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Effectiveness Between Virtual Reality Based Exercises Versus Conventional Exercises in Patients with Vertigo

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ABSTRACT

BACKGROUND: Benign Paroxysmal Positional Vertigo (BPPV) is a condition characterised by brief episodes of nystagmus and dizziness. There are several studies which involve simulated environment such as crossing a road, walking down the aisle or manoeuvring in a supermarket as treatment protocol in the virtual reality group which can be complex for our subset of population. So, our study involves customised videos based on principles of conventional exercises such as gaze stability and habituation exercises involving biofeedback which provide simplified commands to the rural population affected by this condition. Therefore, our study will compare the effectiveness between conventional and virtual reality-based exercises in patients with vertigo.

MATERIALS AND METHODS: The population (n=34) was divided into conventional group (17) and virtual reality-based group (17). Participants with dizziness caused by central vestibular disorders (e.g., stroke, multiple sclerosis), Meniere's disease, migraine, or severe cervical spondylosis were excluded from the study. Two validated questionnaires such as the Dizziness Handicap Inventory scale (DHI-S) and Motion sensitivity quotient (MSQ) index were used as outcome measures.

RESULTS: Both groups showed improvement in both outcome measures. The mean DHI score for the conventional group pre intervention was 42 ± 2.7 and for the Virtual reality-based group was 40 ± 2.4. For MSQ, the mean score for conventional group was 25 ± 2.5 and for the Virtual reality-based group was 23 ± 2.2. But post-intervention, the mean DHI score for conventional group decreased to 38 ± 2.5 and for VRB group the score was 37 ± 2.4. Similarly, for MSQ, the mean score for conventional group was 22 ± 2.1 and for the VRB group was 20 ± 1.9.

CONCLUSION: This study demonstrates that both conventional vestibular rehabilitation exercises and those enhanced by virtual reality (VR) technology resulted in improved patient reported symptoms for DHI and MSQ. While conventional methods have proven to be effective, the integration of VR offers an engaging, adaptive, and potentially more effective means of rehabilitation.

1. INTRODUCTION

Benign Paroxysmal Positional Vertigo (BPPV) is characterized by brief periods of vertigo triggered by a changing head position relative to gravity. It is the most common peripheral vestibular disorder, accounting for one third of vestibular diagnosis in the population. It is most commonly seen in older ages due to the degeneration of statoconia, arising from demineralization.[1]

Although there isn't any specific cause of BPPV, it can be linked to head trauma, lying in a position for a long period of time and disorders involving the inner ears.[2] One recent meta-analysis concluded various risk factors associated with BPPV which is the female gender, vitamin D deficiency, osteoporosis, high Total Cholesterol (TC) level, migraine and head trauma.[3] One of the most commonly affected canals in BPPV is the posterior canal. The features presented by the affected canal differ respectively.

The two prevailing theories regarding pathophysiology of BPPV are the canalithiasis and cupulolithiasis models, and they differ with respect to how endolymphatic debris influences cupular dynamics. In the cupulolithiasis model, the particulate matter becomes adherent to the cupula itself. This cupular loading renders the system sensitive to gravitational forces, and the resulting alterations in cupular deflection led to pathological perceptions of motion. It has been suggested that this mechanism may represent the more chronic form of BPPV.[4]

The gold standard clinical test used in the diagnosis of BPPV is usually the Dix Hallpike maneuver. In the Dix-Hallpike maneuver, the patient is rapidly moved from a sitting to a supine posture with the head turned 45 degrees to the right. After 20 to 30 seconds, the patient returns to the sitting position. If no nystagmus exists, the same procedure is repeated on the left side. [5]

There are several articles which show the effectiveness of vestibular rehabilitation in ameliorating symptoms of dizziness and motion in adults. So, performing conventional exercises in patients with vertigo can have positive effects but there are some instances where the patients can enjoy the treatment when given via Virtual reality as it provides an immersive and innovative experience. Recently, a study showed that being exposed to immersive VR using a head mounted display (HMD) is a feasible, safe approach to providing beneficial experiences to older adults with mobility, sensory, and/or cognitive impairments.[6]

There are many studies which simulate real life environment or scenarios such as crossing a road, walking down the aisle or manoeuvring in a supermarket as a part of the Virtual reality based vestibular rehabilitation. But incorporating this into the rural population can be a little bit difficult so we've made customised videos which can be played via a head mounted display on a Virtual reality headset based upon the principle of the conventional protocol such as of habituation exercises and gaze stability exercises which are simplified so that the commands can be followed by the rural population. So, the objective of this study was to investigate and compare the effectiveness of conventional exercises versus virtual reality-based exercises on symptoms induced by dizziness and motion.

2. MATERIALS AND METHODOLOGY

This study has compared the effectiveness between conventional exercises and virtual reality-based exercises in patients with vertigo. The study was conducted in Karad. The Ethical Committee and Protocol Committee of Krishna Vishwa Vidyapeeth authorized the research investigation (protocol number- 300/2024-2025). Patients were selected according to inclusion and exclusion criteria. Informed consent was obtained, and data was collected. The duration of the study was six months.

Local ENT clinics and hospitals were visited to find patients diagnosed with benign paroxysmal positional vertigo (BPPV). Some of the hospitals were not allowed to share contacts due to privacy policies.

PARTICIPANTS

There was a total of 34 participants in our study who fulfilled the age criteria of 40 to 70 years. Inclusion criteria were participants who were diagnosed with BPPV. A positive Dix Hallpike position is the gold standard test which can diagnose this condition. Participants with dizziness caused by central vestibular disorders (e.g., stroke, multiple sclerosis), Meniere's disease, migraine, or severe cervical spondylosis were excluded from the study.

Two groups were formed after contacting the samples. One group followed the conventional treatment protocol whereas the other group followed the Virtual reality-based protocol. Both groups consisted of 17 participants. Simple random sampling technique was used.

ASSESSMENT TOOL

Two validated outcome measures—the Dizziness Handicap Inventory (DHI) scale and the Motion Sensitivity Quotient (MSQ) index—were employed to comprehensively evaluate patients' functional status and symptom severity. The DHI is a 25-item, patient-reported questionnaire designed to quantify the self-perceived disability caused by dizziness, vertigo, or unsteadiness. Developed by Jacobson and Newman in 1990, it evaluates three domains: functional (9 items, impact on daily activities), emotional (9 items, psychological distress), and physical (7 items, physical challenges triggered by dizziness).[7] MSQ is a clinical assessment tool designed to quantify motion-provoked dizziness in patients with vestibular disorders. It measures the severity and duration of dizziness triggered by a series of head and body position changes, providing a standardized metric to evaluate motion sensitivity, guide treatment planning.[8] Baseline and post-intervention assessments were conducted using the validated outcome measures prior to treatment commencement and immediately following the conclusion of the protocol.

STATISTICAL ANALYSIS

Statistical analysis was performed using GraphPad Prism software. Mean and standard deviation (SD) were calculated for each group. An unpaired T test was used to compare the mean DHI and MSQ index between the conventional and virtual reality-based group.

TREATMENT PROTOCOL

Both groups followed the standard treatment protocol of around 4 weeks. The same principle of exercises has been used in the VR headset. Customized videos involving exercises were played in the VR headset with the participant following the commands. A Jio VR headset was used for the treatment.

The conventional exercises were performed 5 times/ week with a duration of total 30 mins for 4 weeks.

Two customized VR based videos made from Microsoft PPT of 3 mins each were used in the VR based protocol. An in-built shooting balloons game was played in the Jio VR headset for the 3rd week. A 2 mins break was given in between the sets. A detailed treatment protocol is given below.

Duration	Conventional Protocol	Virtual reality protocol
Week 1	Gaze Stability Exercises: Patient will start with 1x paradigm exercises. In this, the patient will be instructed to focus on a stationary target while moving the head horizontally in both directions. Total sets – 2 with 10 repetitions Habituation Exercises: Start with eye movements – Up and down, From side to side These exercises must be done in the lying position	Gaze Stability Exercises: A video will be recorded where instructions will be given upon how to perform the exercises. In that video, the patient will be asked to focus on that point while moving the head horizontally in both directions. Total sets – 2 with 10 repetitions Habituation Exercises In this, the patient will be asked to focus on the moving object inside the VR and then start with the eye movements.
Week 2	While sitting, perform the same gaze stability exercises but with increased speed. Total sets 2 with 10 repetitions For Habituation Exercises, start moving your head up and down and then side to side.	While sitting, perform the same gaze stability exercises but with increased speed. Total sets 2 with 10 repetitions For Habituation exercises, tasks will be given to the patient which will require them to move their head up and down and then side to side.
Week 3	For Gaze stability, the patient can initiate with 2x paradigm exercises. In this, the patient has to move his head to the opposite side of the moving object while maintaining focus on the object. Total sets 2 with 10 repetitions For Habituation Exercises, ask the patient to throw a ball until the eye level.	For the VR group, a moving object will be placed and in the same way, patient has to move his head to the opposite side of the moving object while maintaining focus on the object. Total sets 2 with 10 repetitions In VR, the patient will be asked to play a simple game where he has to shoot a balloon coming from different directions.
Week 4	Same Exercises as week 3 but with increased intensity and repetitions. Total sets 2 with 20 reps	Same Exercises as week 3 but with increased intensity and repetitions. Total sets 2 with 20 reps

3. RESULTS

Table 1 – Demographic Data

		FREQUENCY	
AGE		Conventional (n=17)	Virtual reality based (n=17)
	40 – 50	3	5
	51 – 60	6	5
	61 – 70	8	7
GENDER	Males	9	10
	Females	8	7
FALL HISTORY	None	14	13
	One	3	4
OCCUPATION	Retired	7	7
	Electricians/Technicians	3	0
	Teachers	1	3
	Engineers (working on site)	3	2
	Healthcare workers	3	2
	Drivers	0	3

Interpretation – The above table represents the demographic data of the current samples. In the Conventional group, 47.06% of individuals are between the ages of 61-70, while in the Virtual Reality based group, this age group comprises 41.18%. The 51-60 age group has a similar proportion in both groups (35.29% in Conventional, 29.41% in Virtual Reality), while the 40-50 age group is slightly more represented in the Virtual Reality-based group (29.41%) compared to the Conventional group (17.65%). In the Conventional group, 52.94% are male, and 47.06% are female whereas in the Virtual Reality-based group, 58.82% are male, and 41.18% are female, showing a slightly higher proportion of males in this group. Both groups show a high percentage of individuals with no fall history: 82.35% in the Conventional group and 76.47% in the Virtual Reality group. A small percentage (17.65% in Conventional and 23.53% in Virtual Reality) have experienced at least one fall. The Occupation was categorized into different domains like teachers, electricians/technicians, Engineers (working on site), healthcare workers and drivers. Major proportion of the population were retired in both groups (41.18%).

OUTCOME MEASURE	CONVENTIONAL GROUP (Mean ± SD)	VRB GROUP (Mean ± SD)
DHI Functional $_{(Pre)}$	17 ± 1.5	16 ± 1.4
DHI Physical $_{(Pre)}$	13 ± 1.8	12 ± 1.7
DHI Emotional $_{(Pre)}$	12 ± 1.7	12 ± 1.5
DHI Total $_{(Pre)}$	42 ± 2.7	40 ± 2.4

Table 2 – Pre-Dizziness Handicap Inventory (DHI) score for both groups

Interpretation - In the above table, DHI $_{(Pre)}$ scores for both the groups have been mentioned. The mean DHI Total $_{(Pre)}$ for the conventional group is 42 whereas for the virtual reality-based group the score is 40. Participants in the VRB group reported marginally less dizziness related disability before the intervention.

OUTCOME MEASURE	CONVENTIONAL GROUP (Mean ± SD)	VRB GROUP (Mean ± SD)
MSQ Positional Sensitivity (Pre)	7.5 ± 2.3	6.8 ± 2.1
MSQ Intensity (Pre)	2.94 ± 1.2	2.82 ± 1.1
MSQ Duration (Pre)	1.29 ± 0.8	1.29 ± 0.7
MSQ Total (Pre)	25 ± 2.5	23 ± 2.2

Table 3 – Pre-Motion Sensitivity Quotient (MSQ) Index for both groups

Interpretation – In the above table, MSQ (Pre) scores for both the groups have been mentioned. The VRB group has slightly less Mean MSQ Total score than the conventional group. Also, they have reported slightly less positional sensitivity and intensity.

OUTCOME MEASURE	CONVENTIONAL GROUP (Mean ± SD)	VRB GROUP (Mean ± SD)	P – value
DHI Functional (Post)	15 ± 1.4	14 ± 1.3	0.0385
DHI Physical (Post)	12 ± 1.6	11 ± 1.5	0.0692
DHI Emotional (Post)	11 ± 1.5	12 ± 1.4	0.0530
DHI Total (Post)	38 ± 2.5	37 ± 2.4	0.0242

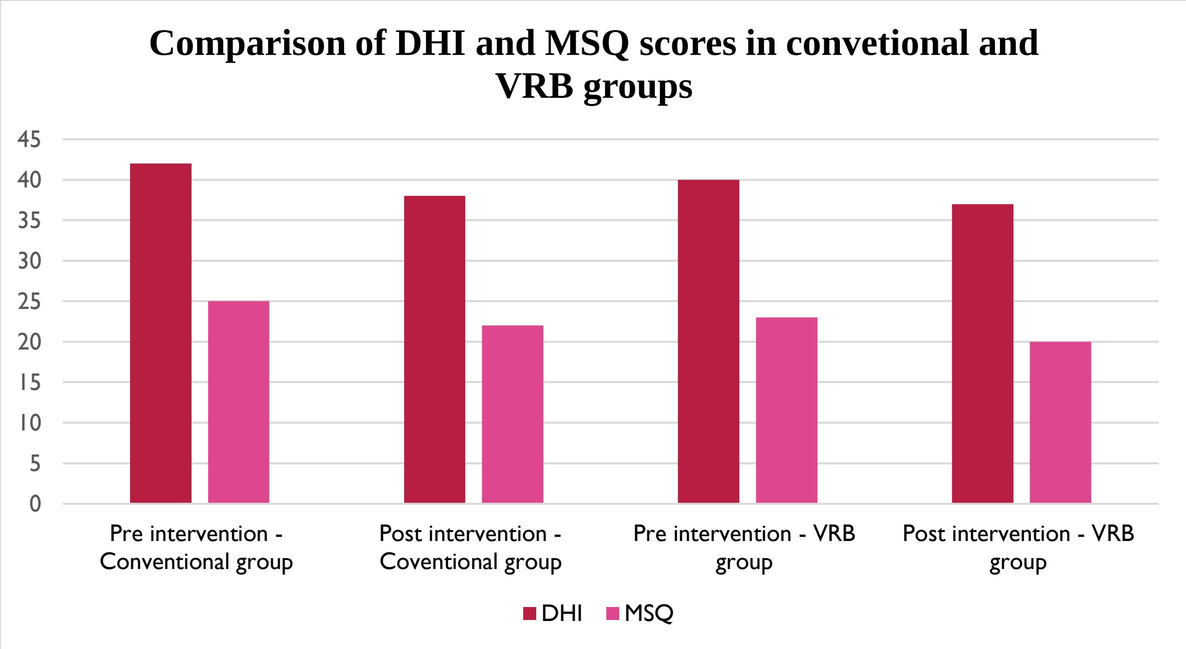
Table 4 – Post- Dizziness Handicap Inventory (DHI) score for both groups

Interpretation – In the above table, DHI scores post – intervention is mentioned. When compared to pre – intervention, both the groups reported less dizziness associated symptoms in all domains. The conventional group showed slightly more improvement when compared to the VRB group.

OUTCOME MEASURE	CONVENTIONAL GROUP (Mean ± SD)	VRB GROUP (Mean ± SD)	P – value
MSQ Positional Sensitivity (Post)	7 ± 2.0	6 ± 1.9	0.0032
MSQ Intensity (Post)	2.5 ± 1.2	2.3 ± 1.1	0.0065
MSQ Duration (Post)	1.1 ± 0.8	1.0 ± 0.7	0.0066
MSQ Total (Post)	22 ± 2.1	20 ± 1.9	0.0017

Table 5 – Post-Motion Sensitivity Quotient (MSQ) Index for both groups

Interpretation - In the above table, MSQ scores post – intervention is mentioned. When compared to pre – intervention, both groups showed improvement in the patient reported symptoms. The p – value suggests very significant findings showing the effectiveness of both the conventional and virtual reality-based group.



Interpretation - Above is a graphical representation of the comparison between outcome measures (DHI and MSQ) of the conventional and Virtual reality-based group pre and post intervention.

4. DISCUSSION

The current study is focused on comparing the effectiveness between conventional and virtual reality-based exercises in patients with vertigo. Both groups underwent the treatment protocol of four weeks. Both groups were assessed with DHI and MSQ outcome measures pre and post – intervention.

Both groups showed improvements in dizziness and motion related symptoms and the results were also very similar. The VRB group demonstrated a marginal improvement in the MSQ index compared to the conventional protocol, although the conventional protocol was slightly more effective for DHI scores.

The conventional protocol which was followed for 4 weeks showed improvements in all domains of dizziness handicap inventory scale (DHI-S). The conventional protocol included Cooksey and Cawthorne exercises along with gaze stability exercise. There was a decrease in the DHI score post intervention after 4 weeks in the conventional group. This could be due to the effect of Cooksey and Cawthorne exercises also known as habituation exercises, which seem to wane the vestibular system's hypersensitivity over time, thereby reducing symptom intensity. A study by Bhadouriya SKS et al, revealed that these exercises were effective in improving the DHI scores in their cohort, thereby aligning with our findings.[9]

In the Virtual reality group, same principle of the conventional exercises was used but they were delivered via a video in the VR headset. More significance was shed on the gaze stability exercises which have shown to improve the DHI scores post intervention after four weeks. Virtual reality (VR) has demonstrated efficacy in enhancing vestibulo-ocular reflex (VOR) function by enabling patients to perform gaze stabilization exercises within immersive, headset-based environment. These findings coincide with a study by Kanyilmaz et al., wherein VR-enhanced vestibular rehabilitation protocols were shown to optimize symptom management, particularly in mitigating dizziness and restoring dynamic balance and ambulatory function.[10]

The next outcome measure motion sensitivity quotient index assesses an individual's sensitivity to dizziness induced by specific head movements. Both the groups demonstrated a decrease in the MSQ symptoms and both treatments yielded similar results. Cooksey and Cawthorne exercises are exercises involving head, eye and body movements which are made on the principle of more repetitions which provoke symptoms of dizziness induced by motion in a controlled manner and promote vestibular adaptation. A study by Clendaniel demonstrated comparable improvements, showing that both habituation and gaze stability exercises led to a reduction in patient-reported symptoms, as reflected in DHI and MSQ scores.[11]

MSQ scores were similarly decreased in the VRB group. The immersive nature of the VR allows for controlled exposure to motion stimuli, facilitating habituation and desensitization to movements that typically provoke dizziness. While specific data on effectiveness of virtual reality on MSQ scores are limited, the overall reduction in dizziness and motion sensitivity suggests that VR interventions can be a valuable tool in managing vertigo symptoms.

Limitation of the study includes a low sample size, which may limit the generalizability of the findings. While the results showed positive outcomes, larger studies with more diverse populations are needed to confirm the broader applicability of these findings.

5. CONCLUSION

In conclusion, our study demonstrates that both conventional vestibular rehabilitation exercises and those enhanced by virtual reality (VR) technology resulted in improved patient reported symptoms for DHI and MSQ. While conventional methods have proven to be effective, the integration of VR offers an engaging, adaptive, and potentially more effective means of rehabilitation.

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