Cross Sectional Study

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The Effects of Motion Sickness on Balance and Gait

Shreya Neetu Yogesh Pai[1], Sukhada Sudhir Prabhu[2]

[1]Intern, School of Physiotherapy, D.Y. Patil University, Navi Mumbai, [2]Associate Professor, Dept of Kinesiotherapy & Physical Diagnosis, School of Physiotherapy, D.Y. Patil University, Navi-Mumbai

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Abstract

Background: The term "motion sickness" (also called "kinetosis") describes a set of symptoms that occur in association with motion of a person or his or her surroundings, triggering a stress reaction that results in autonomic symptoms. The onset is often insidious, with drowsiness/yawning, dizziness, reduced alertness, and symptoms progress through cold sweating, pallor, excessive salivation, and occasionally headache, to nausea and vomiting with incapacitation that can be severe. Motion sickness usually occurs due to a visuo-vestibular conflict. Part of it is psychological as well as the symptoms of motion sickness are triggered in some people by just reading about it.

Method: A cross-sectional study was performed in college going students for six months using the MSSQ-short and the Mini BESTest to assess the susceptibility of motion sickness as well as balance and gait respectively.

Conclusion: Balance and gait was found to be significantly affected in people with motion sickness.

Keywords: Balance; Gait; Motion sickness; Physiotherapy; Visuo-vestibular conflict.

Introduction

Motion sickness is most typically associated with seasickness and travel sickness. Similar symptoms can be elicited by advanced simulators and virtual reality. Being car-sick, air-sick, sea-sick, cyber-sick, etc. all fall under the spectrum of motion sickness. It is also known to occur by the intense stimulation of the vestibular system, especially by horizontal oscillatory movements. Even travelling on camels and elephants can make people sick. Simulator based environment can also be a trigger for the same. The intersensory conflict hypothesis, which includes the vestibular, visual, and proprioceptive systems as well as postural instability and asymmetry of the otolith organs, nicely sums up the multiple types of motion sickness. Pharmacotherapy can include scopolamine and H1-antihistamines like dimenhydrinate and cinnarizine.[1] But the side effect for these drugs is drowsiness which makes the consumption of these drugs in day- to-day life very difficult for students.

The frequency of lateral oscillation has a relatively profound impact on the development of minor nausea. The recent observations were combined with those from a former experiment that utilized higher oscillation frequencies to generate a frequency grading for motion sickness induced by lateral oscillation

Corresponding Author: Shreya Neetu Yogesh Pai, C-17/18, New Shanti Bana, near St. Pius church, Pandit Malviya Road, Mulund West, Mumbai-400080

E-mail: shreyapai7383@gmail.com

in the 0.0315 to 0.8 Hz range.[2] Increase in postural sway occurred before the initiation of subjective motion sickness symptoms, according to an analysis of postural motion during exposure to the moving room. This reinforces an essential prediction of the motion sickness hypothesis of postural instability.[3]

Vulnerability to motion sickness has been linked to sensitivity to discrepant or "conflicting" perceptual information from the visual, vestibular and somatosensory systems and an inability to adapt readily to these perceptual conditions. This inability to successfully resolve apparent perceptual conflicts might also result in postural instability. Motion sickness susceptibility correlated most strongly with increased sway when the visual and somatosensory feedback was absent or distorted.[4]

Environmental circumstances that result in ambiguity or conflict with the patterns of sensory stimulation may adversely affect the vestibular system. The effect of this conflict in sensory information may be dizziness, a sense of imbalance, nausea, and motion sickness sometimes even to seemingly minor daily head movement activities. In some, it is not only exposure to motion but also the observation of objects in motion around them such as in supermarket aisles or other places with visual commotion; this can lead to dizziness, nausea, or a feeling of motion sickness that is referred to as visual vertigo. All people with normal vestibular function can be made to experience motion sickness, although individual susceptibility varies widely and is at least partially heritable.[5]

College going students have been chosen as the sample population as these people have to travel the most frequently for longer duration of time. They also use modes of transport that can act as triggering factors for motion sickness, like buses, trains, cars, auto rickshaw, etc. It should also be noted that the symptoms associated with motion sickness do not disappear immediately after lack of the triggering factor. The symptoms still persist throughout the day. This not only makes it difficult for college going students, the sample population, to focus during their lectures but also decreases their motivation to attend college. The after effects of motion sickness are not pleasant too. This includes acidic taste in the mouth, loss of appetite, headaches, sensitivity to slightest of head movements, dizziness, loss of balance, etc.

Other than difficulty in travelling and sitting on rides in amusement parks, people with motion sickness also have issues of balance and gait. There is also a lack of awareness regarding the other treatment strategies available for motion sickness. Balance training, vestibular adaptation exercises, behavioral changes, optokinetic stimulation help in improving the balance and gait of these individuals.[6-9] These strategies also help in decreasing the symptoms of motion sickness as they make the vestibular system more used to the triggering factors thus reducing its sensitivity to motion as well.

Materials and Methods

The experimental study design was a cross sectional study. The duration of the study was six months. It was conducted in D.Y Patil Deemed to be University, School of Physiotherapy in 2022.30 college going students voluntarily participated in this study. They were in the age range of 18-25 years who travelled at least five days a week using the modes of transports like car, bus, train, autorickshaw, scooter, etc. for a duration of at least more than 15 minutes per day. The study included both healthy individuals as well as patients suffering from motion sickness.

Patients with vestibular impairments such as BPPV, Vertigo, hearing loss, Meniere's disease, etc., those who have had an episode of recent ear infection in the past six weeks as well as those not willing to participate were excluded from this study.

The primary outcomes of this study were:

- To assess balance and gait in patients with motion sickness (Group A: experimental group) using Mini BESTest.
- To assess balance and gait using Mini BESTest in age-matched healthy individuals (Group B: control group).
- To compare the balance and gait in patients with motion sickness and healthy age-matched individuals.

The outcome measures used were MSSQ (Motion Sickness Susceptibility Questionnaire)-short[10] and Mini BES (Balance Evaluation Systems) Test.[11]

A consent form will be circulated among the sample population before conducting the study. The above-mentioned scales would be used. Each individual will be evaluated separately and will be categorized in either "Individuals with motion sickness" (Group A), which is the experimental group or "Healthy age-matched individuals" (Group B), which is the control group. Balance and gait will be assessed in these individuals and the data collected will be analyzed. The Motion Sickness Susceptibility Questionnaire-short would be used to assess the susceptibility of the individual to motion sickness in different modes of transport. The Mini BES (Balance Evaluation Systems) Test will be used to assess the balance as well as gait while checking under the different domains of Anticipatory postural control, reactive postural control, sensory orientation and dynamic gait.

The demographic data collected was further analyzed in the form of bar graphs (for distribution based on gender) and pie charts (for distribution based on age and modes of transport). Statistical analysis was performed to compare the scores of balance and gait in the above-mentioned domains in both patients with and without motion sickness. Mean and standard deviation was calculated for each domain and one sample t-test (sigma two-tailed) was done for the same.

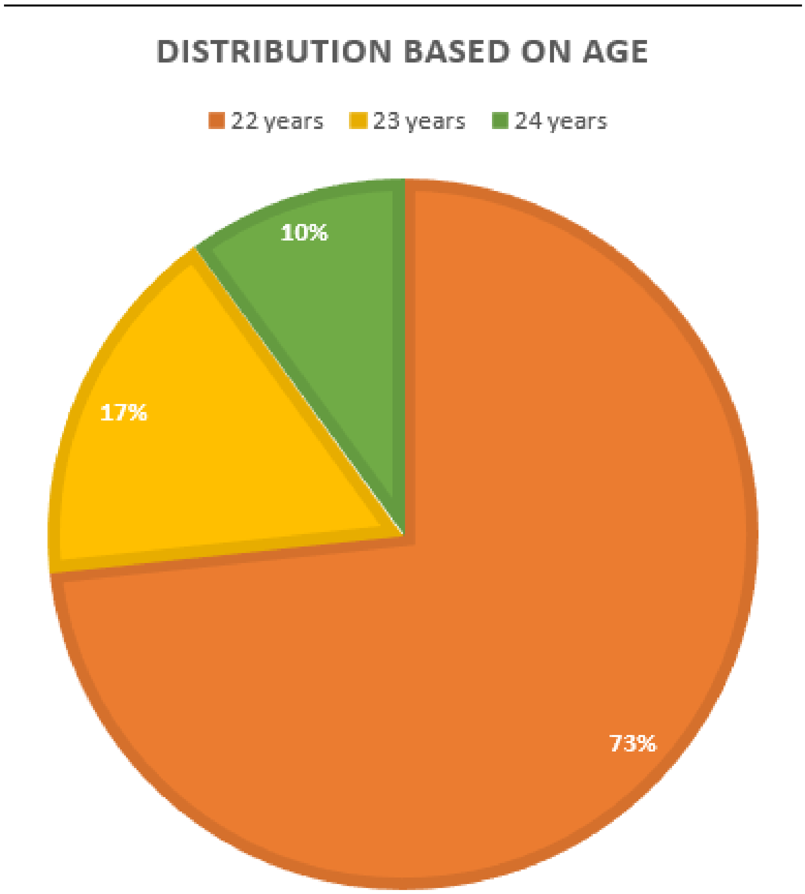
Results

1. ***Distribution based on gender:***

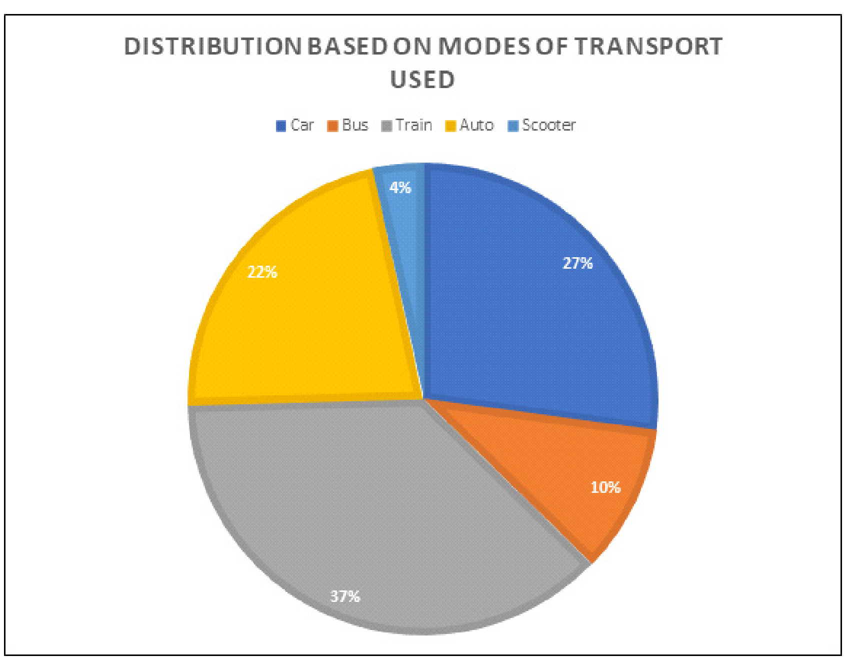
Inference:

- This bar graph depicts the percentage of males and females in the control as well as experimental group.
- 93% females have participated in this study against 7% males.
- It is evident that a greater number of females have participated in this study than males.

2. Distribution based on age:



3. Distribution based on modes of transport:



Inference:

- This pie chart depicts the modes of transport used by the sample population.
- It is to be noted that people travel through more than one mode of transport.

4. *Statistical Analysis:*

Table 1: Characteristics of Groups

Domain	PTS With Motion Sickness (mean ± SD)	PTS Without Motion Sickness (mean ± SD)
1. Anticipatory Postural Control	5.266 ± 0.457	5.733 ± 0.457
2. Reactive Postural Control	4.2 ± 0.861	5.6 ± 0.910
3. Sensory Orientation	4.8 ± 1.082	5.466 ± 0.743
4. Dynamic Gait	8.533 ± 0.833	8.866 ± 0.693
5. Total Score	22.80 ± 1.971	25.667 ± 1.290

Table 2: One Sample Test in Patients with Motion Sickness

Test value=0	**Domains**				
	Anticipatory Postural Control	**Reactive Postural Control**	**Sensory Orientation**	**Dynamic Gait**	**Total Mini BESTest score**
T	44.562	18.873	17.176	39.637	44.797
Df	14	14	14	14	14
Sig. (2-tailed)	.000	.000	.000	.000	.000
Mean difference	5.26667	4.20000	4.80000	8.53333	22.80000
95% confidence interval of the difference:					
Lower	5.0132	3.7227	4.2006	8.0716	21.7084
Upper	5.5202	4.6773	5.3994	8.9951	23.8916

Table 3: One Sample Test In Patients Without Motion Sickness

Test value=0	Domains				
	Anticipatory Postural Control	Reactive Postural Control	Sensory Orientation	Dynamic Gait	Total Mini BESTest score
T	48.511	23.827	28.487	53.662	77.000
Df	14	14	14	14	14
Sig. (2-tailed)	.000	.000	.000	.000	.000
Mean difference	5.73333	5.60000	5.46667	8.86667	25.66667
95% confidence interval of the difference:					
Lower	5.4798	5.0959	5.0551	8.5123	24.9517
Upper	5.9868	6.1041	5.8783	9.2211	26.3816

Inference: In tables 2 and 3, it has been noted that there is statistically significant difference noted between two groups with p value of 0.000 in the anticipatory and reactive postural control, sensory orientation and dynamic gait domains as well as the total score of Mini BESTest.

Discussion

As we all know, postural instability precedes motion sickness. Motion sickness simply acts as an aggravating factor for postural instability, especially anticipatory postural control. The reason behind this is the sudden increased gravitational loading of joints. Gravity acts as resistance and influences the output of muscle spindle receptors. This gives off the illusion of movement when the person is actually standing still. The sensory conflict theory says that certain stimuli lead to a conflict between the visual, vestibular and the somatosensory systems. This mismatch is what aggravates the symptoms of motion sickness in the individual. It is also the contributing factor for the presence of simulator sickness in pilots, commanders, cosmonauts, etc.[12]

A contributing factor for affection of reactive postural control is the unpredictability of the stimuli and the inability of the balance systems to compensate for it. The main trigger for motion sickness is found to be not movement but the occurrence of repeated challenges to redetermine the eye-head or the head-body systems.[13] When travelling in a vehicle it is found that the movement of the head is larger than the movement of the body. Therefore, it is noted that motion sickness can be minimized by holding the head in one fixed position or by actively tilting the head in the direction of the tilted gravitoinertia. It has also been observed that the main reason for motion sickness in cars is due to the lateral acceleration experienced leading to head tilts which acts as a trigger for the overstimulated vestibular system.[14] A similar kind of problem occurs when a person sits on the side opposite to the direction that the train is moving in. This is a major trigger for the people travelling in trains with tilting seats as well.

The vestibular system is hypersensitive in people with motion sickness. This is further proved when sensory orientation is tested in the subjects with no visual and distorted proprioceptive cues. A study was conducted where a vibrator was attached to the calf muscles to distort the proprioceptive cues and the subjects were asked to stand on a flat stable platform with their eyes open and then with their eyes closed. The postural sway is found to be more when the subjects' eyes were closed. The vibrating calf muscles contributed further to the aggravation of motion sickness. Thus, it was proven that there is heavy dependence of the vestibular system on visual and somatosensory feedback to maintain balance, especially in subjects with motion sickness.[12]

Another study also proved that virtual reality, while being a contributing factor for postural instability and motion sickness, can also be used as a rehabilitation tool to reduce the dependency on visual inputs. In this study, virtual reality is used as a means to create visuo-vestibulo-somatosensory conflict by keeping the subjects still while the surroundings move with interactive computer graphics.[15]

Motion sickness is basically a maladaptive response of the body to an external stimulus. It is said that the external stimulus that causes sensory conflict is perceived by the body as ingestion of neurotoxins which leads to the gastrointestinal symptoms of nausea, vomiting, acidic aftertaste, etc.[13] This sensory conflict has been also proven to affect the dynamic components of gait such as head tilts, pivotal turning, stepping over obstacles as well as dual tasking (Consecutive subtraction by 3 from 100 while walking), etc. It is also noted that it is easier for the patient to walk while focusing on a fixed target. The moment the focus is shifted, changes can be noted in the subject's gait with respect to cadence, postural sway, balance, etc. A study was also conducted in subjects with vestibular migraine, who had high susceptibility to motion sickness as well as poor DGI scores.[16]

Conclusion

A statistically significant difference was seen on evaluation of balance and gait in patients with & without motion sickness. Thus, in present study, when compared with healthy age matched individuals, gait and balance was found to be severely affected in people with motion sickness.

Ethical Clearance: Taken from Institutional Ethics Committee for Biomedical and Health Research, DY Patil Medical College, Navi Mumbai. (Reference number: 2022/047)

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Conflict of interests: Nil

References

1. Koch A, Cascorbi I, Westhofen M, Dafotakis M, Klapa S, Kuhtz-Buschbeck JP. (PDF) The Neurophysiology and Treatment of Motion Sickness Deutsches Ärzteblatt International. (2018 Oct); 115(41): 687.
2. Donohew BE, Griffin MJ. Motion sickness: effect of the frequency of lateral oscillation. Aviation, Space, and Environmental Medicine. (2004 Aug 1); 75(8): 649-656. PMID: 15328780.
3. Stoffregen TA, Smart Jr LJ. Postural instability precedes motion sickness. Brain research bulletin. (1998 Nov 15); 47 (5): 437-448. https://doi.org/10.1016/S0361-9230(98)00102-6.
4. Bles, W et al. "Motion sickness." Current opinion in neurology vol. 13,1 (2000): 19-25. doi:10.1097/00019052-200002000-00005.
5. Bronstein AM, Golding JF, Gresty MA. Visual vertigo, motion sickness, and disorientation in vehicles. InSeminars in Neurology 2020 Feb Vol. 40, No. 01, pp. 116-129. Thieme Medical Publishers. DOI: 10.1055/s-0040-1701653.
6. Singh, Anshika & Kumar, Sanjai & Meena, Raj. (09, 2016). Role of Vestibular Adaptation Exercises on Motion Sickness. 95-102. DOI: http://dx.doi.org/10.21088/potj.0974.5777.9316.3
7. Tharani G, Rajalaxmi V, Ramachandran S, Kamatchi K, Naong Mung AC. EFFECTS OF BALANCE AND VESTIBULAR TRAINING IN PERSONS WITH ...
8. Jannu C. An experimental study to findout the effect of visual-vestibular habituation and balance training exercises in patients with motion sickness. Indian Journal of Physiotherapy and Occupational Therapy (2015 Jul); 9(3): 224-229 DOI Number: 10.5958/0973-5674.2014. 00001.
9. Maffert A, Aupy B Optokinetic stimulation efficiency for sea sickness ... International maritime health. (2020); 71(4): 249-252.
10. Golding JF. Motion sickness susceptibility questionnaire revised and ... Brain research bulletin. (1998 Nov 15); 47(5): 507-516.
11. Godi M, Franchignoni F, Caligari M, Giordano A, Turcato AM, Nardone A. Comparison of reliability, validity, and responsiveness of ... Physical therapy. (2013 Feb 1); 93(2): 158-167.
12. Reschke MF, Bloomberg JJ, Harm DL, Paloski WH, Layne C, McDonald V. Posture, locomotion, spatial orientation, and motion sickness as a function of space flight. Brain Research Reviews. (1998 Nov 1); 28(1-2): 102-17. PMID: 9795167 DOI: 10.1016/s0165-0173(98)00031-9
13. Treisman M. Motion Sickness: An Evolutionary Hypothesis Science. (1977 Jul 29); 197(4302):493-495.

14. Bertolini G, Straumann D. Moving in a moving world: a review on vestibular motion sickness. Frontiers in neurology. (2016 Feb 15); 7:14. PMID: 26913019 PMCID: PMC4753518 DOI: 10.3389/fneur.2016.00014

15. Nishiike, Suetaka & Okazaki, Suzuyo & Watanabe, Hiroshi & Akizuki, Hironori & Imai, Takao & Uno, Atsuhiko & Kitahara, Tadashi & Horii, Arata & Takeda, Noriaki & Inohara, Hidenori. (2013). The effect of visual-vestibulosomatosensory conflict induced by virtual reality on postural stability in humans. The journal of medical investigation: JMI. 60. 236-239. PMID: 24190041 DOI: 10.2152/jmi.60.236

16. Balcı B, Akdal G. Imbalance, motion sensitivity, anxiety and handicap in vestibular migraine and migraine only patients. Auris Nasus Larynx. (2020 Oct 1); 47(5): 747-51. PMID: 32178946 DOI: 10.1016/j.anl.2020.02.015.