6-2016

Effect of Progressive Gaze Stability Exercises on Holistic Aspects of Chronic Motion Sensitivity

Shilpa B. Gaikwad

LOMA LINDA UNIVERSITY
School of Allied Health Professions
in conjunction with the
Faculty of Graduate Studies

Effect of Progressive Gaze Stability Exercises on Holistic Aspects of Chronic Motion Sensitivity

by

Shilpa B. Gaikwad

A Dissertation submitted in partial satisfaction of
the requirements for the degree
Doctor of Philosophy in Rehabilitation Sciences

June 2016

Each person whose signature appears below certifies that this dissertation in his/her opinion is adequate, in scope and quality, as a dissertation for the degree Doctor of Philosophy.

_____, Chairperson

Eric G. Johnson, Professor of Physical Therapy

_____

Noha S. Daher, Professor of Epidemiology and Biostatistics

_____

Dragana Krpalek, Assistant Professor of Occupational Therapy

_____

Todd Nelson, Assistant Professor of Physical Therapy

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to Dr. Eric G. Johnson for his expert guidance throughout my program. He was very patient and encouraging towards me. I wish to thank Dr. Noha S. Daher for her constant support and for providing her expertise of statistics in this research. I would also like to express my gratitude towards Dr. Todd Nelson's constant encouragement and Dr. Dragana Krpalek's guidance regarding qualitative aspect of my research.

I wish to thank Dr. Grenith Zimmerman without her support and trust in me, I couldn't have completed this research successfully.

This research is an example of tireless team work of my colleagues and I wish to thank them for their commitment towards it.

I would like to express my gratitude towards my family and friends, your love and support through this long endeavor was my strength. I thank my parents for always believing in me and giving me the freedom to pursue my dreams.

And finally, I would like to thank the superior spiritual power which always protects me and guides me to make the right decisions in my life and to take correct steps towards my goal.

CONTENT

FIGURES

Figures Page

TABLES

Tables Page

ABBREVIATIONS

VR	Vestibular Rehabilitation
HEP	Home Exercise Program
CDP-IVR	Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality
MSQ	Motion Sensitivity Quotient
MSSQ-Short	Motion Sensitivity Susceptibility Questionnaire Short-Form
STAI	State - Trait Anxiety Inventory for Adults (STAI Form Y-2)
SD	Standard Deviation
SE	Standard Error
BMI	Body Mass Index
C 1	CDP-IVR Condition 1
C 2	CDP-IVR Condition 2

ABSTRACT OF THE DISSERTATION

Effect of Progressive Gaze Stability Exercises on Holistic Aspects of Chronic Motion Sensitivity

by

Shilpa B. Gaikwad
Doctor of Philosophy, Graduate Program in Rehabilitation Sciences
Loma Linda University, June 2016
Dr. Eric G. Johnson, Chairperson

Background: Motion sensitivity, also referred to as motion sickness, is a common condition among general population. It is a complex syndrome and is associated with presence of nausea and vomiting headache, drowsiness, cold sweating, pallor of varying degrees, increased salivation. Postural instability and anxiety are also identified to be associated with motion sensitivity. There is a close relationship between the vestibular system and motion sensitivity and vestibular system. The aim of this study was to investigate the effect of progressive gaze stability exercises on holistic aspects of chronic motion sensitivity.

Methods: A single blind randomized controlled trial was conducted where participants were blinded to type of intervention. Forty one healthy young adults of both genders within the age group of 20 to 40 years with chronic motion sensitivity were recruited in the study. Baseline and post intervention assessment of postural stability, motion sensitivity, and anxiety was measured for each participant using, Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR), Motion Sensitivity Quotient (MSQ), Motion Sensitivity

Susceptibility Questionnaire Short Form (MSSQ-Short), and State-Trait Anxiety Inventory for Adults (STAI Form Y-2).

Results: There was a significant difference for condition 2 (p=0.05), but not for condition 1 (p=0.44) for the mean CDP-IVR average score post intervention between the intervention and sham groups. For condition 2, the intervention group had 117% increase in CDP-IVR average score compared to 35.2% increase in the sham group. Also, there was a significant difference in mean MSQ between the two groups (p=0.045). There was a significant inverse correlation between MSQ and CDP-IVR average equilibrium % of Condition 1 ($\rho = -0.44$, $p = 0.004$).

Conclusions: Progressive gaze stability exercises reduced motion sensitivity and improved postural stability in participants with chronic motion sensitivity. Also, perception of motion sensitivity was observed to be inversely correlated with postural stability. There was no impact of gaze stability exercises observed on subjective perception of anxiety among this population. Also, HEP adherence strategies were beneficial to ensure exercise adherence in participants with chronic motion sensitivity.

Keywords: Motion sensitivity, gaze stability exercises, vestibular rehabilitation, home exercise program

CHAPTER ONE

INTRODUCTION

Motion sensitivity, also referred to as motion sickness, is a common condition with a prevalence of 28% in the general population and is more common in women (27.3%) as compared to men (16.8%).[1] It is a complex syndrome which is related to the presence of nausea and vomiting headache, drowsiness, cold sweating, pallor of varying degrees, increased salivation.[2,3] Postural instability and anxiety are also identified to be associated with motion sensitivity.[4-7] There is a close relationship between the vestibular system and motion sensitivity and the pathways integrating vestibular and emetic gastrointestinal signals producing nausea and vomiting are being identified.[8]

Vestibular rehabilitation (VR) involves exercises that are administered for the intervention of vestibular dysfunction by promoting vestibular adaptation and substitution.[8] VR focuses on utilizing the plasticity of the balance system to improve the natural compensation process.[9] The aim of VR is to improve gaze and postural stability, reduce symptoms of vertigo, and to improve activities of daily life.[8] Decreased gain of vestibular response to head movements gives rise to gaze instability in patients with vestibular dysfunction.[10] Inducing retinal slip by horizontal or vertical head movements while maintaining visual fixation on a target, increases the gain of the vestibular response.[11,12] For vestibular adaptation to occur, retinal slip needs to be induced repeatedly.[11] Gaze stability exercises induce this retinal slip and they are prescribed as much as four to five times daily for a total duration of 20-40 minutes.[13]

Vestibular exercises require regular and consistent repetition for vestibular adaptation to occur, thus, patient's adherence to the HEP is a critical factor. Adherence is

defined as "the extent to which a person's behavior - taking medications, following a diet, and/or executing life-style changes, corresponds with agreed recommendations from a health care provider."[14] The level of adherence is influenced by patient's perceptions about their injuries, symptoms, and coping mechanism.[15] Adherence to HEP is even more critical for dysfunctions that may demand long-term intervention such as vestibular dysfunctions.

Although interventions like optokinetic training have been used in seasickness, there is limited research available related to intervention for terrestrial motion sensitivity, which is experienced during transportation in cars, buses, trains and recreational activities such as roller coaster rides. Based on the results of current literature, minimal dosage of vestibular adaptation exercises demonstrated improvement in postural stability of younger adults with chronic motion sensitivity.[16] Gaps were identified in the literature regarding the effectiveness of progression of gaze stability exercises on perception of motion sensitivity, anxiety and postural stability. Hence, the aim of this study was to investigate the effect of progressive gaze stability exercises on motion sensitivity and postural stability and anxiety in participants with chronic motion sensitivity.

References

1. Sharma K, and Aparna. Prevalence and correlates of susceptibility to motion sickness. Acta Genet Med Gemellol (Roma). 1997;46(2):105-21. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9492893

2. Lackner JR. Motion sickness: more than nausea and vomiting. Experimental Brain Research. 2014;232(8):2493-2510.doi:10.1007/s00221-014-4008-8

3. Graybiel A, et al. Diagnostic criteria for grading the severity of acute motion sickness. AerospMed. 1968;39(5):453-5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/5648730

4. Paillard AC, et al. Motion sickness susceptibility in healthy subjects and vestibular patients: effects of gender, age and trait-anxiety. J Vestib Res. 2013; 23(4-5):203-9. doi: 10.3233/VES-130501

5. Owen N, Leadbetter AG, and Yardley L. Relationship between postural control and motion sickness in healthy subjects. Brain Res Bull. 1998;47(5):471-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10052576

6. Bos JE. Nuancing the relationship between motion sickness and postural stability. Displays. 2011; 32(4):189-193. doi:10.1016/j.displa.2010.09.005

7. Riccio GE, and Stoffregen TA. An ecological Theory of Motion Sickness and Postural Instability. Ecological Psychology.1991;3(3):195-240. Retrieved from http://dx.doi.org/10.1207/s15326969eco0303_2

8. Han BI, Song HS, Kim JS. Vestibular rehabilitation therapy: review of indications,mechanisms, and key exercises. J Clin Neurol. 2011;7(4):184-96. doi: 10.3988/jcn.2011.7.4.184

9. NT, Telian SA, Smith-Wheelock M. Habituation and balance retraining therapy: a retrospective review. Neurologic clinics. 1990;8(2):459-475. Retrieved fromhttp://www.ncbi.nlm.nih.gov/pubmed/?term=Habituation+and+balance+retraining+therapy%3A+a+retrospective+review

10. SJ. Advances in the treatment of vestibular disorders. Phys Ther. 1997;77(6):602-18. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9184686

11. SJ. Role of vestibular adaptation in vestibular rehabilitation. Otolaryngol Head and Neck Surg. 1998;119(1):49-54. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9674514

12. GM, Robinson DA. Adaptation of the human vestibuloocular reflex to magnifying lenses. Brain Res. 1975;92(2):331-5. Retrived from http://www.ncbi.nlm.nih.gov/pubmed/1080685

13. SJ, Hall CD, Schubert MC, Das VE, Tusa RJ. Recovery of dynamic visual acuity in bilateral vestibular hypofunction. Arch Otolaryngol Head Neck Surg. 2007;133(4):383-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17438254

14. . Adherence to long-term therapies - evidence for action. Geneva: World Health Organization; 2003. Retrieved from http://www.who.int/chp/knowledge/publications/adherence_report/en/

15. BW. Adherence to sport injury rehabilitation regimens. S J Bull ed. New York: John Wiley and Sons; 1999:145-68**.** doi:10.1080/10413209808406378

16. D, et al. Effect of vestibular adaptation exercises on chronic motionsensitivity: a randomized controlled trial. Physical Therapy and Rehabilitation. 2016;3(1):1.DOI : http://dx.doi.org/10.7243/2055-2386-3-1

CHAPTER TWO

HOME EXERCISE PROGRAM ADHERENCE STRATEGIES IN VESTIBULAR REHABILITATION: A SYSTEMATIC REVIEW

Gaikwad SB[1], Mukherjee T[2], Shah PV[2], Ambode OI[2], Johnson EG[3], Daher NS[4]

[1]Doctoral Student, Loma Linda University, School of Allied Health Professions, Department of Allied Health Studies, Loma Linda, California, USA.

[2]Doctoral Student, Loma Linda University, School of Allied Health Professions, Department of Physical Therapy, Loma Linda, California, USA.

[3]Professor, Loma Linda University, School of Allied Health Professions, Department of Physical Therapy, Loma Linda, California, USA.

[4]Professor, Loma Linda University, School of Allied Health Professions, Loma Linda, California, USA.

Abstract

The aim of this systematic review was to investigate effective strategies to improve home exercise program (HEP) adherence in vestibular rehabilitation (VR). Six databases, Academic Search Premier, Cochrane Library, CINAHL, PUBMED, PsycINFO and Web of Science were searched from their inception to December 31, 2015. The keywords used for search were 'home program', 'home intervention, 'compliance', 'adherence', 'vestibular rehabilitation', 'motion sickness', and motion sensitivity'. A total of eight studies were selected to be included in the review. There was 95.2% agreement between the two reviewers who reviewed the studies using quality assessment tool. The overall inter-rater agreement ($\kappa = 0.73$) showed good agreement between the reviewers. Strong evidence was identified for 3 major categories of effective HEP adherence strategies, 1) providing patient with written summary of HEP, 2) asking patient to maintain a record of HEP and symptoms; and 3) providing tele-rehabilitation in form of email and/or telephone support along with in person treatment sessions. Also, based on strong evidence, computerized technology was not found to be superior to other strategies for improving patients' HEP adherence in VR. The effective strategies for improving HEP in VR include written summary of exercise, maintenance of log of HEP and symptoms and tele-rehabilitation along with in person treatment sessions.

Key words: Home program, home intervention, compliance, adherence, vestibular rehabilitation.

Introduction

Home exercise programs (HEP) are an integral part of physical therapy interventions. However, HEP prescription is not sufficient, but patient's adherence to HEP is critical for overall treatment outcome.[1] Adherence is defined as "the extent to which a person's behavior - taking medications, following a diet, and/or executing life-style changes, corresponds with agreed recommendations from a health care provider."[2] This adherence and its level are influenced by patient's perceptions about their injuries, symptoms, and coping mechanism.[3] Adherence to HEP is even more critical for dysfunctions that may demand long-term intervention such as vestibular dysfunctions.

Vestibular rehabilitation (VR) involves exercises that are administered for the intervention of vestibular dysfunction by promoting vestibular adaptation and substitution.[4] VR focuses on utilizing the plasticity of the balance system to improve the natural compensation process.[5] The aim of VR is to improve gaze and postural stability, reduce symptoms of vertigo, and to improve activities of daily life.[4] Decreased gain of vestibular response to head movements gives rise to gaze instability in patients with vestibular dysfunction.[6] Inducing retinal slip by horizontal or vertical head movements while maintaining visual fixation on a target, increases the gain of the vestibular response.[7,8] For vestibular adaptation to occur, retinal slip needs to be induced repeatedly.[7] Gaze stability exercises induce this retinal slip and they are prescribed as much as four to five times daily for a total duration of 20-40 minutes.[9]

Vestibular exercises require regular and consistent repetition for vestibular adaptation to occur, thus, patient's adherence to the HEP is a critical factor. Various HEP adherence strategies have been implemented in the field of vestibular rehabilitation to

ensure patient's adherence to HEP. Examples of these strategies include a recording calendar,[9] booklet-based vestibular rehabilitation and telephone support,[10] and written summary and homework assignment.[11] Among the HEP strategies available to physical therapists for providing effective VR, it is unclear which HEP strategy is most effective for improving adherence. To the best of our knowledge, there has been no systematic review conducted for investigating the HEP adherence in VR. The aim of this systematic review was to determine the most effective strategies to ensure maximum adherence to HEP among patients undergoing VR.

Methods

Data Sources and Search Strategies

An individualized search strategy was developed for each of the 6 databases in collaboration with a librarian. The following databases were searched from their inception to December 31, 2015: Academic Search Premier, Cochrane Library, CINAHL, PUBMED, PsycINFO and Web of Science. The following keywords were used: 'home program', 'home intervention', 'compliance', 'adherence', 'vestibular rehabilitation', 'motion sickness', and motion sensitivity'. The references of the studies that were identified were reviewed for further relevant citation.

Study Selection

This systematic review included studies that were: 1) published in English

language, 2) randomized controlled trials, case control studies, observational studies and cross-sectional surveys that were published in peer-reviewed journals, 3) related to VR and motion sensitivity intervention, and 4) related to implementation of HEP adherence strategies. The studies that investigated pediatric population were excluded.

Six databases were searched to identify potential relevant studies based on titles and abstracts. Also, the references of studies were reviewed to find more relevant citations. Two investigators (SG and EJ) reviewed the relevant studies to confirm whether or not they met the selection criteria. Based on the agreement of both investigators, SG and EJ, studies that met the selection criteria were included in the review.

Quality Assessment of Studies

Two reviewers (TM and PS) independently reviewed each study based on a quality assessment tool adapted from Jack et al. 2010.[12] This systematic review focused on investigating adherence to HEP and we chose to use the modified form of quality assessment tool, which consists of a standardized set of 13 predefined criteria.[12] The criteria used in the quality assessment tool checks for both internal and external validity of a study.[13] A score of 0 was given to criteria that did not meet the quality standard while a criterion that met the quality standard was given a score of one. We summed the scores of 13 criteria; the tool scoring range was 0 to 13. A study was considered to be of high quality when it received a score of ≥ 7 while a study that received a score of < 7 was considered as a low quality study according to quality assessment tool.[12]

Table 1. Quality assessment tool (adapted from Jack et al., 2010; Borghouts et al., 1998)

Criteria	Score
Study Population	
(A) Description of source population	+/-/?
(B) Description of inclusion and exclusion criteria	+/-/?
Study design	
(C) Prospective study design	+/-/?
(D) Study size $\geq$ 300	+/-/?
Drop-outs	
(E) Information completers versus loss of follow up/drop-outs	+/-/?
Prognostic factors	
(F) Description of potential prognostic factors	+/-/?
(G) Standardized or valid measurements	+/-/?
(H) Data presentation of most important prognostic factors	+/-/?
Outcome measures	
(I) Relevant outcome measures	+/-/?
(J) Standardized or valid measurements	+/-/?
(K) Data presentation of most important outcome measures	+/-/?
Analysis and data presentation	
(L) Appropriate univariate crude estimates	+/-/?
(M) Appropriate multivariate analysis techniques	+/-/?

[+ = positive (design/conduct adequate, scores 1 point); - = negative (design or conduct inadequate, scores 0 points); ? = unclear (item insufficiently described, scores 0 points)]

Data Extraction and Synthesis

Two reviewers' extracted data related to study population, study design, dropouts, prognostic factors, outcome measures, and data analysis and data presentation. Inter-

reviewer reliability of quality assessment of the research studies was examined by calculating percent agreement and kappa co-efficient. The qualitative conclusion about the effective strategies for HEP adherence was based on levels of evidence (Table 2).[12] The significance of strategies affecting adherence in VR was derived from multivariate analysis, analysis of covariance and non-parametric statistics.

Table 2: Levels of evidence

Strong	Consistent finding in at least 2 high quality cohorts/RCTs
Moderate	Finding from 1 high quality cohort/RCT and consistent findings from 1 or more low quality cohorts/RCTs
Limited	Findings from 1 high quality cohort/RCT or consistent findings from 1 or more low quality cohorts/RCTs
Conflicting	Inconsistent findings regardless of quality
No evidence	No studies found

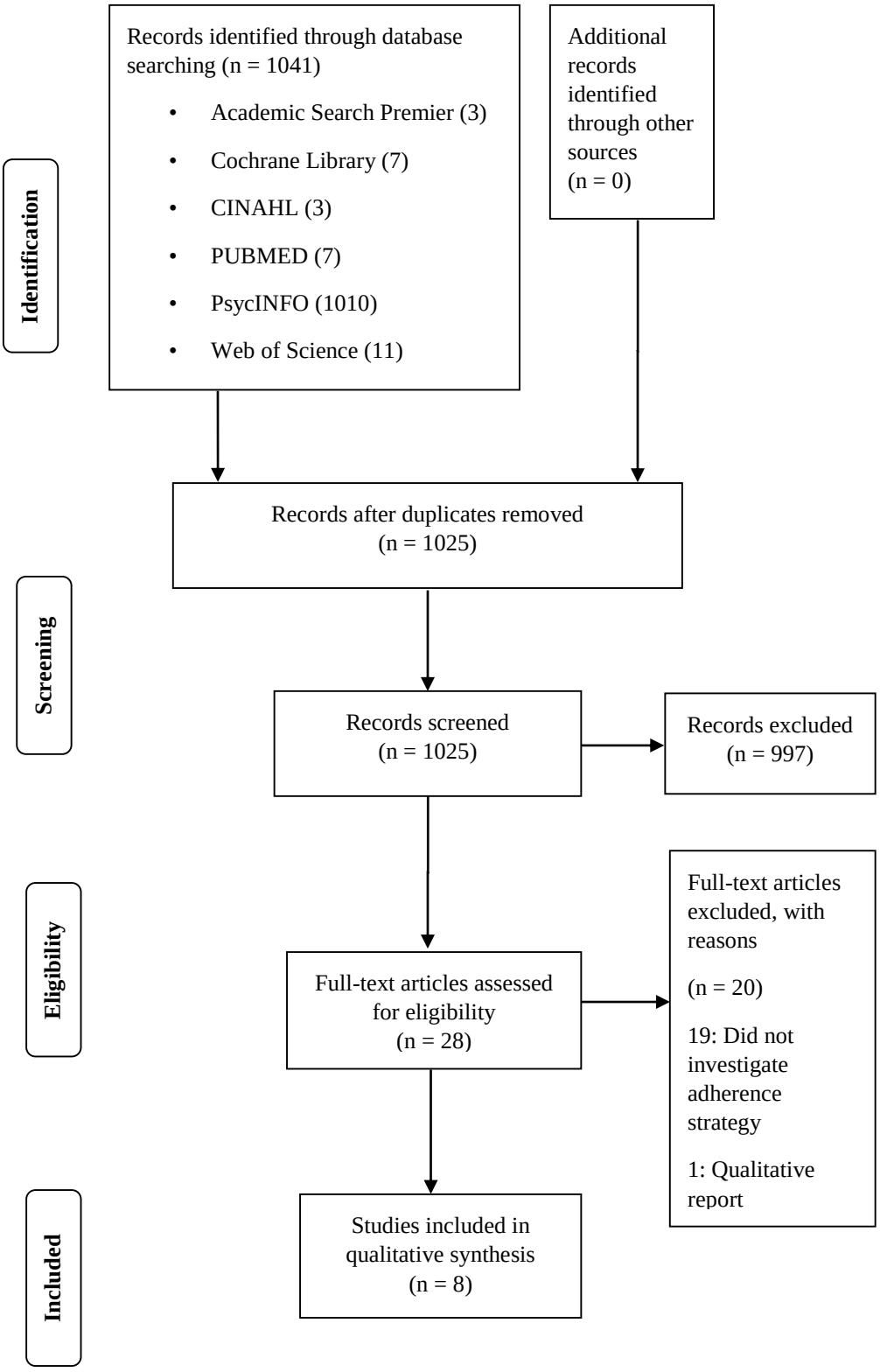

Figure 1. PRISMA flow diagram showing flow of information through the review

Results

The steps of study selection are shown in Figure 1. A total of 1041 citations were identified from six databases. After the first screening 1003 studies were excluded and 28 relevant studies were saved for secondary screening. A total of 28 studies were reviewed by two investigators SG and EJ. After achieving consensus between the opinions of these two investigators a total of eight studies were selected to be included in the review.

Methodological Quality

Two reviewers TM and PS independently scored 104 items and disagreed on 5 items (95.2% agreement). The overall inter-rater agreement ($\kappa = 0.73$) showed good agreement between the reviewers. The total score of quality assessment of the reviewed studies ranged from 9 to 13 (Table 3). This indicated that all of the studies included in the systematic review were high quality based on the quality assessment tool.

Table 3. Results of methodological assessment

Study	A	B	C	D	E	F	G	H	I	J	K	L	M	Quality Score
Meldrum et al., 2015	1	1	1	0	1	1	0	1	1	1	1	1	1	11
Pavlou et al., 2013	1	1	1	0	1	1	1	1	1	1	1	1	1	12
Smaerup et al., 2015	1	1	1	0	1	1	1	1	1	1	1	1	1	12
Yardley et al., 2004	1	1	1	0	1	1	1	1	1	0	1	1	1	11
Yardley et al., 2006	1	1	1	1	1	1	1	1	1	1	1	1	1	13
Yardley et al., 2012	1	1	1	1	1	1	1	1	1	1	1	1	1	13
Sztrum et al., 2015	1	1	1	0	1	1	1	1	1	1	1	1	1	12
Topuz et al., 2004	1	1	1	0	1	1	0	1	1	0	1	1	0	9

Study Characteristics

A total of eight studies were included in this systematic review. There were six randomized controlled trials, one case series and one prospective intervention study (Table 4). Out of eight studies, one study recruited adults with Meniere's disease,[14] four studies recruited adults with chronic dizziness.[10,15-17] One study recruited older adults with chronic dizziness,[18] and two studies recruited patients with unilateral vestibular dysfunction.[19,20]

Table 4. Study Characteristics

	Population	Intervention Duration	Intervention Description	Adherence Strategy	Results
			Randomized Controlled Trials		
1)	**Meldrum et al., 2015**	6 weeks	Conventional balance exercises during vestibular rehabilitation (36 participants)	Weekly exercise booklet, exercise diary and foam balance mat for home exercise	Both groups reported a high level of adherence to HEP: 78.5% in the conventional group and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention.
			Virtual reality-based balance exercises during vestibular rehabilitation (36 participants)	Weekly exercise booklet, exercise diary and virtual reality gaming system for home exercise	
2)	**Pavlou et al., 2013**	8 weeks	Optokinetic training via a full-field visual environment rotator (20 participants)	Customized exercises and video for HEP; diary record of symptoms was reviewed at each session	Dropout rate was significantly higher 55% for unsupervised exercise group compared to 10% dropout rate for both supervised exercise groups. There was no significant difference
			Optokinetic training supervised video (20 participants)	Customized exercises and video for HEP; diary record of symptoms was reviewed at each session	

			No supervised physical therapy session (20 patients)	Customized exercises and video HEP; diary record of symptoms was reviewed at final session only	between the groups post intervention.
3)	**Smaerup et al., 2015**	16 weeks	Vestibular rehabilitation with computer assisted HEP (32 participants)	HEP was assisted with computer training program "Move It To Improve It" (Mittii)	Overall compliance rate for computer program exercise was 57% and there was no significant difference between the groups post intervention.
			Vestibular rehabilitation with printed instructions assisted HEP (31 patients)	HEP was assisted with printed instructions	
4)	**Yardley et al., 2004**	12 weeks	Vestibular rehabilitation (VR) and treatment booklet (83 patients)	**First 3 months:** Booklet and telephone call support was provided by nurses at 1 and 3 weeks after initial session **Next 3 months:** None	Self-reported adherence was fair, as 71% of patients carried out the exercises most days of the weeks, 55% continued the exercises for at least 9 weeks or until symptoms subsided. Telephone counseling was given to 85% of patients 1 week after initial session and to 76% of patients 3 weeks after initial session. There was a significant difference between groups at 3 month follow up post intervention as VR group showed significant
			Usual medical care (87 patients)	**First 3 months**: None **Next 3 months:** Booklet and telephone call support was provided by nurses at 1 and 3 weeks after initial session	

					improvement on all primary outcome measures.
5)	**Yardley et al., 2006**	12 weeks	Booklet-based education in vestibular rehabilitation (VR) (120 patients)	VR booklet for daily balance training exercises performed at home including instruction on how to tailor them to particular symptoms experienced	Adherence was significantly different between groups with 50% of SC group reporting adherence to exercises compared to 37.5% of the VR group. There was a significant interaction between level of adherence and change over time in secondary outcome measures post intervention.
			Symptom control self-management booklet (SC) (120 patients)	SC booklet gave details concerning how to carry out daily relaxation and controlled breathing exercises and how to use distraction to reduce attention to symptoms	
			Waiting list control without booklet (120 patients)		
6)	**Yardley et al., 2012**	12 weeks	Booklet-based vestibular rehabilitation (VR) (113 patients)	Exercise booklet provided comprehensive advice on undertaking VR HEP daily for up to 12 weeks using cognitive behavioral techniques to promote positive beliefs and treatment adherence	Adherence to exercise was 44% for the booklet self management along with telephone support group, while it was 34% in the booklet self management only group. This difference was not significant between groups.
			Booklet-based vestibular rehabilitation (VR) with telephone support (112 patients)	Exercise booklet provided comprehensive advice on undertaking VR HEP daily for up to 12 weeks to promote treatment adherence; also, three brief sessions of telephone support was offered from a vestibular therapist	

			Routine medical care (112 patients)		
			Case Series		
7)	**Sztrum et al., 2015**	12 weeks	Home-based computer game vestibular rehabilitation (9 patients)	Home-based computer game with head rotation input device provided a simple method of grading gaze exercises; weekly email or telephone call was given to monitor progress, answer questions and to progress exercises; weekly exercise log was maintained by patients	All patients performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. Daily exercise log showed that average exercise time was 35.4 minutes per session which exceeded the instructed exercise time.
			Prospective Intervention Study		
8)	**Topuz et al., 2004**	8 weeks	Clinic (112 patients) and Home (93 patients)	Patients continued same exercises at home with support of a written HEP on a daily basis for 6 weeks; HEP adherence was monitored with a daily chart completed by patients	Post intervention 80% patients showed improvement on outcome measures. Faster recovery was noticed during supervised sessions in clinic while there was no significant improvement noticed at the end of stage 2 of intervention.

HEP Adherence Strategies

The HEP adherence strategies used in eight studies included in this systematic review were grouped into four main categories: 1) HEP with written summary of exercises, 2) HEP with computerized technology, 3) HEP with tele-rehabilitation, and 4) HEP with exercise maintenance log.

1) HEP with Written Summary of Exercises

Six high quality studies investigated the use of written summary of exercises to improve patient's HEP adherence. Yardley et al., 2006 used two types of self-help symptom management booklets to manage vertigo and dizziness in patients with Meniere's disease, booklet-based education in VR versus symptom control self-management booklet (SC) versus control. As compared to the 15.8% patient improvement that was observed in control group, the VR and SC group showed 37.5% and 39.2% improvement respectively. When compared to control group, both booklet-based intervention groups reported greater ability to understand and cope with symptoms ($p < 0.001$). Adherence was significantly different between the intervention groups with 50% of SC group reporting adherence to HEP as compared to 37.5% of the VR group. This study provided evidence that patients' HEP adherence can be improved with booklet-based self-management HEP.

Smaerup et al., 2015 compared the effectiveness of VR in clinic along with computer program assisted HEP to VR in clinic with printed exercise instruction assisted HEP for older adults with chronic dizziness. There was no significant difference between the two groups post intervention. The compliance rate to computer program exercise was

57%. This study provided evidence that computer program assisted HEP was not more effective in improving outcome and treatment adherence than printed exercise instruction assisted HEP.

Yardley et al., 2012 studied the effectiveness of booklet-based VR versus booklet-based VR with telephone support versus routine medical care. Adherence to exercise was 44% for the booklet self-management along with telephone support group, while it was 34% in the booklet self-management only group. This difference was not significant, but the group with telephone support carried out the exercises at a greater intensity than the booklet only group. This study provided evidence that both booklet interventions with or without telephone support were highly cost effective.

Yardley et al., 2004 investigated effectiveness of exercise booklet and telephone call supported HEP to usual medical care in adults with chronic dizziness. Self-reported adherence was fair, 71% of participants carried out the exercises most of the days of the week, 55% continued the exercises for at least 9 weeks or until symptoms subsided. Telephone counseling was given to 85% of participants 1 week after initial session and to 76% of participants 3 weeks after initial session. At 3 months follow up post intervention, VR group showed significant improvement on all primary outcome measures as compared to usual medical care group. This study provided evidence that exercise booklet along with telephone call supported HEP provided a fair level of adherence to exercise program.

Topuz et al., 2004, studied the post intervention results of clinical along with home VR that was supported with written exercise instructions for patients with unilateral chronic vestibular dysfunction. At the end of the first stage (clinic), 68.8% of patients

were in the exercise program while at the end of second stage (home program), 65.6% of patients continued to be in the exercise program. Post intervention, 80% patients showed improvement on outcome measures. Faster recovery was noticed during supervised sessions in clinic while there was no significant improvement noticed at the end of stage 2 of intervention. This study provided evidence that written instruction helps to ensure patients' adherence to HEP.

Meldrum et al., 2015, investigated HEP adherence with conventional balance exercise in VR versus virtual reality gaming system-based HEP in patients with unilateral peripheral vestibular loss. Patients in both groups were given an exercise booklet to refer for HEP and they also maintained an exercise diary. A high level of adherence to exercise was reported for groups, 78.5% in the conventional group and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention. This study provided evidence that referring to an exercise booklet and maintenance of exercise dairy for both virtual reality gaming system-based balance exercises and conventional balance exercises reported high level of adherence to HEP.

2) HEP with Computerized Technology

Four high quality studies investigated the effectiveness of computerized technology to improve patient's HEP adherence. Meldrum et al., 2015, investigated HEP adherence with conventional balance exercise in VR versus virtual reality gaming system-based HEP in patients with unilateral peripheral vestibular loss. Both groups reported a high level of adherence to exercise, 78.5% in the conventional group and 77.1% in the virtual reality group. There was no significant difference between the

groups post intervention. This study provided evidence that virtual reality gaming system-based balance exercises are not more effective as compared to conventional balance exercises for improving patient's HEP adherence.

Pavlou et al., 2013, studied effectiveness of supervised physical therapy session of optokinetic training via a full-field visual environment rotator (OKF) versus supervised physical therapy session of optokinetic training with digital versatile disk (video) versus unsupervised video for HEP. Each group received customized exercises video for HEP. The dropout rate was significantly high, 55% for unsupervised exercise group (OKU) compared to 10% dropout rate for both supervised exercise groups (OKF and OKS). There was no significant difference in the outcome measures among the groups post intervention. This study provided evidence that instructing patients to follow video alone for HEP is not effective for decreasing the patients' dropout rate and hence doesn't help to improve their HEP adherence.

Smaerup et al., 2015 compared the effectiveness of a computer assisted HEP versus conservative home training with printed exercise instructions in older adults with chronic dizziness. There was no significant difference between both programs with the reported compliance rate for computer program exercise being 57%. This study provided evidence that computer program assisted HEP was not more effective in improving outcome and treatment adherence than printed exercise instruction assisted HEP.

Sztrum et al., 2015, studied the post intervention effect of home computer game-based VR in adults with peripheral vestibular dysfunction. There were no dropouts, 100% adherence to exercise program, and all participants performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. A limitation

addressed by the authors was that the study was a pre post-case series with no comparisons that can be made to the existing VR. This study provided evidence that use of computer game-based VR can improve HEP adherence.

3) HEP with Tele-Rehabilitation

Three high quality studies investigated the effectiveness of tele-rehabilitation to improve HEP adherence. Yardley et al., 2012 studied the effectiveness of booklet-based VR versus booklet-based VR with telephone support versus routine medical care. Adherence to exercise was 44% for the booklet self-management along with telephone support group, while it was 34% in the booklet self-management only group. This difference was not significant but the group with telephone support reported carrying out the exercises at a greater intensity than the booklet only group. This study provided evidence that both booklet interventions with or without telephone support were highly cost effective.

Yardley et al., 2004 investigated effectiveness of exercise booklet and telephone call supported HEP to usual medical care in adults with chronic dizziness. Self-reported adherence was fair, 71% of participants carried out the exercises most days of the weeks, and 55% continued the exercises for at least 9 weeks or until symptoms subsided. Telephone counseling was given to 85% of participants 1 week after initial session and to 76% of participants 3 weeks after initial session. At 3 months follow up post intervention, VR group showed significant improvement on all primary outcome measures as compared to usual medical care group. This study provided evidence that exercise booklet along with telephone call supported HEP gives a fair level of adherence to HEP.

Sztrum et al., 2015, studied the post intervention effect of home computer game-based VR in adults with peripheral vestibular dysfunction. Weekly email or telephone contact was made with patients to monitor progress, answer questions, and to progress exercises. Also, weekly exercise log was maintained by patients. Daily exercise log showed that average exercise time was 35.4 minutes per session, with 5 sessions per week, which exceeded the 20 minutes time per session that the patients were instructed to perform. There were no dropouts, 100% adherence to exercise program, and all patients performed HEP for 12 weeks. There was a significant difference in the outcome measures post intervention. A limitation addressed by the authors was that the study was a pre post-case series with no comparisons that can be made to the existing VR. This study provided evidence that use of computer game-based VR along with weekly email or telephone call can improve patient's HEP adherence.

4) HEP with Exercise Maintenance Log

Four high quality studies investigated the effectiveness of maintenance of exercise log to improve patient's HEP adherence. Meldrum et al., 2015, investigated HEP adherence with conventional balance exercise in VR versus virtual reality gaming system-based HEP in patients with unilateral peripheral vestibular loss. Patients in both groups maintained an exercise diary. A high level of adherence to HEP was reported for groups, 78.5% in the conventional group, and 77.1% in the virtual reality group. There was no significant difference between the groups post intervention. This study provided evidence that maintenance of exercise diary for both virtual reality gaming system-based

balance exercises and conventional balance exercises reported high level of adherence to HEP.

Pavlou et al., 2013, studied effectiveness of supervised physical therapy session of optokinetic training via a full-field visual environment rotator (OKF) versus supervised physical therapy session of optokinetic training (OKS) with video versus unsupervised (OKU) video for HEP. Each group received customized exercises video for HEP. Each group maintained a dairy to record frequency, duration, and symptom level for each customized and video HEP. Diary was reviewed at each session for OKF and OKS group, while for OKU group the diary was reviewed at the final session only. The dropout rate was significantly high, 55% for unsupervised exercise group (OKU) compared to 10% dropout rate for both supervised exercise groups (OKF and OKS). There was no significant difference in the outcome measures among the groups post intervention. This study provided evidence that supervised exercise sessions along with video for HEP and maintenance of dairy to record exercise symptoms helps to decrease the patients' dropout rate and hence, improve their HEP adherence.

Sztrum et al., 2015, studied the post intervention effect of home computer game-based VR in adults with peripheral vestibular dysfunction. Weekly email or telephone contact was made with patients to monitor progress, answer questions, and to progress exercises. Also, patients maintained a weekly exercise log. Daily exercise log showed that average exercise time was 35.4 minutes per session, patients performed 5 sessions per week, which exceeded the 20 minutes time per session that they were instructed to perform. There were no dropouts, 100% adherence to HEP and all patients performed HEP for 12 weeks. There was a significant difference in the outcome measures post

intervention. A limitation that was addressed by the authors was that the study was a pre post-case series with no comparisons that can be made to the existing VR. This study provided evidence that use of computer game-based VR along with weekly email or telephone call and maintenance of daily exercise log can improve HEP adherence.

Topuz et al., 2004, studied the post intervention results of clinical along with home VR that was supported with written exercise instructions for patients with unilateral chronic vestibular dysfunction. Patients maintained a daily exercise chart. At the end of first stage (clinic), 68.8% of patients were in the exercise program, while at the end of second stage (home program) 65.6% of patients continued to be in the exercise program. Post intervention, 80% of the patients showed improvement on outcome measures. Faster recovery was noticed during supervised sessions in clinic while there was no significant improvement at the end of stage 2 of intervention. This study provided evidence that written exercise instructions and maintenance of a daily exercise chart by patients helps to ensure their adherence to HEP.

Discussion

This systematic review evaluated eight high quality studies. Strong evidence was identified for 3 categories of strategies used in VR HEP adherence research. These categories included providing patient with written summary of HEP, asking patient to maintain HEP record and symptoms, and providing tele-rehabilitation along with in person treatment sessions. Strong evidence was reported for computerized technology not been more effective for improving HEP adherence (e.g. home-based computer gaming

program, unsupervised use of HEP video and home-based virtual reality program) than other strategies.

Non-adherence to HEP is influenced by multidimensional factors.[21] A combination of specific adherence strategies such as telephone follow-up, supportive care, information, reminders, and self-monitoring were identified as helpful in improving treatment adherence in varying populations.[22,23,24] In a systematic review conducted to investigate exercise adherence in patients with Parkinson's disease, it was reported that several trials identified maintenance of daily log of exercise helps to achieve high level of HEP adherence in patients.[25]

In this systematic review, strong evidence was identified for providing patients with a written summary of the HEP in the form of HEP booklet and printed HEP (6 trials, 1,207 participants). Strong evidence was also identified for patients maintaining the record of exercise and symptoms influenced their adherence to HEP and the overall outcome of intervention (4 trials, 234 participants). Also, tele-rehabilitation in the form of email support or telephone support along with in person treatment session showed strong evidence for improving HEP adherence and the outcome of the treatment program (3 trials, 516 participants). Strong evidence was reported for computerized technology not been more effective for improving HEP adherence in VR (4 trials, 204 participants) than other strategies.

Studies published in non-indexed journals, unpublished studies and those published in languages other than English may have been missed. Smaerup et al., 2015, did not report the HEP adherence rate for the control group, which can affect the confidence in the finding of the studies included in this systematic review. Identification

of just eight studies in this systematic review could thereby limit the conclusion that can be drawn. This emphasizes the necessity for further investigation of HEP adherence strategies in VR.

Conclusion

This systematic review included 8 relevant studies. Strong evidence was identified for 3 major categories of effective HEP adherence strategies including providing patients with written summary of HEP, asking patients to maintain a record of HEP and symptoms, and providing tele-rehabilitation in the form of email and/or telephone support along with in person treatment sessions. Finally, strong evidence indicated that computerized technology was not superior to other strategies for improving HEP adherence in VR. Further research is needed to identify the barriers influencing patients' HEP adherence in VR. Identification of barriers to adherence may help to develop more strategies to enhance HEP adherence in VR.

References

1. Sluijs EM, Kok GJ, van der Zee J. Correlates of exercise compliance in physical therapy. Phys Ther. 1993;73(11):771-82. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8234458

2. WHO. Adherence to long-term therapies - evidence for action. Geneva: World Health Organization; 2003. Retrieved from http://www.who.int/chp/knowledge/publications/adherence_report/en/

3. Brewer BW. Adherence to sport injury rehabilitation regimens. S J Bull ed. New York: John Wiley and Sons; 1999. p.145-68. doi:10.1080/10413209808406378

4. Han BI, Song HS, Kim JS. Vestibular rehabilitation therapy: review of indications, mechanisms, and key exercises. J Clin Neurol. 2011;7(4):184-96. doi: 10.3988/jcn.2011.7.4.184

5. Shepard NT, Telian SA, Smith-Wheelock M. Habituation and balance retraining therapy: a retrospective review. Neurologic clinics. 1990;8(2):459-475. Retrieved fromhttp://www.ncbi.nlm.nih.gov/pubmed/?term=Habituation+and+balance+retraining+therapy%3A+a+retrospective+review

6. Herdman SJ. Advances in the treatment of vestibular disorders. Phys Ther. 1997;77(6):602-18. . Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9184686

7. Herdman SJ. Role of vestibular adaptation in vestibular rehabilitation. Otolaryngol Head and Neck Surg. 1998;119(1):49-54. Retrieved fromhttp://www.ncbi.nlm.nih.gov/pubmed/9674514

8. Gauthier GM, Robinson DA. Adaptation of the human vestibuloocular reflex to magnifying lenses. Brain Res. 1975;92(2):331-5. Retrived from http://www.ncbi.nlm.nih.gov/pubmed/1080685

9. Herdman SJ, Hall CD, Schubert MC, Das VE, Tusa RJ. Recovery of dynamic visual acuity in bilateral vestibular hypofunction. Arch Otolaryngol Head Neck Surg. 2007;133(4):383-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17438254

10. Yardley L, Barker F, Muller I, Turner D, Kirby S, Mullee M, et al. Clinical and cost effectiveness of booklet based vestibular rehabilitation for chronic dizziness in primary care: single blind, parallel group, pragmatic, randomized controlled trial. BMJ. 2012;344. doi: http://dx.doi.org/10.1136/bmj.e2237

11. Johansson M, Akerlund D, Larsen HC, Andersson G. Randomized controlled trial of vestibular rehabilitation combined with cognitive-behavioral therapy for dizziness in older people. Otolaryngol Head Neck Surg. 2001;125(3):151-6. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11555746

12. Jack K, McLean SM, Moffett JK, Gardiner E. Barriers to treatment adherence in physiotherapy outpatient clinics: a systematic review. Man Ther. 2010;15(3-2):220-8. doi: 10.1016/j.math.2009.12.004

13. Borghouts JA, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systematic review. Pain. 1998;77(1):1-13. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9755013

14. Yardley L, Kirby S. Evaluation of booklet-based self-management of symptoms in Meniere's disease: a randomized controlled trial. Psychosom Med. 2006;68(5):762-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17012531

15. Szturm T, Reimer KM, Hochman J. Home-based computer gaming in vestibular rehabilitation of gaze and balance impairment. Games Health J. 2015;4(3):211-20. doi: 10.1089/g4h.2014.0093

16. Pavlou M, Bronstein AM, Davies RA. Randomized trial of supervised versus unsupervised optokinetic exercise in persons with peripheral vestibular disorders. Neurorehabil Neural Repair. 2013;27(3):208-18. doi: 10.1177/1545968312461715

17. Yardley L, Donovan-Hall M, Smith HE, Walsh BM, Mullee M, Bronstein AM. Effectiveness of primary care-based vestibular rehabilitation for chronic dizziness. Ann Intern Med. 2004;141(8):598-605. http://www.ncbi.nlm.nih.gov/pubmed/15492339

18. Smaerup M, Gronvall E, Larsen SB, Laessoe U, Henriksen JJ, Damsgaard EM. Computer-assisted training as a complement in rehabilitation of patients with chronic vestibular dizziness-a randomized controlled trial. Arch Phys Med Rehabil. 2015;96(3):395-401.doi: 10.1016/j.apmr.2014.10.005

19. Meldrum D, Herdman S, Vance R, Murray D, Malone K, Duffy D, et al. Effectiveness of conventional versus virtual reality-based balance exercises in vestibular rehabilitation for unilateral peripheral vestibular loss: results of a randomized controlled trial. Arch Phys Med Rehabil. 2015;96(7):1319-28.e1. doi: 10.1016/j.apmr.2015.02.032.

20. Topuz O, Topuz B, Ardic FN, Sarhus M, Ogmen G, Ardic F. Efficacy of vestibular rehabilitation on chronic unilateral vestibular dysfunction. Clin Rehabil. 2004;18(1):76-83. http://www.ncbi.nlm.nih.gov/pubmed/14763722

21. Kolt GS, Brewer BW, Pizzari T, Schoo AMM, Garrett N. The sport injury rehabilitation adherence scale: a reliable scale for use in clinical physiotherapy. Physiotherapy. 2007;93(1):17-22. Retrieved from http://www.academia.edu/953425/The_Sport_Injury_Rehabilitation_Adherence_Scale_a_reliable_scale_for_use_in_clinical_physiotherapy

22. McLean SM, Burton M, Bradley L, Littlewood C. Interventions for enhancing adherence with physiotherapy: A systematic review. Man Ther. 2010;15(6):514-21. doi: 10.1016/j.math.2010.05.012.

23. Haynes RB, Ackloo E, Sahota N, McDonald HP, Yao X. Interventions for enhancing medication adherence. Cochrane Database Syst Rev. 2008(2):CD000011. doi: 10.1002/14651858.CD000011.pub3.

24. Schroeder K, Fahey T, Ebrahim S. Interventions for improving adherence to treatment in patients with high blood pressure in ambulatory settings. Cochrane Database Syst Rev. 2004;(2):CD004804. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15106262

25. Allen NE, Sherrington C, Suriyarachchi GD, Paul SS, Song J, Canning CG. Exercise and motor training in people with Parkinson's disease: a systematic review of participant characteristics, intervention delivery, retention rates, adherence, and adverse events in clinical trials. Parkinson's disease. 2012;2012. http://dx.doi.org/10.1155/2012/854328

CHAPTER THREE

EFFECT OF PROGRESSIVE GAZE STABILITY EXERCISES ON HOLISTIC ASPECTS OF CHRONIC MOTION SENSITIVITY - A SINGLE BLIND RANDOMIZED CONTROLLED TRIAL

Gaikwad SB[1], Johnson EG[2], Nelson TC[3], Daher NS[4], Krpalek D[5], Ambode OI[6]

Albalwi AA[6], Alharbi AA[6]

[1]Doctoral Student, Loma Linda University, School of Allied Health Professions, Department of Allied Health Studies, Loma Linda, California, USA.

[2]Professor, Loma Linda University, School of Allied Health Professions, Department of Physical Therapy, Loma Linda, California, USA.

[3]Assistant Professor, Loma Linda University, School of Allied Health Professions, Department of Physical Therapy, Loma Linda, California, USA.

[4]Professor, Loma Linda University, School of Allied Health Professions, Loma Linda, California, USA.

[5] Assistant Professor, Loma Linda University, School of Allied Health Professions, Department of Occupational Therapy, Loma Linda, California, USA.

[6]Doctoral Student, Loma Linda University, School of Allied Health Professions, Department of Physical Therapy, Loma Linda, California, USA.

Abstract

Background: Motion sensitivity, also referred to as motion sickness, is a common condition among general population. It is a complex syndrome and is associated with presence of nausea and vomiting headache, drowsiness, cold sweating, pallor of varying degrees, increased salivation. Postural instability and anxiety are also identified to be associated with motion sensitivity. There is a close relationship between the vestibular system and motion sensitivity and vestibular system. The aim of this study was to investigate the effect of progressive gaze stability exercises on holistic aspects of chronic motion sensitivity.

Methods: A single blind randomized controlled trial was conducted where participants were blinded to type of intervention. Forty one healthy young adults of both genders within the age group of 20 to 40 years with chronic motion sensitivity were recruited in the study. Baseline and post intervention assessment of postural stability, motion sensitivity, and anxiety was measured for each participant using, Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR), Motion Sensitivity Quotient (MSQ), Motion Sensitivity Susceptibility Questionnaire Short Form (MSSQ-Short), and State-Trait Anxiety Inventory for Adults (STAI Form Y-2).

Results: There was a significant difference for condition 2 ($p=0.05$), but not for condition 1 ($p=0.44$) for the mean CDP-IVR average score post intervention between the intervention and sham groups. For condition 2, the intervention group had 117% increase in CDP-IVR average score compared to 35.2% increase in the sham group. Also, there was a significant difference in mean MSQ between the two groups ($p=0.045$). There was

a significant inverse correlation between MSQ and CDP-IVR average equilibrium % of Condition 1 ($\rho = -0.44$, $p = 0.004$).

Conclusions: Progressive gaze stability exercises reduced motion sensitivity and improved postural stability in participants with chronic motion sensitivity. Also, perception of motion sensitivity was observed to be inversely correlated with postural stability. There was no impact of gaze stability exercises observed on subjective perception of anxiety among this population. Also, HEP adherence strategies were beneficial to ensure exercise adherence in participants with chronic motion sensitivity.
Keywords: Motion sensitivity, gaze stability exercises, vestibular rehabilitation, home exercise program

Introduction

Motion sensitivity, also referred to as motion sickness, is a common condition with a prevalence of 28% in the general population and is more common in women (27.3%) as compared to men (16.8%).[1] There are several definitions of motion sensitivity available including the onset of vomiting or nausea experienced by land, air, sea, or space traveler resulting in impaired function.[2-4] Also, according to the neural mismatch model proposed by Reason et al., motion sensitivity can be defined as "a self-inflicted maladaptation phenomenon that occurs at the onset and cessation of conditions of sensory rearrangement when the prevailing inputs from the visual and vestibular systems are at variance with stored patterns derived from previous transactions with the spatial environment."[4]

Motion sensitivity is almost always associated with the presence of nausea and vomiting but it is a complex syndrome in itself.[5] In addition to nausea and vomiting, symptoms of motion sensitivity can also include headache, drowsiness, cold sweating, pallor of varying degrees, and increased salivation.[6] Postural instability and anxiety are also identified to be related to motion sensitivity.[7-10] Considering the complex nature of motion sensitivity, it can occur during various forms of mode of transportation such as, sea travel by ship, space flight, terrestrial transportation including car, bus or train transport as well as during roller coaster rides, and exposure to oscillating visual field motion. Motion sensitivity can be provoked by pitch or roll head movements while rotating, which causes bizarre patterns of stimulation of the semicircular canals called as "Coriolis cross-coupling."[5,6,11,12] Evidence shows that motion sensitivity experienced during vehicular transportation generates nausea at a mechanical frequency of

approximately 0.2 Hz.[13] This frequency dependent nausea is believed to be occurring because of a phase error in signaling motion between semicircular canal-otolith and somatosensory systems, or a frequency dependent phase error between the sensed vertical and the expected vertical position.[14] Based on the various investigations conducted to determine the etiology and symptoms of motion sensitivity, the conflict between visual and vestibular information can be the probable underlying mechanism responsible for this ailment, andthis mechanism is also related to visual stabilization and postural control.[15,16]

Various interventions are available for motion sensitivity including pharmacological and behavioral. Pharmacological interventions have been the most common choice of treatment for motion sensitivity for many years. Antimuscarinics (e.g. scopolamine), H_1 antihistamines (e.g., dimenhydrinate), and sympathomimetics (e.g., amphetamines) are the common drugs of choice but they have side effects such as sedation.[14,17] There is a close relationship between the vestibular system and motion sensitivity, and the pathways integrating vestibular and emetic gastrointestinal signals producing nausea and vomiting are being identified.[18] The reduced level of motion susceptibility is associated with shorter time constants of the central vestibular velocity store.[5] Evidence indicates that more than the time constant, the ability to modify the time constant may be an important criteria in motion sensitivity improvement.[14] Also, the thresholds of cervical vestibular-evoked myogenic potential are known to predict the habituation to seasickness.[19] There is evidence of reduction in seasickness seen in subjects who underwent optokinetic training.[20] Vestibular rehabilitation involving gaze stability exercises has been reported as an effective intervention for vestibular dysfunction.[21,22]

Although interventions like optokinetic training have been used in seasickness, there is limited research available related to treatment of terrestrial motion sensitivity, which is experienced during transportation in cars, buses, trains, and recreational activities such as roller coaster rides. Results from a recent study showed that minimal dosage of vestibular adaptation exercises improved postural stability of younger adults with chronic motion sensitivity.[23] Gaps were identified in the literature regarding the effectiveness of progression of gaze stability exercises on perception of motion sensitivity, anxiety and postural stability. Hence, the aim of this study was to investigate the effect of progressive gaze stability exercises on motion sensitivity and postural stability and anxiety in participants with chronic motion sensitivity.

Methods

Participants

Forty one participants of both genders were recruited from Loma Linda University and surrounding community. Participants within the age group of 20 to 40 years with history of chronic motion sensitivity, normal cervical range of motion, and MSQ of more than zero but less than 30 were included in the study. Participants with history of vestibular dysfunction, central nervous system dysfunction, head or neck injury, migraine, seizure disorder, any musculoskeletal dysfunction that limited their participation in the study, and those who could not discontinue the consumption of anti-motion sensitivity medication were excluded from the study. Ethical approval for this study was granted by institutional review board of Loma Linda University and all participants provided written informed consent.

Study Design and Randomization

A single blind randomized controlled trial was conducted where participants were blinded to the type of intervention. Participants were randomly assigned to either intervention group (n = 21) or sham group (n = 20) using a random number table.

Study Procedures

Participants in the experimental group performed gaze stability exercises daily while those in the sham group performed saccadic eye movement exercise daily. Both groups performed their respective exercises for duration of six weeks. Participants from both groups used exercise card with the letter E optotype imprinted on it (Figure 5)

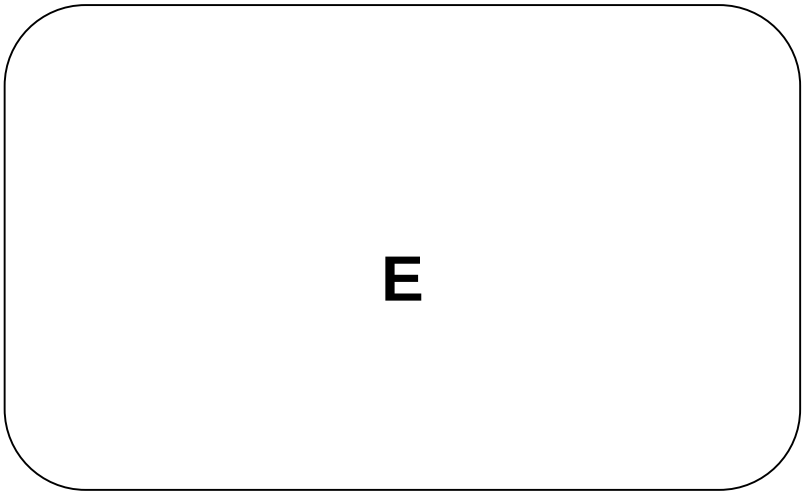

Figure 1. Exercise card

Gaze Stability Exercises (Appendix C) [22, 23]

Participants in the experimental group performed the gaze stability exercises using a hand held or wall mounted exercise card. While keeping the eyes focused on the

optotype, participants smoothly rotated their head horizontally from side to side as tolerated for 1 minute followed by a rest period of 1 minute. This was repeated for 5 minutes one time a day during week one. From week 2 onward until week 6, exercise progression included duration (minimum 5 minutes and maximum 10 minutes daily), frequency (minimum one time and maximum 2 times daily), amplitude (as tolerated), velocity (as tolerated), and directionality of head movements (horizontal and vertical).

Sham Exercises (Appendix D) [21]

Participants in the sham group performed saccadic eye movement exercises using a hand held or wall mounted card. While keeping the eyes focused on the optotype, participants performed saccadic eye movements horizontally from side to side without moving their head for 1 minute followed by a rest period of 1 minute. The sequence of eye movements included center for 20 seconds, left for 20 seconds, and right for 20 seconds. This was repeated for 5 minutes one time a day during week one. From week 2 onward until week 6, exercise progression was made based on duration (minimum 5 minutes and maximum 10 minutes daily), frequency (minimum one time and maximum 2 times daily), and directionality of eye movements (horizontal and vertical).

To ensure participants' adherence to exercise program, various home program adherence strategies were implemented during these six weeks for both groups. These techniques were: 1) participants were given written instructions of the exercises; 2) weekly text and email reminder was sent to participants about their weekly follow up visit; 3) participants were given an exercise log sheet for every week to be returned during weekly follow up visit (Appendix B); 4) weekly in person or tele-rehabilitation

visit using FaceTime® [Apple Inc] or Skype™ was scheduled according to participants' convenience;[24-26] and 5) weekly subjective examination was conducted using a weekly assessment form during follow up visit (Appendix A).

Outcome Measures

Baseline and post intervention assessment of postural stability, motion sensitivity, and anxiety was measured for each participant. The following measurement tools were used: 1) Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR) [30-33]; 2) Motion Sensitivity Quotient (MSQ);[27] Motion Sensitivity Susceptibility Questionnaire Short From (MSSQ-Short),[28,29] and State - Trait Anxiety Inventory for Adults (STAI Form Y-2)[7,38]

Bertec Balance Advantage-Dynamic Computerized Dynamic Posturography with Immersion Virtual Reality (CDP-IVR)[30-33]

This tool provides the objective outcome measure of postural stability and had been shown to have good test-retest reliability (ICC=0.66; 95% CI (0.49, 0.79)[34] The equipment consists of a 20" x 18" x 1.5" (W x L x H) dual balance force plate split into left and right halves, 22" 1080p LED curved virtual reality projection screen, a computer, Bertec Balance Advantage™ software, and adj ustable balance standard harness for dynamic systems with 300 pounds max load capacity (Figure 1, 2)[35]

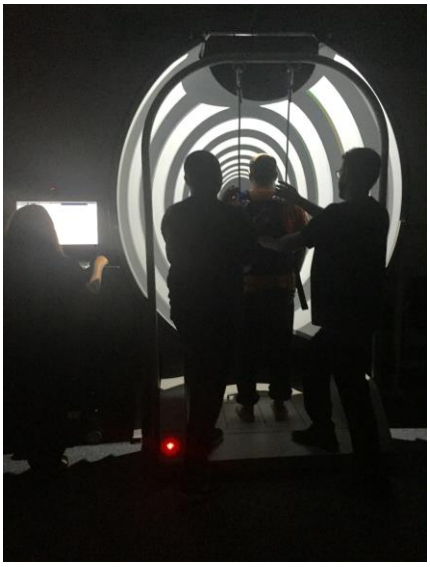

Figure 2. Bertec Balance Advantage- Dynamic CDP with Immersion Virtual Reality (CDP-IVR).

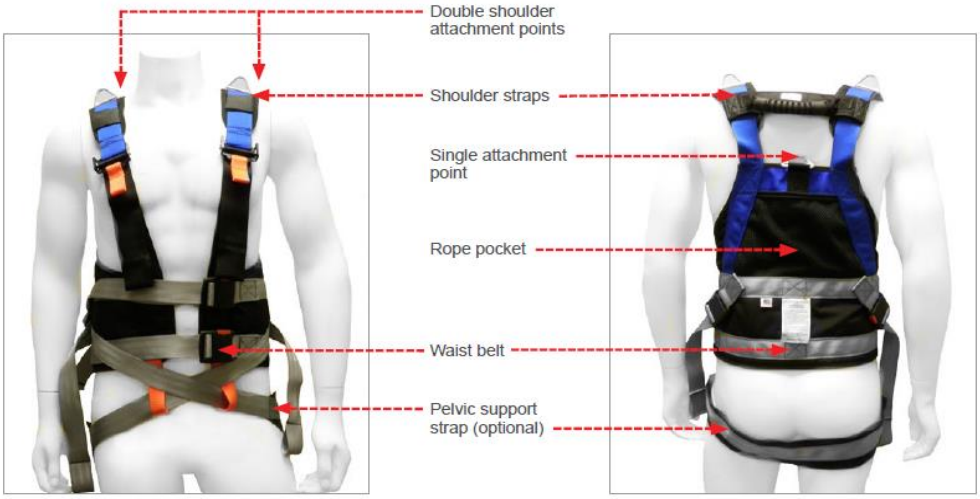

Figure 3. Bertec harness

For baseline and post measurement, participants were requested to take off their foot ware and the investigator helped position their feet on the force plate, in order for the

medial malleoli to align with the horizontal line running from left to right and the lateral calcanei to align with the small, medium or larger vertical lines depending upon their height (Figure 3).

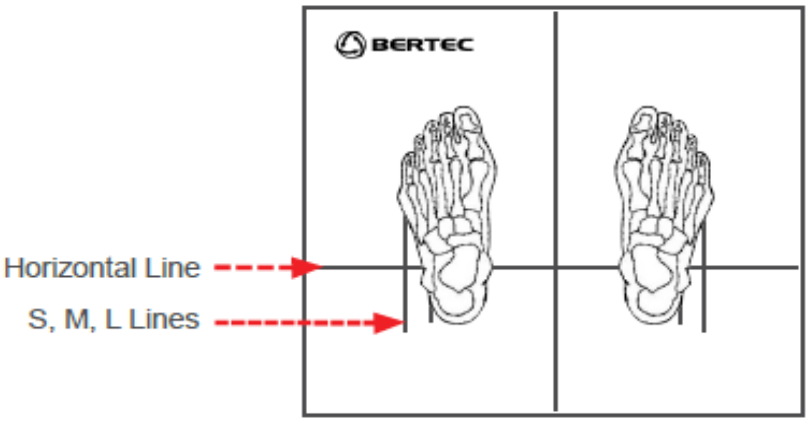

Figure 4. Foot placement on Bertec Balance Advantage-Dynamic CDP force plate

The curved virtual reality projection screen projected an optokinetic visual flow of an infinite moving tunnel in the form of alternate black and white circular pattern, which moved in the participant's direction. The density and the velocity of the circular pattern was maintained constant for all the participants (Figure 4).

Figure 5. Optokinetic visual flow

Participant's postural stability was assessed in dark environment on two conditions of CDP-IVR, condition 1 had fixed support while condition 2 had sway-referenced support. In both conditions, the visual flow was independent of participant's sway. Participants in both groups received one practice trial to familiarize them with the equipment for baseline and post intervention assessments.[36, 37] This was followed by a total of 6 trials; three on each condition of CDP-IVR, and the average of the three trials for each condition was recorded. Each trial lasted for 20 seconds with a total of 60-seconds duration to complete all the trials. The computer software generated an equilibrium score that provided quantitative measurement of the participant's sway velocity during each trial.

Motion Sensitivity Quotient (MSQ)

It is a clinical protocol that measures participant's motion-provoked dizziness during a series of 16 quick changes to head or body positions. This tool is reliable across raters (ICC= 0.99), test sessions (ICC= 0.98 and 0.96) and it has good validity.[27]

Motion Sensitivity Susceptibility Questionnaire Short Form (MSSQ-Short)

MSSQ predict individual differences in motion sickness caused by variety of stimuli. MSSQ-Short is easier to complete by participants and requires less scoring effort by experimenters as compared to original MSSQ. MSSQ-Short demonstrated a reliability of Cronbrach's alpha 0.87; test-retest reliability around r=0.9; Part A (child) with Part B (adult) r=0.68.[28,29] MSSQ-Short is a reliable tool and provides an efficient revision of MSSQ based on length (reduced time cost) and validity (predicted motion susceptibility).

State - Trait Anxiety Inventory for Adults (STAI Form Y-2)[7,38]

STAI is a widely used tool to measure anxiety. STAI Form Y-2 specifically measures the general propensity to be anxious. Total items in form Y-2 are 20 and he score is based on participants' self-report. This is a reliable tool with internal consistency alpha coefficients being high ranging from 0.86 to 0.95.[38] Content validity of STAI test with Taylor Manifest Anxiety Scale and Cattell and Scheier's Anxiety Scale Questionnaire was 0.73 and 0.85, respectively.[38]

Statistical Analysis

Forty one subjects were recruited into the study. Sample size was estimated using

a medium effect size of 0.50, a power of 0.80 and the level of significance was set at 0.05. Data was analyzed using SPSS statistics Grad Pack 24.0 for windows. Mean $\pm$ SD was computed for quantitative variables and frequencies (%) for categorical variables. Normality of the quantitative variables was assessed using Shapiro-Wilk test and box plots. We compared mean age (years), height (meters), weight (kg), and Body Mass Index (kg/m^2), and objective measures of postural stability of participants using conditions 1 and 2 of CDP-IVR in both groups at baseline using independent t-test. The distribution of gender by group type was examined using Fishers's Chi Square test. Mean measures of motion sensitivity (MSA, MSB, MSSQ percentile, and MSQ) and anxiety (STAI) at baseline by study group were compared using Mann-Whitney U test. To examine the effect of the type of intervention on postural stability over time, a 2x2 mixed factorial ANOVA was conducted. To assess changes in measures of motion sensitivity and anxiety within each study group, Wilcoxon Signed rank test was used, and between the two groups using Mann-Whitney U test.

Spearman's rank order correlation was conducted to assess the relationship between the subjective measure of motion sensitivity MSQ and the objective measure of postural stability. The level of significance was set at $p \leq 0.05$.

Results

A total of 41 participants with mean age of 26.7±4.1 years and a mean body mass index of 23.7±5.7 kg/m^2 participated in the study. Eighty five percent of the participants were females (n=35). Sixteen participants (76.2%) in the intervention group were females compared to 19 participants (95.0%) in the sham group (p=0.18). There was no

significant difference between the two groups in terms of mean age, BMI, the CDP-IVR scores for conditions 1 and 2, subjective measures of motion sensitivity, and anxiety at baseline ($p>0.05$, Table 1).

In the intervention group, there was a significant difference in mean ± standard error (SE) familiarization between baseline and six weeks later for condition 1 (86.9±1.8 vs. 91.8±0.8, $p=0.004$), and condition 2 (20.9±5.7 vs. 53.2±4.8, $p=0.001$). In addition, there was a significant difference in CDP-IVR average scores for condition 2 (36.0±5.6 vs. 65.4±2.8, $p<0.001$) (Table 2). Also, there was a significant difference in mean motion sickness quotient (MSQ) between baseline and post six weeks (4.0±1.2 vs. 1.9±0.9, $p=0.004$).

In the sham group, there was a significant difference in mean CDP-IVR average score post versus pre for condition 1 (86.8±1.8 vs. 90.4±0.8, $p=0.05$), condition 2 (48.1±5.8 vs. 67.3±3.5, $p<0.001$), and for condition 2 familiarization (34.6±5.9 vs. 57.4±0.8, $p=0.001$, Table 2). Also, there was a significant difference in mean state trait anxiety inventory (STAI) between baseline and post six weeks (38.2±1.9 vs. 35.8±2.2, $p=0.03$, Table 2).

When comparing the mean CDP-IVR average score between the intervention and sham groups, there was a significant difference for condition 2 ($p=0.05$), but not for condition 1 ($p=0.44$, Table 2). For condition 2, the intervention group had 117% increase in CDP-IVR average score compared to 35.2% increase in the sham group. Also, there was a significant difference in mean MSQ between the two groups ($p=0.045$). There was a significant inverse correlation between MSQ and CDP-IVR average equilibrium % of Condition 1 ($\rho = -0.44$, $p = 0.004$). Both study groups were adherent to the exercise

program they were assigned to (95% in the intervention versus 90% in the sham group, p=0.97).

Table 1. Mean (SD) of general characteristics by type of group at baseline (N= 41)

	Intervention Group (n_1=21)	Sham Group (n_2=20)	p –value[a]
Female; n (%)[b]	16(76.2)	19(95.0)	0.18
Age (years)[c]	27.5(4.5)	25.8(3.7)	0.18
BMI (kg/m^2)	25.2(5.3)	22.3(4.9)	0.05
MSA	11.8(6.6)	14.9(7.1)	0.13
MSB	14.6(5.4)	13.2(5.4)	0.65
MSSQ Percentile	83.9(16.5)	83.2(20.4)	0.53
STAI	36.4(12.3)	38.2(8.5)	0.17
MSQ	4.0(5.4)	2.2(3.5)	0.25
C1Familiarization	86.9(8.4)	87.5(7.6)	0.88
C1 Average	85.6(11.3)	86.8(8.1)	0.67
C2 Familiarization	20.9(26.3)	34.6(26.6)	0.09
C2 Average	36.0(25.5)	48.1(25.7)	0.16

Abbreviation: SD, Standard deviation; BMI, Body mass index;
MSA, Motion sickness susceptibility questionnaire section A (child);
MSB, Motion sickness susceptibility questionnaire section B (Adult)
MSSQ, Motion sickness susceptibility questionnaire
STAI, State trait anxiety inventory
MSQ, Motion sickness quotient
C1, Condition 1 of immersion virtual reality computerized dynamic posturography
C2, Condition 2 of immersion virtual reality computerized dynamic posturography ,
[a]Mann-Whitney U test, [b] Fisher's Exact test, [c]Independent t-test

TABLE 2 Changes in outcome measures between intervention and sham groups

	Intervention (n = 21)				Sham (n = 20)				
	Baseline *M (SE)*	Post 6 weeks *M (SE)*	Difference (%)	p-value[a] (within group)	Baseline *M (SE)*	Post 6 weeks *M (SE)*	Difference (%)	p-value[a] (within group)	p-value[b] (between groups)
MSA	11.8 (1.4)	12.6 (1.6)	8.7	0.12	14.9(1.6)	15.3(1.4)	6.8	0.51	0.13
MSB	14.6 (1.2)	14.7 (1.4)	8.1	0.78	13.2(1.2)	13.5(1.4)	3.3	0.78	0.25
MSSQ Percentile	83.9 (3.6)	81.9 (5.3)	-3.7	0.69	83.2(5.4)	84.7(5.3)	2.5	0.81	0.46
STAI	36.4 (2.7)	35.7 (2.3)	0.4	0.81	38.2(1.9)	35.8(2.2)	-6.3	0.03	0.16
MSQ	4.0 (1.2)	1.9 (0.9)	-46.6	0.004	2.2(0.9)	1.5(0.5)	10.7	0.62	0.045
C1 Familiarization[c]	86.9 (1.8)	91.8 (0.8)	6.6	0.004	87.5(1.7)	90.5(1.6)	3.9	0.06	0.32
C1 Average[c]	85.6 (2.5)	89.9 (0.6)	7.3	0.06	86.8(1.8)	90.4(0.8)	4.9	0.05	0.44
C2 Familiarization[c]	20.9 (5.7)	53.2 (4.8)	73.8	0.001	34.6(5.9)	57.4(5.2)	47.2	0.001	0.15
C2 Average[c]	36.0 (5.6)	65.4 (2.8)	117.0	< 0.001	48.1(5.8)	67.3(3.5)	35.2	< 0.001	0.05

Abbreviation: SD, Standard deviation; BMI, Body mass index;
MSA, Motion sickness susceptibility questionnaire section A (child);
MSB, Motion sickness susceptibility questionnaire section B (Adult);
MSSQ, Motion sickness susceptibility questionnaire percentile;
STAI, State trait anxiety inventory;
MSQ, Motion sickness quotient;
C1, Condition 1 computerized dynamic posturography- immersion virtual reality;
C2, Condition 2 computerized dynamic posturography- immersion virtual reality;
[a]Wilcoxon Signed Ranks Test, [b] Mann Whitney U Test, [c] 2x2 Mixed Factorial ANOVA

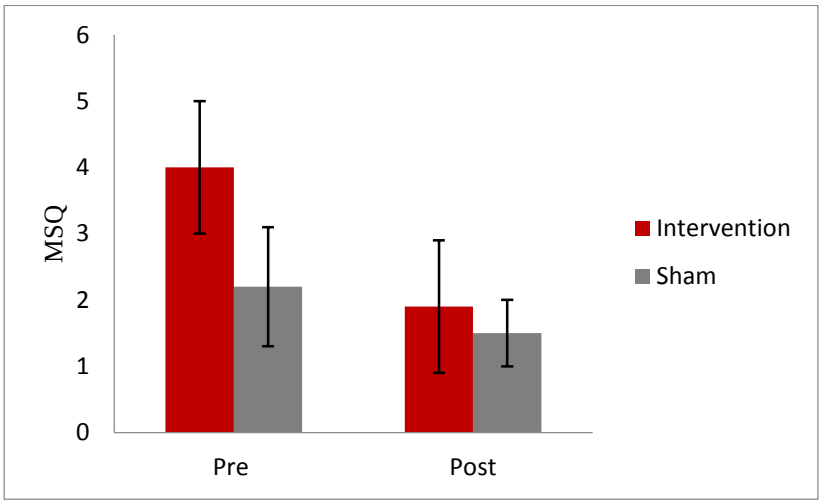

Figure 6. Mean (SE) of MSQ by group over time (N = 41)

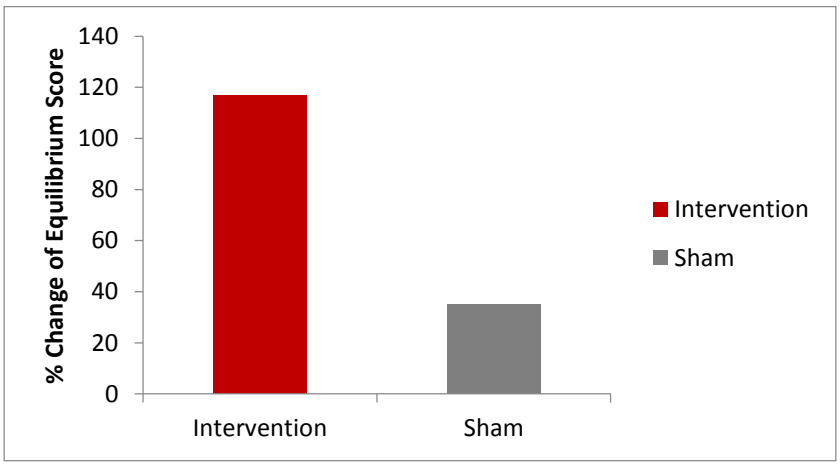

Figure 7. Percent change in mean equilibrium score of condition 2 by group over time

Discussion

This single blind randomized controlled trial investigated the effect of progressive gaze stability exercises on holistic aspects of chronic motion sensitivity among healthy young adults. Effectiveness of progressive gaze stability exercises were compared with sham intervention of saccadic eye movement exercises. Postural stability, perception of motion sensitivity and anxiety were assessed under holistic aspects of chronic motion sensitivity.

Postural stability of participants was assessed using CDP-IVR[30-33] condition 1 and 2, perception of motion sensitivity was measured using MSQ[27] and MSSQ-Short,[28,29] and perception of anxiety was assessed using STAI Form Y-2.[7,38] The results of the study supported the hypothesis that progressive gaze stability exercises will reduce perception of motion sensitivity and improve postural stability. However, there was no significant change observed in perception of anxiety among intervention group while, the anxiety reduced among the sham group post intervention.

Forty one healthy participants with mean age of 26.7±4.1 years participated in the study. Among the forty one participants eighty five percent were females (n=35). This observed gender prevalence of motion sensitivity supports the previous evidence in which women (27.3%) were identified to be more prone to motion sensitivity as compared to men (16.8).[1] At the end of six weeks of intervention both intervention and sham group demonstrated significant increase in CDP-IVR average score of condition 2, however the intervention group had 117% increase in CDP-IVR average score compared to 35.2% increase in the sham group. This finding is consistent with the recent evidence in which Alyahya et al. reported that minimal dosage of adaptation exercises significantly

improved postural stability of participants with chronic motion sensitivity.[23] In this study the improvement observed in postural stability of sham group could be attributed to placebo effect a saccadic eye movement exercises prescribed to sham group are considered as "vestibular neutral" because they do not influence the vestibular system[21] Also, the familiarization trials given to participants from both group for CDP-IVR condition 1 and 2 may have minimized the possibility of learned effect being the reason of improvement seen in shame group.

Intervention group demonstrated significant reduction in the perception of motion sensitivity post intervention as compared to sham group as measured by MSQ. These findings support the results reported by Rine, R.M., Schubert M.C., and Balkany T.J. in which gaze stability exercises reduced perception of motion sensitivity of a participant experiencing sea sickness. Also a significant inverse correlation between MSQ and CDP-IVR average equilibrium % of Condition 1 ($\rho = -0.44$, $p = 0.004$) was identified which is consistent with the results of a study conducted by Cobb S.V.G were strong correlation was identified between self-reported symptoms of simulator sickness and postural instability.[39]

HEP adherence strategies implemented in this study in the form of written exercise instructions, daily exercise log and tele-rehabilitation in the form of FaceTime® [Apple Inc] or Skype™ demonstrated to be beneficial for ensuring HEP adherence. Both study groups were adherent to the exercise program they were assigned to (95% in the intervention versus 90% in the sham group, p=0.97).

The results of this study are limited to a narrow age group of 20-40 years and these results cannot be generalized to an older population. Also, this study did not

consider the level of physical activity of participants from both groups. The authors suspect that individual level of physical activity may influence the postural stability. For future research, participants level physical activity and older age group may be considered allow generalizability of these results.

Conclusion

Progressive gaze stability exercises reduced motion sensitivity and improved postural stability in participants with chronic motion sensitivity. Also, perception of motion sensitivity was observed to be inversely correlated with postural stability. There was no impact of gaze stability exercises observed on subjective perception of anxiety among this population. Also, HEP adherence strategies such as written exercise instructions, daily log of exercise and tele-rehabilitation in the form of FaceTime® [Apple Inc] or Skype™ was beneficial to improve exercise adherence in participants with chronic motion sensitivity.

References

1. Sharma K, and Aparna. Prevalence and correlates of susceptibility to motion sickness. Acta Genet Med Gemellol (Roma). 1997;46(2):105-21. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9492893

2. Rine RM, Schubert MC, and Balkany TJ. Visual-vestibular habituation and balance training for motion sickness. Phys Ther, 1999;79(10):949-57. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10498971

3. Battista R. Motion sickness syndrome. Otolaryngology, 1994; 9:1-8.

4. Reason JT. Motion sickness adaptation: a neural mismatch model. J R Soc Med, 1978;71(11):819-29. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/731645

5. Lackner JR. Motion sickness: more than nausea and vomiting. Experimental Brain Research. 2014;232(8):2493-2510.doi:10.1007/s00221-014-4008-8

6. Graybiel A, et al. Diagnostic criteria for grading the severity of acute motion sickness. AerospMed. 1968;39(5):453-5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/5648730

4. Paillard AC, et al. Motion sickness susceptibility in healthy subjects and vestibular patients: effects of gender, age and trait-anxiety. J Vestib Res. 2013; 23(4-5):203-9. doi: 10.3233/VES-130501

8. Owen N, Leadbetter AG, and Yardley L. Relationship between postural control and motion sickness in healthy subjects. Brain Res Bull. 1998;47(5):471-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10052576

6. Bos JE. Nuancing the relationship between motion sickness and postural stability. Displays. 2011; 32(4):189-193. doi:10.1016/j.displa.2010.09.005

7. Riccio GE, and Stoffregen TA. An ecological Theory of Motion Sickness and Postural Instability. Ecological Psychology.1991;3(3):195-240. Retrieved from http://dx.doi.org/10.1207/s15326969eco0303_2

11. Miller EF, and Graybiel A. Motion sickness produced by head movement as a function of rotational velocity. Aerosp Med.1970;41(10):1180-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/5458202

12. Guedry FE, and Graybiel A. Compensatory nystagmus conditioned during adaptation to living in a rotating room. J Appl Physiol. 1962;17:398-404. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/13902616

13. Diels C, and Howarth PA. Frequency characteristics of visually induced motion sickness. Hum Factors. 2013;55(3):595-604. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23829033

14. Golding JF, and Gresty MA. Motion Sickness and Disorientation in Vehicles. 2013, 'Oxford University Press': Oxford, UK. Retrieved from http://oxfordmedicine.com/view/10.1093/med/9780199608997.001.0001/med-9780199608997-chapter-28

15. Kennedy RS, Drexler J, and Kennedy RC. Research in visually induced motion sickness. Applied Ergonomics. 2010;41(4):494-503. doi: 10.1016/j.apergo.2009.11.006.

16. Eyeson-Annan M, et al. Visual and vestibular components of motion sickness. Aviat Space Environ Med.1996;67(10):955-62. Retrived from http://www.ncbi.nlm.nih.gov/pubmed/9025818

17. Golding JF, and Gresty MA, Pathophysiology and treatment of motion sickness. Current Opinion in Neurology. 2015;28(1).Retrived from http://www.medscape.com/viewarticle/837616

18. Yates BJ, et al. Integration of vestibular and emetic gastrointestinal signals that produce nausea and vomiting: potential contributions to motion sickness. Exp Brain Res. 2014;232(8):2455-69. doi: 10.1007/s00221-014-3937-6.

19. Fowler CG, Sweet A, and Steffel E. Effects of Motion Sickness Severity on the Vestibular-Evoked Myogenic Potentials. J Am Acad Audiol. 2014;25(9):814-822. doi: 10.3766/jaaa.25.9.4.

20. Ressiot E, et al. Prospective study on the efficacy of optokinetic training in the treatment of seasickness. European Annals of Otorhinolaryngology, Head and Neck Diseases. 2013;130(5):263-268. doi:10.1016/j.anorl.2012.03.009

21. Herdman SJ, Hall CD, Schubert MC, Das VE, Tusa RJ. Recovery of dynamic visual acuity in bilateral vestibular hypofunction. Arch Otolaryngol Head Neck Surg. 2007;133(4):383-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17438254

22. Han BI, Song HS, Kim JS. Vestibular rehabilitation therapy: review of indications,mechanisms, and key exercises. J Clin Neurol. 2011;7(4):184-96. doi: 10.3988/jcn.2011.7.4.184

23. Alyahya D, et al. Effect of vestibular adaptation exercises on chronic motionsensitivity: a randomized controlled trial. Phys Ther Rehabil. 2016;3(1):1.DOI : http://dx.doi.org/10.7243/2055-2386-3-1

24. Russell TG, et al. Internet-Based Outpatient Telerehabilitation for Patients Following Total Knee Arthroplasty. J Bone Joint Surg AM. 2011;93(2):113-120. doi: 10.2106/JBJS.I.01375.

25. Palacín-Marín F, et al. Agreement between telerehabilitation and face-to-face clinical outcome assessments for low back pain in primary care. Spine. 2013;38(11):947-952. doi: 10.1097/BRS.0b013e318281a36c.

26. Dicianno BE, et al. Perspectives on the evolution of mobile (mHealth) technologies and application to rehabilitation. Phys ther. 2015;95(3):397-405. doi: 10.2522/ptj.20130534.

27. Akin FW and Davenport MJ. Validity and reliability of the Motion Sensitivity Test. J Rehabil Res dev. 2003;40(5):415-422. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15080226

28. Golding JF. Predicting individual differences in motion sickness susceptibility by questionnaire. Personality and Individual differences. 2006;41(2):237-248. Retrieved from http://dx.doi.org/10.1016/j.paid.2006.01.012

29. Golding JF. Motion sickness susceptibility questionnaire revised and its relationship to other forms of sickness. Brain Res Bull. 1998;47(5):507-516. Retrived from http://www.ncbi.nlm.nih.gov/pubmed/10052582

30. Mirka A, and Black FO. Clinical application of dynamic posturography for evaluating sensory integration and vestibular dysfunction. Neurol Clin. 1990;8(2):351-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/2193216

31. Norre ME, Forrez G, and Beckers A. Posturography measuring instability in vestibular dysfunction in the elderly. Age Ageing. 1987;16(2):89-93. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3495101

32. Lichtenstein MJ, et al. Clinical Determinants of Biomechanics Platform Measures of Balance in Aged Women. JAGS. 1988;36(11):996-1002. DOI: 10.1111/j.1532-5415.1988.tb04365.x

33. Wolfson L, et al. A dynamic posturography study of balance in healthy elderly. Neurology. 1992;42(11):2069-75. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1436514

34. Ford-Smith CD, et al. Test-retest reliability of the sensory organization test in noninstitutionalized older adults. Arch Phys Med Rehabil. 1995;76(1):77-81. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7811180

35. Bertec balance advantage user manual. 2013. Retrieved from http://bertec.com/bertecbalance/

36. Guerraz M, et al. Visual vertigo: symptom assessment, spatial orientation and postural control. Brain. 2001;124(8):1646-1656. *DOI:* http://dx.doi.org/10.1093/brain/124.8.1646

37. Fetsch CR, et al. Dynamic reweighting of visual and vestibular cues during self-motion perception. J Neurosci. 2009;29(49):15601-15612. doi: 10.1523/JNEUROSCI.2574-09.2009.

38. Julian LJ. Measures of Anxiety. Arthritis care & research. 2011;63(0 11): 10.1002/acr.20561. doi:10.1002/acr.20561.

39. Cobb SVG. Measurement of postural stability before and after immersion in a virtual environment. Appl Ergon. 1999; 30: 47-57. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/?term=Measurement+of+postural+stability+before+and+after+immersion+in+a+virtual+environment

CHAPTER FOUR

DISCUSSION

Motion sensitivity commonly termed as motion sickness is prevalent among general population. It is a complex syndrome believed to be resulting from sensory conflict between visual and vestibular system. Also, according to the neural mismatch model proposed by Reason et al., motion sensitivity can be defined as "a self-inflicted maladaptation phenomenon that occurs at the onset and cessation of conditions of sensory rearrangement when the prevailing inputs from the visual and vestibular systems are at variance with stored patterns derived from previous transactions with the spatial environment."[1]

Along with nausea and vomiting[2] motion sensitivity can also manifest in the form of headache, drowsiness, cold sweating, pallor of varying degrees, and increased salivation.[3] Also, postural instability and anxiety are also identified to be related to motion sensitivity.[4-7] Optokinetic training have been used in seasickness, there is limited research available related to treatment of terrestrial motion sensitivity, which is experienced during transportation in cars, buses, trains, and recreational activities such as roller coaster rides.

According to the results of a recent study, minimal dosage of vestibular adaptation exercises have improved postural stability of younger adults with chronic motion sensitivity.[8] Adaptation exercises area also termed as gaze stability exercises which are a part of vestibular rehabilitation (VR).[9] VR aims to improve gaze and postural stability, reduce symptoms of vertigo, and to improve activities of daily life.[9] Decreased gain of vestibular response to head movements gives rise to gaze instability in patients

with vestibular dysfunction.[10] Inducing retinal slip by horizontal or vertical head movements while maintaining visual fixation on a target, increases the gain of the vestibular response.[10,11] For vestibular adaptation to occur, retinal slip needs to be induced repeatedly.[12] Gaze stability exercises induce this retinal slip and they are prescribed as much as four to five times daily for a total duration of 20-40 minutes.[13] Also, saccadic eye movement exercises are considered to be "vestibular neutral" because they do not influence the vestibular system and hence, have been used as sham exercises in previous studies.[14]

We identified several gaps in the literature regarding the effectiveness of progression of gaze stability exercises on perception of motion sensitivity, anxiety and postural stability. Hence, the aim of this study was to investigate the effect of progressive gaze stability exercises on motion sensitivity and postural stability and anxiety in participants with chronic motion sensitivity.

To answer this research question a single blind randomized controlled trial was conducted to study the effect of progressive gaze stability exercises on holistic aspects of chronic motion sensitivity among healthy young adults. Effectiveness of progressive gaze stability exercises were compared with sham intervention of saccadic eye movement exercises. Postural stability, perception of motion sensitivity and anxiety were assessed under holistic aspects of chronic motion sensitivity.

Adherence to HEP is even more critical for dysfunctions that may demand long-term intervention such as vestibular dysfunctions. Vestibular exercises require regular and consistent repetition for vestibular adaptation to occur, thus, patient's adherence to the HEP is a critical factor. Adherence is defined as "the extent to which a person's

behavior-taking medications, following a diet, and/or executing life-style changes, corresponds with agreed recommendations from a health care provider."[15] The level of adherence is influenced by patient's perceptions about their injuries, symptoms, and coping mechanism.[16]

Lack of evidence was identified regarding the effective HEP adherence strategy that can be used in vestibular rehabilitation. Hence, we conducted a systematic review to answer this research question. This systematic review included 8 relevant studies and it identified strong evidence for 3 major categories of effective HEP adherence strategies including providing patients with written summary of HEP, asking patients to maintain a record of HEP and symptoms, and providing tele-rehabilitation in the form of email and/or telephone support along with in person treatment sessions. Based on the systematic review three HEP adherence strategies were implemented in this study in the form of written exercise instructions, daily exercise log and tele-rehabilitation in the form of FaceTime® [Apple Inc] or Skype™ demonstrated to be beneficial for ensuring HEP adherence. Both study groups were adherent to the exercise program they were assigned to (95% in the intervention versus 90% in the sham group, p=0.97).

The results of the study supported the hypothesis that progressive gaze stability exercises will reduce perception of motion sensitivity and improve postural stability. However, there was no significant change observed in perception of anxiety among intervention group while, the anxiety reduced among the sham group post intervention. After six weeks of intervention both intervention and sham group demonstrated significant increase in CDP-IVR average score of condition 2, however the intervention group had 117% increase in CDP-IVR average score compared to 35.2% increase in the

sham group. This result supported the recent evidence which reported that minimal dosage of adaptation exercises significantly improved postural stability of participants with chronic motion sensitivity.[8]

Significant reduction in the perception of motion sensitivity post intervention was observed in intervention group compared to sham group as measured by MSQ. Similar finding was reported in the past by Rine, R.M., Schubert M.C., and Balkany T.J. in which gaze stability exercises reduced perception of motion sensitivity of a participant experiencing sea sickness. Also a significant inverse correlation between MSQ and CDP-IVR average equilibrium % of Condition 1 ($\rho = -0.44$, $p = 0.004$) was identified which is consistent with the results of a study conducted by Cobb S.V.G were strong correlation was identified between self-reported symptoms of simulator sickness and postural instability.[17]

Written exercise instructions, daily exercise log and tele-rehabilitation in the form of FaceTime® [Apple Inc] or Skype™ demonstrated to be beneficial for ensuring HEP adherence. Both study groups were adherent to the exercise program they were assigned to (95% in the intervention versus 90% in the sham group, p=0.97).

Conclusion

This single blind randomized controlled trial concluded that adding progression to gaze stability exercises reduced motion sensitivity and improved postural stability in participants with chronic motion sensitivity. Also, perception of motion sensitivity was observed to be inversely correlated with postural stability. Written exercise instructions, daily log of exercise and tele-rehabilitation in the form of FaceTime® [Apple Inc] or

Skype™ were beneficial HEP adherence strategies to encourage exercise adherence of participant with chronic motion sensitivity.

References

1. Reason JT. Motion sickness adaptation: a neural mismatch model. J R Soc Med, 1978;71(11):819-29. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/731645

2. Lackner JR. Motion sickness: more than nausea and vomiting. Experimental Brain Research. 2014;232(8):2493-2510.doi:10.1007/s00221-014-4008-8

3. Graybiel A, et al. Diagnostic criteria for grading the severity of acute motion sickness. AerospMed. 1968;39(5):453-5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/5648730

4. Paillard AC, et al. Motion sickness susceptibility in healthy subjects and vestibular patients: effects of gender, age and trait-anxiety. J Vestib Res. 2013; 23(4-5):203-9. doi: 10.3233/VES-130501

5. Owen N, Leadbetter AG, and Yardley L. Relationship between postural control and motion sickness in healthy subjects. Brain Res Bull. 1998;47(5):471-4. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10052576

6. Bos JE. Nuancing the relationship between motion sickness and postural stability. Displays. 2011; 32(4):189-193. doi:10.1016/j.displa.2010.09.005

7. Riccio GE, and Stoffregen TA. An ecological Theory of Motion Sickness and Postural Instability. Ecological Psychology.1991;3(3):195-240. Retrieved from http://dx.doi.org/10.1207/s15326969eco0303_2

8. Alyahya D, et al. Effect of vestibular adaptation exercises on chronic motionsensitivity: a randomized controlled trial. Phys Ther Rehabil. 2016;3(1):1.DOI : http://dx.doi.org/10.7243/2055-2386-3-1

9. Han BI, Song HS, Kim JS. Vestibular rehabilitation therapy: review of indications,mechanisms, and key exercises. J Clin Neurol. 2011;7(4):184-96. doi: 10.3988/jcn.2011.7.4.184

26. Herdman SJ. Advances in the treatment of vestibular disorders. Phys Ther. 1997;77(6):602-18. . Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9184686

10. Herdman SJ. Role of vestibular adaptation in vestibular rehabilitation. Otolaryngol Head and Neck Surg. 1998;119(1):49-54. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9674514

11. Gauthier GM, Robinson DA. Adaptation of the human vestibuloocular reflex to magnifying lenses. Brain Res. 1975;92(2):331-5. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1080685

12. Herdman SJ, Hall CD, Schubert MC, Das VE, Tusa RJ. Recovery of dynamic visual acuity in bilateral vestibular hypofunction. Arch Otolaryngol Head Neck Surg. 2007;133(4):383-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17438254

13. Herdman SJ, et al. Recovery of dynamic visual acuity in unilateral vestibular hypofunction. Arch Otolaryngol Head Neck Surg. 2003;129(8):819-824. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12925338

14. Yardley L, Kirby S. Evaluation of booklet-based self-management of symptoms in Meniere's disease: a randomized controlled trial. Psychosom Med. 2006;68(5):762-9. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/17012531

15. Szturm T, Reimer KM, Hochman J. Home-based computer gaming in vestibular rehabilitation of gaze and balance impairment. Games Health J. 2015;4(3):211-20. doi: 10.1089/g4h.2014.0093

16. Cobb SVG. Measurement of postural stability before and after immersion in a virtual environment. Appl Ergon. 1999; 30: 47-57. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/?term=Measurement+of+postural+stability+before+and+after+immersion+in+a+virtual+environment.

APPENDIX A

WEEKLY ASSESSMENT FORM

Participant's ID: _____ Follow up Week # _____ Date: _____

1. Did you do the exercises all 7 days of the week? Yes / No
    - If No, please give the reason_____
    - How many days did you do the exercises?_____
2. How many times in a day did you do the exercises?_____
3. What is the current duration of your individual exercise session?_____
4. Could you increase the amplitude of your head movements during the exercise? Yes/No/Not applicable
5. Did you add Up and Down head movements/eye movements to your exercises? Yes/No
6. Did you experience any motion sensitivity related symptom/s while doing the exercises? Yes/No
    - If yes, please mention the symptom/s_____
    - Please grade your symptom/s on the scale of 0 to 10 (0=No symptom at all, 10=Worst symptom)
7. Did you happen to go on a long distance travel in this week? Yes/No
    - If yes, please mention the type of transportation used_____
    - Did you experience any motion sickness symptom/s during the travel? Yes/No

- If yes, please mention the symptom/s_____
- Please grade your symptom/s on the scale of 0 to 10 (0=No symptom at all, 10=Worst symptom)

Any other comments_____

APPENDIX B

LOG SHEET

Participant's ID: _____ Follow up Week # _____ Date: _____

Please write either 0/1/2 in the boxes depending on the number of times you did the exercises each day.

↓Week/Day→	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday

APPENDIX C

GAZE STABILITY EXERCISES HOME PROGRAM SHEET

- Stand in a corner of the room
- Hold/Tape the exercise card at eye level against a plane background
- Keep eyes focused on optotype
- Rotate head smoothly horizontally from side to side as tolerated for 1 minute, then rest for 1 minute
- Perform this exercise for a total of 5 minutes daily during week one
- Week 2 onward until week 6, investigator will recommend weekly exercise progression as tolerated
- Please maintain a daily exercise log sheet and turn it in during weekly follow up visit with investigator

APPENDIX D

SHAM EXERCISES HOME PROGRAM SHEET

- Stand in a corner of the room
- Hold/Tape the exercise card at eye level against a plane background
- Keep eyes focused on optotype
- Look at optotype for 20 seconds, then without moving your head look to your left for 20 seconds, then look to your right for 20 seconds
- After this take a 1 minute rest pause
- Perform this exercise for a total of 5 minutes daily during week one
- Week 2 onward until week 6, investigator will recommend weekly exercise progression as tolerated
- Please maintain a daily exercise log sheet and turn it in during weekly follow up visit with investigator

APPENDIX E

INFORMED CONSENT

TITLE: **EFFECT OF GAZE STABILITY EXERCISES ON CHRONIC MOTION SENSITIVITY**

SPONSOR: **Department of Allied Health Studies, Loma Linda University**

PRINCIPAL INVESTIGATOR: Eric Glenn Johnson, DSc, PT, MS-HPEd, NCS

Professor, Physical Therapy Department

Loma Linda University, Loma Linda CA

School of Allied Health Professions

Nichol Hall Room #A-712

Phone: (909) 558-4632 Extension 47471

Fax: *(909) 558-0459*

Email Address: ejohnson@llu.edu

1. WHY IS THIS STUDY BEING DONE?

The purpose of this student research study is to determine the effect of progressive eye gaze exercises on stability and motion sickness in subjects already sensitive to motion. Gaze exercises are an approach for patients with dizziness. Our purpose is to determine if the exercises will help. You are invited to participate in this student research study because you are an adult between the ages of 20-40 with chronic motion sensitivity.

2. HOW MANY PEOPLE WILL TAKE PART IN THIS STUDY?

Approximately 50 subjects will be in this study.

3. HOW LONG WILL THE STUDY GO ON?

The study will last approximately six weeks. It will require 90 minutes on the first day for pre-study data collection. Your eye gaze exercises will require a maximum of 15 minutes daily. Weekly follow-up visits will require 10 minutes and can occur either in Nichol Hall #A-712 or web meeting using Skype or FaceTime. After finishing 6 weeks of eye gaze exercises you will come back to Nichol Hall #A-712 for about 60 minutes. Finally,

you will be requested to be in a 60 minute group interview to share your experience. All your data collection appointments will be individual except for the final group interview.

4. HOW WILL I BE INVOLVED?

The study involves the following:
Your date of birth, height and weight will be recorded. You will then be assessed using an inclusion criteria survey for motion sensitivity. If you meet the inclusion criteria:

- You will be randomly assigned to one of two different exercise groups.
- Next, you will complete a form to determine the frequency of your motion sensitivity.
- Next, you will complete a form to determine your level of anxiety in general.
- Finally, your postural stability will be assessed using a non-invasive computerized device.
- At the conclusion of the study all the assessments will be repeated.
- You will perform simple eye gaze exercises maximum for a duration of 15 minutes daily for a period of 6 weeks.
- You will have weekly face to face or web meeting using Skype or FaceTime with the investigator for a duration of 6 weeks.
- You will receive daily text reminder to perform the exercises and you will maintain an exercise log sheet.
- Finally you will participate in a group interview pertaining to your experience during the research participation.
- If you agree to participate in this study, you will be responsible for your own travel to and from the research lab.

5. WHAT ARE THE REASONABLY FORESEEABLE RISKS OR DISCOMFORTS I MIGHT HAVE?

Participating in this study exposes you to minimal risk because you may lose your balance during assessment of postural stability. To prevent falling, you will be wearing a safety harness and two researchers will be standing beside you at all times. Improper performance of the exercises can potential reduce the benefits of the exercises. The investigators will coach you and monitor the exercise performance during the follow-up sessions. There is also a minimal risk of breach of confidentiality.

6. WILL THERE BE ANY BENEFIT TO ME OR OTHERS?

The expected benefit to humanity is the data obtained from this study may identify a home exercise program to improve chronic motion sensitivity. It is possible that subjects in either of the exercise groups may personally benefit from participation in the study through improved postural stability, reduced motion sensitivity and reduced anxiety. If

one of the two exercise protocols results in better outcomes, they will be offered to you if you were performing the other exercises.

7. WHAT ARE MY RIGHTS AS A SUBJECT?

Participation in this study is voluntary. Your decision whether or not to participate or terminate at any time will not affect your present or future relationship with the Loma Linda University Department of Physical Therapy. You do not give up any legal rights by participating in this study.

8. WHAT HAPPENS IF I WANT TO STOP TAKING PART IN THIS STUDY?

You are free to withdraw from this study at any time. If you decide to withdraw from this study you should notify the research team immediately. The research team may also end your participation in this study if you do not follow instructions, miss scheduled visits, or if your safety and welfare are at risk.

9. HOW WILL INFORMATION ABOUT ME BE KEPT CONFIDENTIAL?

Efforts will be made to keep your personal information confidential, but we cannot guarantee absolute confidentiality. We will use a pseudonym throughout the study for all recorded data so your actual name will not be used. You will not be identified by name in any publications describing the results of this study. Data collected from the focus group will be stored electronically and in hard copy. Data in hard copy will be kept in a locked file cabinet in a locked office and electronic data will be password protected. All audio recordings will be destroyed after focus groups have been transcribed. Upon completion of the research, transcription, and field notes will be stored for a minimum of three years in a locked file in the School of Allied Health Professions at Loma Linda University.

10. WHAT COSTS ARE INVOLVED?

There is no cost to you for your participation in this study beyond the time involved to participate.

11. WILL I BE PAID TO PARTICIPATE IN THIS STUDY?

You will receive a $10 gift card on the first day of pre-intervention data collection and a $40 gift card on the day of focus group interview at the conclusion of the study.

12. WHO DO I CALL IF I HAVE QUESTIONS?

If you feel you have been injured by taking part in this study, consult with a physician or call 911 if the situation is a medical emergency. No funds have been set aside nor any plans made to compensate you for time lost for work, disability, pain or other discomforts resulting from your participation in this research.

If you wish to contact an impartial third party not associated with this study regarding any question or complaint you may have about the study, you may contact the Office of Patient Relations, Loma Linda University Medical Center, Loma Linda, CA 92354, phone (909) 558-4674, e-mail patientrelations@llu.edu for information and assistance.

13. SUBJECT'S STATEMENT OF CONSENT

I have read the contents of the consent form and have listened to the verbal explanation given by the investigators. My questions concerning this study have been answered to my satisfaction. I hereby give voluntary consent to participate in this study. I have been given a copy of this consent form. Signing this consent document does not waive my rights nor does it release the investigators, institution, or sponsors from their responsibilities. I may call and leave a voice message for Eric Johnson, DSc during routine office hours at this number (909) 558-4632 ext. 47471 or e-mail him at ejohnson@llu.edu, if I have additional questions and concerns.

I understand I will be given a copy of this consent form after signing it.

_____ _____

Signature of Subject Printed Name of Subject

_____

Date

15. INVESTIGATOR'S STATEMENT

I have reviewed the contents of this consent form with the person signing above. I have explained potential risks and benefits of the study.

_____ _____

Signature of Investigator Printed Name of Investigator

_____

Date

APPENDIX F

PROTECTED HEALTH INFORMATION

INSTITUTIONAL REVIEW BOARD
Authorization for Use of
Protected Health Information (PHI)
Per 45 CFR §164.508(b)

RESEARCH PROTECTION PROGRAMS

LOMA LINDA UNIVERSITY | Office of the Vice President of Research Affairs

24887 Taylor Street, Suite 202 Loma Linda, CA 92350

(909) 558-4531 (voice) / (909) 558-0131 (fax)/e-mail: irb@llu.edu

TITLE OF STUDY:	The Effect of Gaze Stability Exercises on Chronic Motion Sensitivity
PRINCIPAL INVESTIGATOR:	Eric G. Johnson, DSc, PT, MS-HPEd, NCS
Others who will use, collect, or share PHI:	Authorized Research Personnel

The student research study named above may be performed only by using personal information relating to your health. National and international data protection regulations give you the right to control the use of your medical information. Therefore, by signing this form, you specifically authorize your medical information to be used or shared as described below.

The following personal information, considered "Protected Health Information" (PHI) is needed to conduct this study and may include, but is not limited to name, birth date, phone number, e-mail, and a health questionnaire.

The individual(s) listed above will use or share this PHI in the course of this study with the Institutional Review Board (IRB) and the Office of Research Affairs of Loma Linda University.

The main reason for sharing this information is to be able to conduct the study as described earlier in the consent form. In addition, it is shared to ensure that the study meets legal, institutional, and accreditation standards. Information may also be shared to report adverse events or situations that may help prevent placing other individuals at risk.

All reasonable efforts will be used to protect the confidentiality of your PHI, which may be shared with others to support this study, to carry out their responsibilities, to conduct public health reporting and to comply with the law as applicable. Those who receive the PHI may share with others if they are required by law, and they may share it with others who may not be required to follow national and international "protected health information" (PHI) regulations such as the federal privacy rule.

Subject to any legal limitations, you have the right to access any protected health information created during this study. You may request this information from the Principal Investigator named above but it will only become available after the study analyses are complete.

- This authorization does <u>not</u> expire, and will continue indefinitely unless you notify the researchers that you wish to revoke it.

You may change your mind about this authorization at any time. If this happens, you must withdraw your permission in writing. Beginning on the date you withdraw your permission, no new personal health information will be used for this study. However, study personnel may continue to use the health information that was provided before you withdrew your permission. If you sign this form and enter the study, but later change your mind and withdraw your permission, you will be removed from the study at that time. To withdraw your permission, please contact the Principal Investigator or study personnel at 909-583-4966.

You may refuse to sign this authorization. Refusing to sign will not affect the present or future care you receive at this institution and will not cause any penalty or loss of benefits to which you are entitled. However, if you do not sign this authorization form, you will not be able to take part in the study for which you are being considered. You will receive a copy of this signed and dated authorization prior to your participation in this study.

I agree that my personal health information may be used for the study purposes described in this form.

Signature of Patient *or* Patient's Legal Representative	Date
Printed Name of Legal Representative (if any)	Representative's Authority to Act for Patient
Signature of Investigator Obtaining Authorization	Date