Effect of virtual reality on motion sickness-An experimental Study

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***Abstract*- Background:** Motion sickness occurs due to mismatch sensory inputs between the visual and vestibular system. Vestibular and visual systems coordinate eye movement in order to stabilize retinal images during head rotation. When someone is in stationary position they can still get the impression of self motion under certain conditions known as vection.

Aim: To find out the effect of virtual reality on motion sickness. **Methodology:** It was an experimental study of pre-post design. Total 40 subjects participated in the study. Subjects who experience motion sickness of score more than 3 in modified Borg rating scale for dizziness were included in the study. Virtual Reality headset was used to deal with the problem of motion sickness by habituating visual vestibular system to induce adaptation in the VOR. Frequency of intervention was 3 sessions lasting 6 minutes each for 2 weeks. Dizziness score recorded after every session.

Result: Repeated measures ANOVA showed that that virtual reality habituation lead to slight reduction in dizziness scoring from day 1 to day 11 ($p < 0.001$).

Conclusion: Result of the study concluded that Virtual Reality headset showed improvement in symptoms of motion sickness as measured through modified borg rating scale for dizziness.

***Index Terms*-** Motion sickness, Virtual Reality, Dizziness, Vestibulo-ocular Reflex

I. Introduction

Motion sickness is an ancient problem, having afflicted human for thousands of years[1]. The most common type of motion sickness are sea sickness, air sickness, car sickness and train sickness[2]. It is a syndrome of nausea, vomiting, dizziness, increased salivation, stomach awareness, headache, drowsiness, pallor, sweating. Motion sickness occurs due to mismatch sensory inputs between the visual and vestibular system. When travelling in a vehicle with limited outside visibility. The vestibular system reports motions to the central nervous system, but information from the visual system suggests the individual is not moving. Motion sickness is more common in females than males. It can occur due to vestibular dysfunction[3]. Motion sickness results from over stimulation of the vestibular organ produced by excessive body motion[4]. Many patients with vestibular disorder also report symptoms during external motion[3]. The vestibular system detects head motion and gravitational force on the body[5]. Semicircular canal responds to angular acceleration while otolith organs detect static equilibrium (position of the head in space which is very important for the control of posture) and to change in gravitational force[6,7]. They are also sensitive to linear acceleration[8]. Utricle responds during horizontal acceleration and saccule responds during vertical acceleration[9]. There is an important relationship between the vestibular and visual systems that coordinates eye movement in order to stabilize retinal images during head rotation. This compensatory reflex is known as the Vestibulo-ocular Reflex [VOR][10]. When someone is in a stationary position they can still get the impression of self motion under certain conditions. This deceptive impression of self motion is called vection. Vection can occur when someone in a stationary vehicle while an adjacent vehicle begins to move[10]. When stationary observers are exposed to such a moving visual stimulus, they will at first correctly perceive motion of the visual stimulus (object moving). After a few seconds this perception typically shifts towards oneself being moved and the moving visual stimulus slowing down and finally becoming earth stationary[12]. Optical flow fields are the pattern of visual motion that an observer encounters while moving through the environment. Optical flow patterns provide a sense of self motion based on both translation and rotational component about a head-centered axis in the 3D space[13]. Optical flow pattern on the retina provides visual input that leads to steady self-motion perception[14].

Virtual environment is considered to be a 3D real time graphical environment synthesis by a computer in which the orientation of displayed objects is controlled by the user via body position sensors or user-input device. The virtual reality [VR] environment may be displayed on a desktop monitor, a wide field-of-view display such as a projection screen, or on a head mounted display. A fully immersive virtual reality environment utilizes a head mounted display, wide a head position sensor to control the displayed images so that they appear to remain stable in space when turning the head or moving through the virtual environment[15]. Virtual reality technology offers the sensory complexities found in the physical world in the controlled environment[16]. There are 3 types of virtual reality. In immersive virtual reality effective VR experiences cause you to become unaware of your real surrounding and focus on your existence inside the virtual environment[17]. Non-immersive virtual reality also called desktop VR system. It consists of a standard computer monitor to display the virtual world[18]. Semi-immersive virtual reality provides high level of immersive, while keeping the simplicity of the desktop VR[19]. This system consists of VR and

real world attributes by embodying object the computer graphic into the scene of the reality[18]. VR can be used to induce adaptation in the VOR[20.]

With motion sickness, the 2 primary senses that are involved are vestibular and visual sense. As the subject uses the simulation, the optical flow patterns of the road, buildings, and other part of the environment move past the subject peripheral this gives him/her a sense of vection. The visual system tell the subject a variety of information which includes that he/she is moving in a certain direction, accelerating when pressing gas pedal and decelerating when pressing the break. However, since the subject is not actually moving, the vestibular sense provides no sense of linear or angular acceleration or deceleration. This sensory conflict between visual and vestibular system result in motion sickness[10].

Virtual reality shinecon is an immersive type of VR and it is a plastic headset with pleather covered padding, and an adjustable head strap. The whole front cover of the headset flips down to reveal the smartphone holder. On both sides of headset are knobs that extend the front section of the headset to aid in image focusing. On the top centre of the headset is the pupil distance adjustment knob. Tuning the pupil distance knobs widen the distance between the lenses.

In addition to side effects like dryness of mouth, drowsiness, blurred vision, skin irritation, dizziness[22] and sedation, medications to treat vertigo affects individual's daily active performance by causing performance decrement on tasks requiring continuous attention and memory storage[23]. Many people deal with motion sickness on a daily basis have difficulty in travelling and so often they take a direct approach as medications for precaution at the time of travelling. This motion sickness may influence our daily activities as by symptoms like dizziness, nausea, etc. This study attempts to see the effect of virtual reality on motion sickness by habituating visual vestibular system using virtual reality headset.

Methodology It is an experimental study with pre-post design.carried out in 40 subjects in age group of 18 – 45 years of either gender among the subjects who experience motion sickness while travelling and scored 3 or more in modified borg rating scale for dizziness.**subjects with** hearing problem or auditory symptom ,functional visual problem,painful neck movement, ear infection were excluded from the study.Modified Borg rating scale for dizziness was used as an outcome measure.**Instrument used was** Virtual reality headset with remote control Smartphone**,** Chair**,** A4 sheet with a centered black circle.Reliability of borg scale was 0.78[24] as established by Pfeiffer K.A et al (2002).

Duration	**Mean ± SD**
Day 1	4.8 ± 1.4
Day 3	4.3 ±1.4
Day 5	3.6 ± 1.4
Day 7	2.8 ±1.3
Day 9	2.1 ± 1.2
Day 11	1.5 ± 1.1

II. Procedure

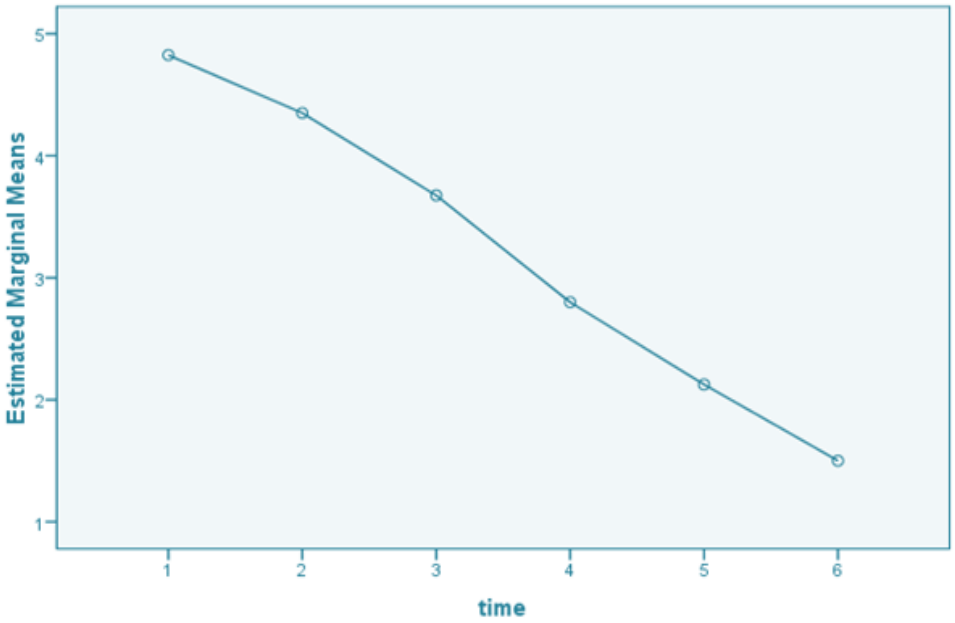
After taking ethical clearance, screening of participants was done based on inclusion and exclusion criteria. Included subjects were informed about the nature of study and written consent was taken from them. Detailed procedure was explained to them. Dizziness score was noted according to modified borg rating scale for dizziness.The individual were asked to sit on a chair comfortably with back straight. The mobile was placed in virtual reality headset which was then set over individual's eyes. Subjects were instructed to report any sort of discomfort so that video can be stopped immediately. After showing 6 minute video, virtual reality headset was removed and the individual were asked to stand up and focus on a point for 10-15 seconds. Any symptoms of motion sickness were scored on the basis of modified borg rating scale for dizziness. Total 3 sessions lasting 6 minutes each for 2 weeks was given to each participant. Data was analyzed using SPSS version 16.0 software. Descriptive statistics was used to summarize the variables. Repeated measure ANOVA with Greenhouse geissere correction was used to see the change in dizziness score from day 1 to day 11. P value < 0.05 was considered statistically significant.

III. Result

Total 40 subjects participated in the study. Mean age of participant was 32.05±8.4. The gender distribution in our study was 55% female and 45% were male. Repeated measures ANOVA showed that Modified Borg Rating Scale for Dizziness scores differ statistically significant between time points with $p < 0.001$. Post hoc test using Bonferroni correction revealed that virtual reality habituation lead to slight reduction in Modified Borg Rating Scale for Dizziness scoring from day 1 to day 11 (From mean 4.8±1.4 to 1.5±1.1). Table 1 shows the gradual decline in mean dizziness scoring from day 1 to day 11

Table 1: Showing change in Modified Borg Rating Scale for Dizziness scoring from day one to eleventh day

Figure 2: Showing gradual decline in mean dizziness scoring with ti



IV. Discussion

Motion sickness is a generic term that reflects body reaction to various kinds of motion stimuli caused during passive transportation or by other devices like swings, etc. This sickness may also be evoked by walking while wearing horizontally reversing goggles both in adults and children. The motion sickness is characterized by symptoms like nausea, vomiting, pallor and cold sweating[25]. Present study was conducted to see the effect of virtual reality on motion sickness. Total 40 participants with mean age being 32.05±8.4 year were included in the study. The gender distribution in our study was 55% female and 45% were male. Perception was higher among females than males across all age groups this result is similar to study done by **Sharma K, Aparna, 1997** were Females (27.3%) were more susceptible to motion sickness than males (16.8%)[25].

While 'adaptation' means a decreased response following continuous stimulation of a receptor system, the reduction of neuronal activity after repeated stimulation is called 'habituation'. The adaptation effects can also be explained by the sensory conflict theory. In situations that commonly produce sensory conflicts (sensory rearrangement) and motion sickness, the brain presumably stores appropriate traces, making the sensory conflict part of our 'exposure history'. Once this occurs, there is no conflict between our expectations and the sensory information received and thus, after some time, motion sickness symptoms no longer occur[26]. Supporting this, study **Pavlou M et al 2012** reported that exposure to dynamic VR environments should be considered as a useful adjunct to vestibular rehabilitation programs for patients with peripheral vestibular disorders and visual vertigo symptoms. The present study reported decrease in the symptoms of motion sickness through habituation by using virtual reality (VR) headset. Treatment duration in our study was 3 sessions lasting for 6 minutes each for 2 weeks. This is supported by **Schmal F, 2013** where repeated or continued exposure to motion resulted in declining motion sickness. Furthermore a preliminary study involving placing patients with chronic vertigo due to a vestibular disorder, in an immersive, computer generated moving visual scene that interacted with their head movements, showed improvements in vestibulo-ocular reflex gain and dizziness handicap after 5 days [27].

Gorini A, Riva G, 2008 presented that Virtual Reality Exposure Therapy seems to be a promising intervention for the treatment of specific phobias and anxiety disorders. In a study by **Rothbaum BO, et al (1995)** treatment with virtual reality graded exposure was successful in reducing fear of height (Acrophobia). The mean rating of subjective discomfort in each session decreased steadily across sessions, indicating habituation[28]. Acrophobia was the first phobia treated with Virtual Reality Exposure Therapy. Several studies shown that claustrophobia, fear of flying, fear of driving, fear of public speaking, panic disorder with agoraphobia, post traumatic stress disorder may be reduced by Virtual Reality Exposure Therapy[29].

VR has many benefits over other treatmen which allow it be be adjunct as therapy in reducing symptoms.The VR allow the user to monitor, control, and observe that feature in the normal scale system, it allows the user to feel and sense the "non-real time." Non- real time means a case or situation either offered in fast time or slow, it is safe more than the real world. VR introduces the students with realism and interactivity it Simulate the interaction and its speed or faster that in the real world. Most of the systems in VR give the users opportunities to repeat the task until the user fulfills that task professionally with desired skills. It gives the users the ability of observations and monitoring from many numbers of views. VR technology support and enhance the distance learning and avoid real danger, break the limitations of time and does not require users to present in the same place of training any system simulation that the user can train even if he/she is in another country[18]. Therefore, use of VR in our study is

justified as it is time independent, safe, and habituation becomes easy which gives positive result.

Although our study reported positive response to VR, the sample size taken was small, so a further study with a larger sample would provide a better generalization of the result. We recommend longer time follow up to see the long term effect of virtual reality.

Conclusion-The present study concluded that Virtual Reality headset showed improvement in symptoms of motion sickness as measured through modified Borg rating scale for dizziness.

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