

Effectiveness of Visual Vestibular Habituation versus Optokinetic Training for Chronic Motion Sensitivity

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Abstract:

Objective: To compare the effectiveness of visual vestibular habituation exercises and optokinetic training for subjects with chronic motion sensitivity.

Material and Methods: This comparative study of the pre-test and post-test type included 50 healthy women based on the inclusion criteria and then randomly divided into Group A and Group B, containing 25 subjects each. Group A performed visual vestibular habituation exercises, Group B performed optokinetic training, and both groups performed balance exercises for 6 weeks. The paired t-test was adopted to find the statistical difference within the groups, and the independent t-test (Student t-Test) was adopted to find the statistical difference between the groups. A p-value of ≤ 0.05 was considered statistically significant.

Results: Both visual vestibular habituation exercises (Group A) and optokinetic training (Group B) produced significant improvements in motion sensitivity symptoms, as measured by Motion Sickness Susceptibility Questionnaire (MSSQ), Motion Sensitivity Quotient (MSQ), State Trait Anxiety Inventory (STAI), and Video Induced Dizziness Time (VIDT) scores ($p\text{-value} \leq 0.05$). Group A showed lower post-intervention scores for MSSQ (56.67 ± 6.21) and MSQ (11.92 ± 3.17), lower anxiety levels on STAI (41.76 ± 3.43), and higher tolerance to video-induced dizziness time (216.72 ± 18.23) compared to Group B.

Conclusion: Visual vestibular habituation exercises are more effective than optokinetic training for alleviating the symptoms of motion sickness in individuals with chronic motion sensitivity.

Keywords: chronic motion sensitivity, optokinetic training, visual vestibular habituation

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Introduction

Chronic motion sensitivity, commonly referred to as motion sickness, encompasses a collection of autonomic symptoms triggered by actual or imagined motion¹⁻³. The autonomic responses during motion sickness vary widely among humans, including nausea, vomiting, headaches, dizziness, sweating, facial pallor (also known as cold sweating), increased salivation, lack of appetite, anxiety, blurry vision, and postural balance^{4,5}. The incidence of motion sickness is approximately 30% in the general population, with a comparatively higher incidence in women than in men^{6,7}.

The ocular, vestibular, and proprioceptive systems are the three sources of motion detection, which usually agree with each other⁸⁻¹⁰. Motion sickness occurs when there is a mismatch between the sensory information transmitted by these three systems to the central nervous system¹¹⁻¹⁴.

The pharmacological management of motion sickness includes antimuscarinics, e.g., scopolamine. H1 Antihistamines, e.g., dimenhydrinate, sympathomimetic, e.g., amphetamine^{14,16}. Various non-pharmacological managements of motion sickness include habituation, multisensory stimulation, gaze stabilization exercise, optokinetic training, and yoga¹⁷.

Recent years have seen an increase in the awareness of motion sickness, which is primarily brought on by the stimulation of the visual system, frequently without any actual physical motion. Visually induced motion Sickness (VIMS) has become a widespread phenomenon because of recent advancements in the technology of visual displays and applications (such as surround-sound theatres, vehicle simulators, virtual reality, and augmented reality)¹⁶. Habituation training simulates the sensory conflict as closely as possible to the stimulating environment^{18,19}. This study focused on two habituation programs that can help improve the symptoms of motion sickness.

Visual vestibular habituation exercises are a specialized form of exercise intended to relieve symptoms caused by chronic motion sickness, like dizziness due to repeated exposure to the particular movements or visual signals that provoke patients' dizziness²⁰. The vestibulo-ocular reflex stabilises visual pictures on the retina despite variations in head position²¹. In visual vestibular rehabilitation, the retinal slip error signal is utilised to enhance the gain of the vestibular response. While keeping your eyes fixed on the subject, you can move your head in either a horizontal or vertical direction to cause a retinal slip^{22,23}. Unlike optokinetic training, they produce a retinal slip by combining active head motions with stationary/moving visual objects, with the intended goal of enhancing Vestibular Ocular Reflex (VOR) gain (adaptation process). These activities enhance gaze stability during normal head motion and directly retrain the vestibulo-ocular reflex, in contrast to optokinetic training²⁴.

Optokinetic training is the process of desensitizing patients through progressive exposure to motion sickness-provoking movements and situations. It also induces retinal slip²⁵⁻²⁷. Earlier studies have shown that a computer screen, a head-mounted display, or a Digital Versatile Disc (DVD) with visual stimulation might all provide similar or less severe stimulation, like high-tech optokinetic drums^{27,28}. Unlike visual habituation training, optokinetic training creates visual-vestibular conflict and desensitises patients to visually caused dizziness by using moving visual surroundings (such as rotating drums, virtual reality, and screen-based stimuli). It is specifically useful for people with disorders where habituation alone does not produce results, such as visual dependency, Persistent Postural-Perceptual Dizziness (PPPD), or visually induced motion sickness²⁹.

Although several unique strategies have been researched with positive results, an effective method to minimize motion sickness has not yet been found. Research is needed to compare the various interventions to determine

the techniques that provide better outcomes for subjects with motion sensitivity. This study aimed to compare the effects of visual vestibular habituation exercises and optokinetic training on individuals with motion sickness.

Material and Methods

Design and setting

The present study was an experimental study that compared the effectiveness of visual vestibular habituation exercises and optokinetic training for subjects with chronic motion sensitivity. The study was conducted at the Physiotherapy Outpatient Department of A.C.Shanmugam (ACS) Medical College and Hospital.

Ethical statement

This research was reviewed and approved by the institutional review board of Faculty of Physiotherapy, Dr.MGR Educational and Research Institute. The approval code is MPT (NEUROLOGY)-03/IRB/PHYSIO/2022-23. Study procedures were explained in full to all the subjects, who were then asked to sign the informed consent. Complete confidentiality was assured.

Inclusion and exclusion criteria

Subjects 20–40 years of age with experiences of motion sickness, a motion sensitivity quotient score (MSQ) of 0–30, and a normal cervical range of motion were included in the study. Subjects without the experience of motion sickness, pregnant women, a diagnosis of vestibular dysfunction, neurologic pathology, migraines, seizures, cervical spine orthopaedic impairments, and currently taking medications causing dizziness/imbalance were excluded from the study.

Procedure

Once the study was approved by the Institutional Review Board, 50 participants fulfilling the inclusion

criteria were selected and randomly divided into 2 groups, Group A and Group B. The study was conducted in the Physiotherapy OPD. The subjects were instructed regarding the benefits of participating in the study, and after obtaining their consent, they were asked to sign informed consent forms, assuring their confidentiality. Subjects in Group A performed visual vestibular exercises along with balance training: each step was repetitively performed for 15 minutes, 5 times/day, 5 days/week.

Subjects in Group B performed optokinetic training along with balance training: each movement was repetitively performed for 15 minutes, 5 times /day, 5 days/week. The tests were performed before and after the intervention.

Outcome measures:

The Motion Sensitivity Quotient (MSQ) demonstrates excellent reliability, with inter-rater ICC values around 0.99 and test-retest ICC values of 0.98 and 0.96, indicating it is a highly reliable measurement tool³⁰.

The MSSQ-Short showed great test-retest reliability ($r \approx 0.90$) and good internal consistency (Cronbach's $\alpha = 0.87$) in the original English edition³¹.

The State-Trait Anxiety Inventory (STAI) manual has shown strong internal consistency with Cronbach's alpha values ranging from 0.86 to 0.95 for both the State and Trait scales³².

Video-induced dizziness time is the outcome measure used in the study.

Intervention

Group A performed visual vestibular habituation exercises:

Step 1. Seated in a chair, the patient is asked to hold an index card with letters at arm's length in front of him/her at eye level. The patient is asked to move the card from left to right repeatedly as they maintain fixation on the letters. Continue for 10 seconds.

If the patient can see the letters clearly at this speed and doesn't have motion sickness, continue for 10 seconds, moving the card faster. Continue increasing speed until the patient identifies the speed that results in mild symptoms. Continue at a maximum speed for 30 seconds. When all the symptoms stop, repeat at the maximum level of speed for 30 seconds, 4 times.

Step 2. Repeat but move the arm and card in the up and down directions, centered in front of him/her.

Step 3. Seated in a chair, the patient is asked to repeat step 1, but to turn the head from left to right, holding the card steady and centered in front.

Step 4. Seated in a chair, the patient is asked to repeat step 3, except this time, to move the head in the up-down direction.

Step 5. Seated in a chair, the patient is asked to repeat step 4, except this time, to tilt the head side to side.

Next, repeat steps 1 through 5 in the standing position, single-leg stance, and tandem stance. March in place and count up to 50, tandem walking and standing on the foam.

Then, the patient is made to sit and asked to hold the card straight out in front, and move both the head and card simultaneously from left to right as they fix their eyes on the letters on the card and perform it at maximum speed as above, and continue for 30 seconds, and repeat 4 times.

Then, the patient is asked to move the arm and head in the up and down directions, next to move the arm and head in opposite directions, and, lastly, to move the arm and head in the opposite directions, but in the up and down directions.

Group B- optokinetic training:

Step 1. The patient is asked to sit on a chair and hold the screen at eye level in front of him/her. The screen moves from left to right and then from right to left. Hold on for 10 seconds.

Step 2. Repeat the previous step, except this time the screen travels from down to up and up and down.

Step 3. Now, the eyes should track the red dot on the screen.

If the patient experiences no symptoms of motion sensitivity and can see a clear image of the screen at this speed, gradually increasing the time of exposure, then the speed of the video can be increased.

Then, repeat steps 1 through 3 in the standing position, single-leg stance, and tandem stance. March in place, count up to 50, tandem walking and standing on the foam.

Statistical analysis

The collected data were tabulated and analysed using both descriptive and inferential statistics. All the parameters were assessed using a statistical package for the social sciences (SPSS) version 24, with a significance level of p-value less than 0.05 and a 95% confidence interval set for all analyses. The Shapiro-Wilk test was used to determine the normality of the data. In this study, the Shapiro-Wilk test showed that the data were normally distributed on the dependent values at $p\text{-value} > 0.05$. Hence, the parametric test was adopted. The paired t-test was adopted to find the statistical difference within the groups, and the independent t-test (Student t-Test) was adopted to find the statistical difference between the groups.

Results

MSSQ score analysis

In Table 1, comparing the mean values of Group A and Group B on MSSQ score, it shows a significant decrease in the post-test mean values in both groups, but Group A (Visual Vestibular Habituation Exercises) shows 56.67 ± 6.21 , which has the lower mean value and is more effective than Group B (Optokinetic Training), 60.26 ± 4.95 at $p\text{-value} \leq 0.05$.

Table 1 Comparison of MSSQ, MSQ, STAI, and VIDT scores between and within group A and group B in the pre and post-test

Outcome measure	Group A Pre-test (Mean±S.D.)	Group A Post-test (Mean±S.D.)	Within group comparison between pre and post test	Group B Pre-test (Mean±S.D.)	Group B Post-test (Mean±S.D.)	Within group comparison between pre and post test	Between-group comparison (Post-test) t-value (p-value)
MSSQ	70.08±5.16	56.67±6.21	t=28.93 p=0.000**	69.99±4.23	60.26±4.95	t=25.93 p=0.000**	t=-2.25, p=0.028**
MSQ	17.00±3.58	11.92±3.17	t=14.68 p=0.000**	17.04±3.20	13.48±2.63	t=11.84 p=0.000**	t=-1.89, p=0.045**
STAI	62.24±4.33	41.76±3.43	t=44.29 p=0.000**	62.32±3.42	48.60±5.12	t=19.49 p=0.000**	t=-5.54, p=0.000**
VIDT	163.72±17.97	216.72±18.23	t= -35.84 p=0.000**	163.84±20.05	196.24±22.00	t= -28.52 p=0.000**	t=3.58, p=0.001**

*p-value>0.05 means Not Significant; **p-value≤0.05 means Significant, MSSQ=Motion Sickness Susceptibility Questionnaire, MSQ=Motion Sensitivity Quotient, STAI=State Trait Anxiety Inventory, VIDT=Video Induced Dizziness Time

MSQ score analysis

In Table 1, comparing the mean values of Group A and Group B on MSQ score, it shows a significant decrease in the post-test mean values in both groups, but Group A (Visual Vestibular Habituation Exercises) shows 11.92±3.17, which has the lower mean value and is more effective than Group B (Optokinetic Training), 13.48±2.63 at p-value≤0.05.

STAI score analysis

In Table 1, comparing the mean values of Group A and Group B on STAI score, it shows a significant decrease in the post-test mean values in both groups, but Group A (Visual Vestibular Habituation Exercises) shows 41.76±3.43, which has the lower mean value and is more effective than Group B (Optokinetic Training), 48.60±5.12 at p-value≤0.05.

VIDT score analysis

In Table 1, comparing the mean values of Group A and Group B on VIDT score, it shows a significant increase in the post-test mean values in both groups, but

Group A (Visual Vestibular Habituation Exercises) shows 216.72±18.23, which has the higher mean value and is more effective than Group B (Optokinetic Training), 196.24±22.00 at p-value≤0.05.

A comparison of the pre-test and post-test within Group A and Group B on MSSQ, MSQ, STAI, and VIDT scores shows significant differences in the mean values at p-value≤0.05.

Discussion

Motion sensitivity, often known as motion sickness, is triggered by incorrect spatial orientation, causing dizziness, blurry vision, nausea, vomiting, loss of balance, and cold sweating³³. Even healthy individuals experience motion sensitivity when engaging in activities like roller coaster rides, boat rides, or reading in moving cars^{34,35}. This experimental study compared the effect of visual-vestibular habituation exercises versus optokinetic training on healthy adults with chronic motion sensitivity. The discernment of motion sensitivity, anxiety, and latency of visually induced dizziness were the outcome measures in the study.

Both interventions led to significant improvements in symptoms; however, participants in Group A (visual vestibular habituation exercises) showed a significantly greater reduction in motion sensitivity than Group B (optokinetic training). This is similar to the conclusion by Rine et al., where visual-vestibular habituation and balance training were found to be effective in reducing motion sensitivity and improving postural stability³⁶.

Optokinetic training also produced significant improvements, similar to the conclusion of Alexis Mafret et al., who found that treating sea sickness by optokinetic stimulation improves the symptoms of motion sickness. Its effects last for longer periods, and it has also been suggested that it can be used to treat other forms of motion sickness³⁷.

Pavlou (2010) suggested that visual motion videos are an economical and user-friendly method of introducing optokinetic training in vestibular rehabilitation. He suggested that improvement in the symptoms of motion sickness after predisposition to optokinetic stimuli is due to neuroplastic adaptive changes that reduce visual dependency³⁸. This study also agrees that optokinetic training using visual motion videos has shown a significant difference in the post-test values; however, visual vestibular habituation exercises showed a significantly greater improvement in VIDT-visually induced dizziness time. This supports the hypothesis that habituation promotes stronger central adaptive changes.

Shilpa B. Gaikwad et al. reported that the sham group in their study on chronic motion sensitivity showed a decrease in anxiety levels post-intervention. This study also demonstrated that both interventions showed a significant difference in the post-test values of STAI scores, thus having a considerable effect on anxiety in individuals with motion sickness³⁹.

Visual vestibular habituation exercises and optokinetic training are rehabilitative approaches where

patients are desensitised through progressive exposure to movements that provoke symptoms of motion sickness. When a sensory conflict arises, there is a disruption in the ability to select appropriate sensory input. These therapeutic approaches train individuals to maintain postural stability in circumstances in which the presence or accuracy of one or more sensory-input signals is disrupted. Optokinetic training, along with balance exercises, promotes desensitisation to visual stimuli and proprioceptive stimuli through exposure to visual motion videos and challenges of balance. Whereas visual vestibular habituation exercises, along with balance training, have a three-dimensional approach, stimulating the visual, vestibular, and proprioceptive systems through gaze stability exercises, head and neck movements, and challenges to balance; thus, this three-dimensional approach gives it an advantage over optokinetic training in treating subjects with motion sickness. When the symptoms of motion sickness are alleviated, the anxiety that is related to them is also reduced.

Thus, after analysing the results of this study, it is proven that visual-vestibular habituation exercises are more effective compared to optokinetic training because they alleviate the symptoms of motion sickness through the adaptive changes caused in the neural circuits.

Conclusion

From the results and statistical analysis, visual vestibular habituation appears effective due to its multisensory stimulation, though optokinetic training can be used, especially for patients with excessive visual dependency. Future studies should examine the long-term sustainability of improvements and examine these exercises in large and diverse populations. Research that incorporates modern technologies like virtual reality or combined rehabilitation procedures may improve the therapeutic efficacy and clinical applicability even further.

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