ball picking, ball catching, ball pitching, and body movement scenarios

Figure 2. Kinect Xbox, , Wii Fit pressure pad , 3D-ready projector with shutter-glasses

Table 1 Characteristics of Patients

Characteristics	Mean (SD)
Age	53.8 (20.5)
Height	167.5 (4.6)
Weight	64.3 (9.3)
Gender, n (%)	
Male	6 (54.6)
Female	5 (45.5)
Disease, n (%)	
Meniere's disease	7 (63.6)
Cervicogenic dizziness	1 (9.1)
Other vertiginous diseases	3 (27.3)

Table 2 MCEE Performance by the First Two Weeks and Last Two Weeks After Rehabilitation

		MCCE score (SD)	
	N	1-2 weeks	3-4 weeks
All	11	74.0 (14.21)	74.8 (9.10)
Age			
<60	7	80.5 (7.50)	82.3 (4.94)
≥60*	4	64.4 (16.39)	70.2 (7.95)

*: $p<0.05$

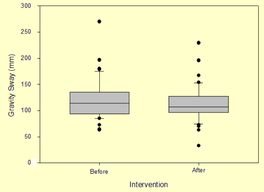

Figure 3 The center of gravity sway after intervention

CONCLUSIONS

- VR has many advantages over traditional rehabilitation techniques in improving the testing or training environment of human performance.
- This study demonstrates that VR technology offers great promise in the field of vestibular rehabilitation.