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To Design and Investigate the Effectiveness of a Gaze Stabilization Application on Patients with Impaired Visual Vestibulo-ocular Reflex

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ABSTRACT

Purpose: Vestibulo-ocular Reflex is the main vision stabilizing system during rapid head movements. In keeping the eyes still during head motion which is referred to as the gaze stability, the VOR has a censorious role. Loss of this vestibular function produces instability of gaze which worsens on motion and activity. Vestibular rehabilitation is one of the treatment modalities for patients with vestibular insufficiency. These exercises include gaze stability, central programming and balance exercise. Here this study is an instrument-based study and this device focuses on visually tracking, using smooth pursuit eye movements on a moving object. It shall not only provide a combined gaze stability adaptive exercise but it will also provide various progressions and biofeedback to the patients. **Methods:** An interventional study, with a sum of 30 participants having significant vestibular hypofunction or dysfunction who voluntarily participated in the study. It was a comparative study and it took place in Krishna Institute of Medical Sciences deemed to be University, Karad city in Maharashtra, India. 6 months was the total time span required to complete this trial. Consecutive sampling with random allocation was done. Those fulfilling the inclusion criteria were recruited and divided into two groups: control and interventional. **Results and Conclusion:** Vestibular dysfunction significantly affected the quality of life and lead to serious disability. Virtual mode of rehabilitation training by tracking the object with the eye, built interest and motivated the patient to regularly exercise as well as to perform smooth eye movements with lower range of saccades.

Keywords: Gaze Stabilization Application, Vestibular Dysfunction/Hypofunction, Vestibular Rehabilitation, Visual Vestibulo Ocular Reflex

1. Introduction

The vestibular system comprises of composite set of structures and neural pathways, therefore, serving as the predominant system for controlling balance and proprioception of our body, it lies in the petrous part of the temporal bone and it encompasses 5 distinct end organs: 3 semicircular canals which are sensitive to angular accelerations and 2 otolith organs that are sensitive to linear accelerations and gravity[1,2]. The labyrinth is a set of interconnected compartments containing all the vestibular sensations, it lies in the main component of the vestibular system that is the inner ear. These receptors send vestibular information via the vestibulocochlear nerve to the cerebellum and to the brainstem nuclei called the vestibular nuclei after which the information is passed to a myriad of targets. The information about the body's head position, motion, spatial orientation and some motion functions which allow us to maintain balance and posture is the primary function of the vestibular system[3]. An association of the Vestibular system and the visual system with each other eventually establishes a link through brain pathways so as to control visual fixation[4]. This ear to eye connection is known as Vestibulo-ocular Reflex (VOR). In keeping the eyes still during head motion which is referred to as the gaze stability, the VOR has a censorious role. Loss of this vestibular function produces instability of gaze which worsens on motion and activity. Hence VOR is known as the main vision stabilizing system during rapid head movements in humans[5,6.] There are two vestibular systems in our body namely: Central and peripheral[7]. Usually, the vestibular apparatus is accompanied by the visual system.[7] Discomfort ranging from acute to severe can occur in cases of any conflict within the vestibular pathway.

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The VOR also transmits a signal to the postural muscles which is pivotal for maintaining balance[3]. Vestibular dysfunctions can occur between diverse mechanisms like infection, neoplasm and direct trauma. Essential tasks such as postural control, gaze stabilization and spatial orientation are limited and the quality of life of the patients is significantly impaired when the vestibular functions are lost[9]. Underlying conditions that imply are: BPPV, vestibular neuronitis, labyrinthitis, acoustic neuroma, brainstem stroke, head trauma, vestibular migraine, multiple sclerosis etc[8]. Normally, VOR gain is inferred when the head and eyes move in opposite direction with equal velocity and is usually -1. Whereas the VOR phase is implicated to the useful measure of the vestibular system representing the amplitude relationship between the eye and the head[10]. Therefore, the above two aren't equivalent. The rotational VOR is independent upon viewing a particular distance. However, a combination of the rotational and translational VOR'S are evoked per head movements. Concluding that the peripheral and central impairments create disturbances in the body's balance systems bringing about the dysfunction of the vestibular apparatus. Patients usually present with vertigo, nystagmus, nausea, vomiting, intolerance to head motion, unsteady gait and postural instability[2]. Vestibular neuritis is known to be the most common form of acute peripheral vestibular dysfunction and ischaemic stroke reckoning for the most common cause of acute central vestibular dysfunction. In the recent studies demyelinating diseases have also been considered to contribute significantly to central dysfunctions.

Studies of the auditory and optokinetic systems provide riveting corroboration that neuronal plasticity is intensified when the error signal navigating adaptation is instead adjusted gradually throughout rehabilitation training. VOR is plastic and hence can be manipulated on volition. Its gain and phase can change and it is said to function optimally when there is no potential motion of the retina during head movement. In case of oculomotor weakness, a given central signal will be inadequate and the world will move on the retina[11]. The human brain has the capability to adjust the signals from VOR's in order to prevent the retinal slip. During convalescence period the symptoms may be severe enough to affect patient's daily routine, social, recreational and work life, hindering the quality of life even though significant neurological deficit is absent[12]. A physical therapist is obliged to identify the signs and symptoms associated with inner ear problems especially when incidence and prevalence rates of vestibular disorders are spiking rapidly. Accurate diagnosis and timely management aids to ameliorate the symptoms[12]. The onset of recovery is delayed if the visuomotor experiences are deprived. It is therefore essential to differentiate a peripheral pathology from the central one.

Vestibular rehabilitation is one of the treatment modalities for patients with vestibular insufficiency. Rehabilitation training inclusive of various task oriented physical activities and exercises are mandatory to promote functional improvements in patients with vestibular disorders. These exercises include gaze stability, central programming and balance exercise.

It reduces symptoms help in improving the quality of life of the patient. It also improves competence and well-being in activities of daily living[12]. Gaze stabilization exercises expose the patients to retinal slip which is necessary for adaptation within the brain[13]. The vestibular system is a poor transducer of very slow rotation (<0.1 Hz)[5]. Therefore, visual system compensates in case of dysfunction of the vestibular system. Here this study is an instrument-based study and this device focuses on visually tracking, using smooth pursuit eye movements on a moving object. It shall not only provide a combined gaze stability adaptive exercise but it will also provide various progressions and biofeedback to the patients. Virtual modes are used so that it becomes easier for the patient to accommodate, later substitute it with a progression in rehabilitation. Usually gaze stabilization has been neglected in terms of vestibular impairment and thus, as per the recent advances, gaze stabilization improves the VOR and other systems that are used to assist gaze stability with head motion.

2. Methods

An interventional study, with a sum of 30 participants having significant vestibular hypofunction or dysfunction voluntarily participated in the study. It was a comparative study and it took place in Krishna Institute of Medical Sciences deemed to be university, Karad city in Maharashtra, India. 6 months was the total time span that was required to complete this trial. Consecutive sampling with random allocation was done using the formula. Both males and females were involved in the study. Patients suffering from vestibular hypofunction or dysfunction that eventually led to impaired visual Vestibulo-ocular Reflex were incorporated in the study. Patients suffering from either peripheral or central pathology were included (BPPV, vestibular neuritis, migraine associated vertigo, cervicogenic dizziness, unilateral and bilateral vestibular hypofunction.)

The materials used for the execution of this study were: Informed consent sheet, data collection sheet and an inch tape. The sample size was derived by the following formula:

$$n = \{z1 - \alpha + z\beta | d\sigma\}^2 \times \underline{p} \times (1 - p)$$

$Z1\text{-}\alpha$ = standard normal variate at 5% level of significance
$Z\beta$ = power of test value when power 80%

$d\sigma$ = difference of treatment effects between 2 treatments (conventional vs application+ conventional)
P = relative proportion = 50%
$n = 2(1.96 + 0.84|0.15)^2 \times 0.5 \times 0.5$
$= 2\ (7.84|0.15) \times 0.25$
$= 2 \times 52.26 \times 0.25$
26+ 10% dropouts
N=30

2.1 Objectives of the Study

- To design the gaze stabilization application.
- To study its effectiveness on patients with impaired visual vestibulo-ocular reflex.

2.2 Exclusion Criteria

- Uncooperative patients.
- Psychologically unstable patients.
- Children and infants.
- Subjects not willing to give consent.
- Subjects with recent history of head injury.
- Subjects with ADHD.

2.3 Procedure

An approval for the study was obtained from the institutional ethical committee of Krishna Institute of Medical Sciences deemed to be university, Karad. Patients with an impaired visual Vestibulo-ocular Reflex and vestibular dysfunction were eligible to participate in the study. All patients diagnosed at KIMS hospital, Karad who wished to willingly volunteer for the study were selected and a trial took place on them. The subjects were further scrutinized based on the inclusion and exclusion criteria. The procedure and the purpose of the study was illustrated in detail and a written informed consent was obtained for the same.

Demographic variables of the subjects were cited (name, age, gender, education, etc). Before proceeding with the application intervention, a thorough detailed assessment of the patient was taken as per the data collection sheet. On the basis of consecutive sampling with random allocation, the participants were divided among two groups. Group A comprising of subjects who received conventional therapy and group B were given the gaze stabilization application, balance exercises and a home protocol on a regular basis for 4-week.

A detailed explanation about the application, its performance and its working were given to all participants priorly. The safety measures and the precautions were also elucidated well in advance. Patients were asked to sit upright on a chair and a set of instructions were given to the subject. Appropriate distance was measured between the patient and the screen via an inch tape. Then he or she was asked to track the object on the application.

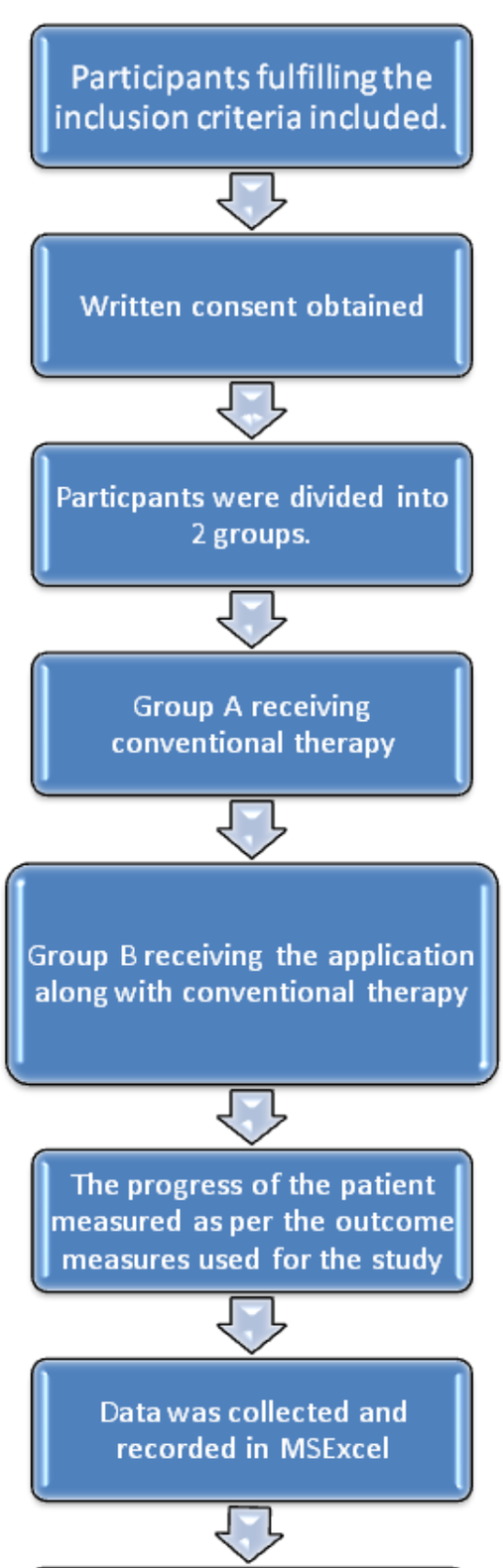
First the activity was demonstrated by the therapist and then carried forward wholly by the patient. They were to track the object with the help of their eyes (eye tracking). Once learnt and confidence was gained by the patient then progressions were made. The speed, shape, regressions, background changes and distractions were added. The mentioned parameters were manoeuvred by the therapist according to the progress and follow up of the patient. Following this balance exercises were prescribed and a home exercise protocol was explained to the person accompanying the patient. The weekly progress of the patient was noted based on the outcome measures of this study.

Rest breaks were permitted if the patient felt too dizzy or uncomfortable. Participants were encouraged to take part effectively. Recording of the symptoms and eye movements was done before and after the intervention. The progress of the patient with the application was then compared with that of the progress made with exclusive conventional treatment. The score was calculated and the Data was recorded in MS-EXCEL. Later statistical analysis was obtained and then these were represented graphically (Table no. 1).

2.4 Intervention

2.4.1 Apparatus

The materials used for the end result of the gaze stabilization application were: A digital control panel, any form of a screen or gadget, the front end was html scripted and the back end was java scripted. This following application is a screen-based tool or an instrument which is easy to use and grasp. A screen was a prerequisite to portray the desired outcome of the coding. Its application can be used in both OPD and IPD and home-based setups for rehabilitation purposes. Its regulators and buttons shall be controlled by the therapist and later taught to the relatives of the patient. The object shall be moving in all directions possible based on the mode of the shape selected (the object can move in linear direction, vertical direction and spiral direction). Initially the object will be set at a very slow speed as per tolerable to the patient (not evoking symptoms) later when he adapts to the set speed, the speed can be altered by increasing it progressively. To further progress, distractions like different objects and disturbance in toggling the object and variations of background are added. Futher to provide a feedback to the patient the camera of the device has been utilized. The application can work both with and without the feedback component. Hence these adaptive measures together shall work on central progressing and gaze stabilization in patients with vestibular hypofunction/dysfunction. Once a particular level is reached and the patient is able to perform it without any difficulty then progressions are added via different modes set in the application itself.


Participants fulfilling the inclusion criteria included.
Written consent obtained
Particpants were divided into 2 groups.
Group A receiving conventional therapy
Group B receiving the application along with conventional therapy
The progress of the patient measured as per the outcome measures used for the study
Data was collected and recorded in MSExcel
Statistical analysis was made using the INSTAT software

2.4.2 Principle of Training

Since eye tracking has played a major role in improving the vestibular dysfunction, this application focuses on gaze stabilization of the patient. The retinal slip is necessary as it is the signal used to drive the vestibular adaptation within the brain. This application reduces the frequency of symptoms of vertigo and assists in improving the quality of life of the patient. It improves the ability of gaze, enhances the VOR and provides biofeedback for which practice can indisputably take place. And as according to the learning pyramid practice holds 75% whereas audio-visual holds 20% of the learning, with this means the patient's confidence as well as independency increases.

A four-week treatment protocol for a single patient was manifested and training session on all alternate days (3 days a week).

2.5 Outcome Measures

Patient Reported Outcomes like the dizziness handicap inventory, visual analogue scale and activities specific balance confidence scale were used to track the progress of the patient.

3. Results

Among the 30 recruited participants fulfilling the inclusion criteria, 15 were allocated with conventional treatment and the rest 15 were allocated with conventional along with therapeutic implication of the gaze stabilization application. Statistical analysis of pre and post interventions was done with the help of an appropriate statistical tool. Pre- and post-test intervention's outcome were calculated within and between the groups t test. Statistical analysis of the recorded data was done by using the software INSTAT version 3. Arithmetic mean and standard deviation was calculated for each outcome measure.

The results revealed that out of the 30 participants 19 participants were ≤ 50 years of age, group A having 35.9 as the mean and 9.56 as the standard deviation whereas 34.11 and 11.63 were the mean and standard deviations of group B respectively for the same age group. 11 participants were above 50 years of age with 60.4 ± 6.14 and 59.33 ± 8.78 mean and standard deviations of the two groups respectively.

After random allocation there were 9 females and 6 males in Group B and 8 females and 7 males in Group A. Different people had different presentations of their dysfunctions, out of which 7 people from Group A and 9 people from Group B presented with BPPV, 2 from Group A and 1 from Group B presented with cervicogenic dizziness, 2 from Group A vertebrobasilar insufficiency, 1 from Group A presented with bilateral vestibular hypofunction and 2 from Group B presented with unilateral vestibular hypofunction, 1 from Group A with migraine related vertigo and 1 from Group B with multiple sclerosis, 2 from Group B presenting with labyrinthitis and acoustic neuroma respectively, whereas 2 from Group A showed idiopathic causes of vestibular dysfunction.

After comparing the Mean ± SD of the outcome measures at the base line level, 2 weeks and 4 weeks. The Results stipulated were as follows:

The Mean ± SD on DHI at the base line level for group A was 58.2 ± 11.13 and for Group B was 57.07 ± 10.43. Post Comparison the P value obtained was 0.7756 considered Not Significant. Following at 2 weeks the Mean ± SD for group A was 46.73 ± 5.2 and for Group B was 35.4 ± 3.90, on comparison p value remarked was <0.0001 considered extremely significant. Lastly, on comparison at 4 weeks 28.27 ± 6.06 was the mean and SD for Group A and 17.27 ± 4.84 was for Group B whose p value was <0.0001, which was also observed to be extremely significant.

Comparison at the intra group level of group A and group B for DHI was done using ANOVA at all the three stages. The F value of Group A was noticed to be 57.175 and Group B was 133.64 for which the p values obtained were <0.0001 considered extremely significant.

The Mean ± SD on VAS at the base line level for Group A was 7.84 ± 1.46 and for Group B was 7.95 ± 1.67. Post Comparison the P value obtained was 0.8534 considered Not Significant. Following at 2 weeks the Mean ± SD for group A was 5.50 ± 1.54 and for Group B was 4.64 ± 1.7, on comparison p value remarked was <0.1767 considered not significant. Lastly, on comparison at 4 weeks 3.21 ± 1.34 was the mean and SD for Group A and 1.83 ± 0.71 was for Group B whose p value was <0.0021, which was also observed to be very significant.

Comparison at the intra group level of Group A and Group B for VAS was done using ANOVA at all the three stages. The F value of Group A was noticed to be 105.44 and Group B was 106.93 for which the p values obtained were <0.0001 considered extremely significant.

The Mean ± SD on ABC at the base line level for Group A was 49.87 ± 9.24 and for Group B was 49.93 ± 9.32. Post Comparison the P value obtained was 0.9844 considered Not Significant. Following at 2 weeks the Mean ± SD for Group A was 57.67± 7.72 and for Group B was 464.06 ± 6.05, on comparison p value remarked was <0.0175 considered significant. Lastly, on comparison at 4 weeks 66.73 ±7.22 was the mean and SD for Group A and 77.2 ± 6.36 was for Group B whose p value was <0.0002, which was also observed to be extremely significant.

Comparison at the intra group level of Group A and Group B for ABC was done using ANOVA at all the three stages. The F value of Group A was noticed to be 62.215 and Group B was 117.95 for which the p values obtained were <0.0001 considered extremely significant.

Table 2. Age wise distribution

Age	Mean ± SD (GROUP A)	Mean ± SD (GROUP B)
≤ 50 (N = 19)	35.9 ± 9.56	34.11 ± 11.63
>50 (N =11)	60.4 ± 6.14	59.33 ± 8.78

Table 3. Gender wise distribution

Gender	GROUP A%	GROUP B%
Male	46.66%	60%
Female	53.33 %	40%

Table 4. Diagnosis wise distribution

Diagnosis	Group A (N = 15)		Group B (N = 15)	
	NO.	Percentage	NO.	Percentage
BPPV	7	46.66%	9	60%
Cervicogenic Dizziness	2	13.33%	1	6.66%
IdiopathiC	2	13.33%	0	0%
Bilateral Vestibular Hypofunction	1	6.66%	0	0%
Vertebrobasilar Insufficiency	2	13.33%	0	0%
Multiple Sclerosis	0	0%	1	6.66%
Migraine Related	1	6.66%	0	0%
Unilateral Vestibular Hypofunction	0	0%	2	13.33%
Labyrinthitis	0	0%	1	6.66%
Acoustic Neuroma	0	0%	1	6.66%

Table 5. Dizziness handicap inventory (comparison between both the groups)

DHI	Mean ± SD (Group A)	Mean ± SD (Group B)	Unpaired T Test	P Value
Baseline	58.2 ± 11.13	57.07 ± 10.43	0.2878	0.7756 NS
At 2 Weeks	46.73 ± 5.2	35.4 ± 3.90	6.747	<0.0001 ES
At 4 Weeks	28.27 ± 6.06	17.27 ± 4.84	5.487	<0.0001 ES

Table 6. Statistical analysis on DHI showing progression of group A and B using ANOVA

DHI	Mean ± SD (Group A)	Mean ± SD (Group B)
Baseline	58.2 ± 11.13	57.07 ± 10.43
At 2 Weeks	46.73 ± 5.2	35.4 ± 3.90
At 4 Weeks	28.27 ± 6.06	17.27 ± 4.84
ANOVA F Value	57.175	133.64
P Value	<0.0001 ES	<0.0001 ES

Table 7. Visual analogue scale (comparison between both the groups)

VAS	Mean ± SD (Group A)	Mean ± SD (Group B)	Unpaired T Test	P Value
Baseline	7.84 ± 1.46	7.95 ± 1.67	0.1865	0.8534 NS
At 2 Weeks	5.50 ± 1.54	4.64 ± 1.7	1.386	0.1767 NS
At 4 Weeks	3.21 ± 1.34	1.83 ± 0.71	3.391	0.0021 VS

Table 8. Statistical analysis on VAS showing progression of group A and B using ANOVA

VAS	Mean ± SD (Group A)	Mean ± SD (Group B)
Baseline	7.84 ± 1.46	7.95 ± 1.67
At 2 Weeks	5.50 ± 1.54	4.64 ± 1.7
At 4 Weeks	3.21 ± 1.34	1.83 ± 0.71
ANOVA F Value	105.44	106.93
P Value	<0.0001 ES	<0.0001 ES

Table 9. Activities specific balance confidence scale (comparison between both the groups)

ABC	Mean ± SD (Group A)	Mean ± SD (Group B)	Unpaired T Test	P Value
Baseline	49.87 ± 9.24	49.93 ± 9.32	0.01968	0.9844 NS
At 2 Weeks	57.67 ± 7.72	64.06 ± 6.05	2.526	0.0175 S
At 4 Weeks	66.73 ± 7.22	77.2 ± 6.36	4.211	0.0002 ES

Table 10. Statistical analysis on ABC showing progression of group A and B using ANOVA

ABC	Mean ± SD (Group A)	Mean ± SD (Group B)
Baseline	49.87 ± 9.24	49.93 ± 9.32
At 2 Weeks	57.67 ± 7.72	64.06 ± 6.05
At 4 Weeks	66.73 ± 7.22	77.2 ± 6.36
ANOVA F Value	62.215	117.95
P Value	<0.0001 ES	<0.0001 ES

4. Discussion

Vestibular rehabilitation in fact is a lesser focused area in the field of physical therapy. In this study, we have reported that the development and validation of a gaze stabilization application for rehabilitation of patients with vestibular dysfunction by obtaining gaze stability and compliancy through receiving feedback. Rehabilitation process was performed in a well-lit room with a viewing distance of 20 cm. Conventional method of training included postural strategies, balance exercises, central programming and gaze stability exercises which were prescribed to Group A individuals[26]. Decrease in the gain of the vestibular response to head movements results in instability of gaze as mentioned (Herdman SJ advances in the treatment of vestibular disorders)[15] and therefore in an unstable lesion, acclimatization will be difficult (Byung In Han, Hyun *et al.*)[25] which is why the primary objective in such patients is to prepare them for anticipated dizziness rather than permanently changing their health status. Vestibular adaptation as well as substitution were the main focus of this study and were best obtained by inducing retinal slip. The difficulty of training can be increased by adding vestibular stimulation such as incorporating head movements (Alahmari *et al.,* 2014)[17] was mentioned as per the previous studies. Following all the points there are some valuable findings present in the current study which imbibed on the significant improvements in the episodes of symptoms, improvement of the VOR and QOL of the individual.

According to the recent guidelines optokinetic devices aided in improving the same mentioned objectives within a couple of weeks as cited by (Marousa Pavlov, 2010)[27] Pavlov also mentioned that exposure to dynamic environments is considered as an adjunct to vestibular rehabilitation. Consequently, acknowledging the recent advances we have

prescribed the gaze stabilization application along with the conventional mode of rehabilitation to our subjects of Group B. There was a significant improvement observed in both the groups, nevertheless additional improvement was observed in Group B when compared to Group A. Rather our protocol focused more on the improvement of VOR and its gain and phase. Secondarily improvising the optokinetic reflex and lowering saccades in order to ameliorate smooth pursuit eye movements. At the end of the week patients were seen to be habituating to the retinal slip errors after which gradual progressions were made. Changes in the outcome variables of DHI[19], VAS and ABC were observed and were found to be extremely significant, although balance, gaze stability, postural changes and an overall improvement were accredited to the rehabilitation process.

This study extends previous literature that used conventional and virtual reality-based methods for treatment. It rather focused on easy to go, portable and readily available application designed mainly to improve the quality of life of such people [20]. This study further powers previous studies that believe that only conventional method along with various virtual stimuli or head movements will significantly improve the outcome of the patient by reducing the complaints. (Micarelli *et al.*).[17] & (Dai. C. *et al.*)[15] Previous protocols foregrounded that in home based vestibular rehabilitation home based patient modifications may improve habituation of VOR (Krammer *et al.*) while reviewing myriad of articles, they had protocols that highlighted vestibular exercises requiring eye movements while fixating on the moving target inducing adaptation as well improving the central programming and reducing catch up saccades to stabilize the gaze (Frederic R Danion *et al.*)[16]. Considering that screen-based application increases the concentration and ability to do exercises. This aligns and supports the theory that states that central programming of eye movements is equally responsible for gaze stability (Herdman *et al.*)[22,24]. This trial also supports the theory of learning pyramid as there is utilization of multiple components of this pyramid. Practice holding 75% whereas audio-visual holding 20% of the learning, with this means the patient's confidence as well as independency improved rapidly.[18] Biofeedback provides information directly to a patient about internal biological mechanisms via audio, visual and various means. It provides feedback to individuals about their internal physiological events in order to state whether they are normal or abnormal and in case of abnormal to accurate them effectively. (Susan O Sullivan 5th edition)[10]. This device utilizes biofeedback by connected the device to raspberry pi which already contains commands given priorly to track eye movements of the patient.

Therefore, the results of this study justify our alternate hypothesis and suggest that the use of gaze stabilization application promoted the recovery and reduction of symptoms.[21] Due to small sample size, our results could be extrapolated to larger population. We couldn't determine whether the effects of this kind of rehabilitation training are long lasting or not because of lesser time span. Similar studies are recommended using homogeneous group (only specific diagnosis) as well as further research can be done in different subjects (impaired eye hand co-ordination). Research is also recommended by adding various optokinetic signals and virtual based inventories.

5. Conclusion

Vestibular dysfunction significantly affects the quality of life and leads to serious disability. Virtual mode of rehabilitation training by tracking the object with the eye builds interest and motivates the patient to regularly exercise as well as to perform smooth eye movements with lower range of saccades. Apart from the above it also provides a new therapeutic approach in addition to the conventional method of training. This study establishes a handy ready to use, transferrable and a compliant application that can improve the condition and reduce the symptoms of vestibular hypofunction/dysfunction.

It also aids in enhancing the visual Vestibulo-ocular Reflex and help the patients to return to activities of daily living without hindrance.

This study confirms the effectiveness of the application along with conventional method of rehabilitation training and a new virtual aspect of rehabilitation for practitioners.

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8. Abbreviations

Sr.no.	Abbreviation	Full Form
1	VVOR	Visual-vestibulo Ocular Reflex
2	BPPV	Benign Paroxysmal Positional Vertigo
3	VOR	Vestibulo-ocular Reflex
4	DHI	Dizziness Handicap Inventory
5	VAS	Visual Analogue Scale
6	ABC	Activities Specific Balance Confidence Scale
7	ADHD	Attention Defecit Hyperactivity Disorder
8	QOL	Quality of Life
9	VS	Very Significant
10	ES	Extremely Significant
11	NS	Not Significant
12	S	Significant