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Physiotherapy interventions for motion sickness: A systematic review

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ABSTRACT

Motion sickness susceptibility depends on the sensitivity of each individual and the ability of the vestibular system to adapt to continued exposure to the stimulus affecting activities of daily living. For this systematic review, data were extracted from PubMed, Pedro, Cochrane, and Google Scholar from 2000 to 2021 publication dates using the following MESH terms: 'motion sickness', 'exercise', 'physiotherapy', and 'physical therapy'. A total of 41,789 articles were identified from 2 databases, of which 41,767 were excluded, and 18 were saved for secondary screening. After a detailed review of these articles, 7 articles were selected, including RCTs, case studies, and experimental studies. Strong evidence was identified for 2 strategies used, including breathing techniques and vestibular adaptation exercises. Physiotherapy interventions play an important role for individuals with motion sickness by alleviating the symptoms.

Keywords: motion sickness; physiotherapy; exercise; therapy; physical therapy

1. INTRODUCTION

1.1 Background

Motion sickness can affect the traveling experience on airplanes, trains, ships, and in cars. Motion sickness is often considered a disabling symptom, significantly limiting business, travel, and leisure activities (Chen, 2009). Therefore, appropriate behavioral and pharmacologic treatment may be required to prevent and/or treat motion sickness and reduce discomfort. Unfortunately, the pharmacological options exhibit adverse effects which affect the traveller. Therefore, it is necessary to investigate innovative methods of managing motion sickness (Chen, 2009).

1.2 Causes of motion sickness

Motion sickness usually shows up with a slightly queasy feeling, making you uncomfortable and unwell. This is also termed travel sickness. Its occurrence depends on the person's sensitivity and the individual's ability to adapt to the stimulus using the vestibular system. The characteristic signs include a range of symptoms like nausea, cold sweat, increased salivation, hyperventilation, and frequent headaches that often occur while traveling. It is more prevalent in females than males (Henriques et al., 2014).

Motion sickness can be a response to the physiology and perception of conflict in the sensory circuits of information about vision, balance, and movement. Susceptibility to motion provokes nausea, feeling hot/warm, dizzy, and tiredness (Russell et al., 2014).

The muscle and joint sensory receptors' feedback mechanism is important in motion sickness symptoms. Another important organ is the inner ear, which sends feedback; this feedback is of utmost importance because people without those motion-sensing organs do not get motion sickness (Green, 2016).

1.3 Incidence and risk factors

It is seen that females are more susceptible than males in a ratio of 1.7:1, which makes females more prone to motion sickness due to the use of oral contraceptives during menstruation or pregnancy (Anuradha and Mishra, 2010). A higher incidence of motion sickness in women has been suggested owing to changes in hormones. Research on genetic characteristics in children in terms of fear and anxiety related to motion sickness also found high susceptibility among girls (Henriques et al., 2014).

Motion sickness is a multi-symptomatic syndrome influenced by factors such as individual susceptibility related to age and sex, stimulus types like self or visual motion, and specific circumstances, namely biological rhythms. Various forms of transportation like air, water, land, along with other moving platforms like in amusement parks, space travel, and vestibular stimulation in laboratories can trigger motion sickness. These lead to nausea, which can be mild or severe. Increased motion sickness susceptibility occurs in individuals with a migraine or vestibular migraine. Motion sickness may coexist and can be impacted by the presence of vestibular disorders. Visually induced motion sickness (VIMS) may cause nausea, stomach awareness, sweating, headache, drowsiness, eye strain and blurred vision (Cha et al., 2021).

1.4 Methods to measure the severity and susceptibility to motion sickness

It is recommended that each scale be used for its specific advantages to the research question or clinical application. The motion sickness susceptibility questionnaire (MSSQ-short form) should be used if several language translations are needed and the simulator susceptibility questionnaire (SSQ) if VIMS is the focus (Cha et al., 2021).

Members of the Classification Committee of the Bárány Society (CCBS), who met in Berlin, Germany, in March 2017, proposed the creation of a subcommittee to develop criteria for motion sickness for the International Classification of Vestibular Disorders (ICVD). Diagnostic criteria were developed through discussions among subcommittee members.

An acute episode of motion sickness is induced by physical motion/visual motion that meets Criteria A through D (Castillo-Bustamante et al., 2022).

A. Physical motion of the person or visual motion elicits sign(s) and/or symptom(s) in at least one of the following categories, experienced at greater-than-minimal severity:

1. Nausea and/or gastrointestinal disturbance
2. Thermoregulatory disruption
3. Alterations in arousal
4. Dizziness and/or vertigo
5. Headache and/or ocular strain

B. Sign(s) and/or symptom(s) appear during motion and build as exposure is prolonged

C. Sign(s) and/or symptom(s) eventually stop after cessation of motion

D. Sign(s) and/or symptom(s) are not better accounted for by another disease or disorder

1.5 Barany Society diagnostic criteria for motion sickness

An existing visual mismatch theory indicates that motion sickness may progress in three phases: Phase I, also called the high resistance phase, occurs at age 1 (Cha, 2021). During this phase, newborn patients are subject to a vestibular-visual disturbance but do not use visual help to acquire the self-perception of movement. In phase II, there is a peak before puberty when a hormonal hypersensitivity presents and a sensory-motor disarrangement occurs, generating a visual and vestibular disturbance (Cha, 2021). Phase III includes a post-puberty decline, consistent in visual and vestibular breakdowns due to the habituation to repetitive stimuli on transportation (Cha, 2021). This sensory conflict hypothesis is the most widely accepted theory for the pathogenesis of motion sickness. Children under the age of 1 might be highly resistant to the susceptibility of motion sickness because they use the visual system only to a limited extent for self-motion perception and, therefore, are less subject to visual-vestibular conflicts. The prepubertal high frequency of susceptibility may indicate an oversensitivity to the visual-vestibular mismatch of motion stimulation. Motion sickness occurs because of low-frequency stimuli that could be vertical, lateral, angular, or rotatory on non-adapted individuals. The severity and duration of symptoms are determined by the grade of incoordination between the stimuli received by the vestibular and central nervous systems and the ability of the individual to adapt to their normal environment.

1.6 Management strategies and treatment options

Motion sickness severity and susceptibility can be modulated by reducing exposure to sickness-inducing stimuli or, conversely, by engaging in measured amounts of motion exposure to induce habituation. Habituation may be stimulus-specific, however, and may not generalize across motion types or situations. Environmental adaptations such as roll-stabilizers on ships, active suspension in cars, or virtual reality displays with short head motion response lags can reduce the chances of inducing motion sickness. Interventions such as habituation exercises (eye-head motion, repeated exposure), pharmacologic pre-treatment (anti-muscarinic, anti-histaminic, anti-cholinergic medications); non-pharmacological treatments (music, smells), and behavioural techniques (breathing exercises, meditation) can all adjust severity (Cha et al., 2021).

Scopolamine is the first-line pharmacological treatment available for the prevention of motion sickness. Behavioral strategies can also be adapted to treat motion sickness; for example, situations are identified that increase the susceptibility to motion sickness. Minimizing exposure to such situations can help reduce the symptoms of motion sickness (Brainard and Gresham, 2014).

Researchers have shown that individuals become more and more vulnerable with a gradual increase in the levels of stimulation (e.g., head movements along with passive body rotation at increased rotation velocities) and allow adaptation without being motion sick by simple behavioral modification like biofeedback, which can prevent motion sickness. Most people adapt to different stimuli experienced due to moving on the road after repeated and prolonged exposure, creating a new addition to the neural store, often known as habituation (Anuradha and Mishra, 2010).

A similar study was done by Rine et al. (1999). In this study, physical therapy consisting of visual, vestibular habituation, and balance training was given for motion sickness to a 34-year-old woman. She went through a home-based exercise program for 10 weeks. After completing this program, her symptoms improved, and she could continue her work (Rine et al., 1999).

This systemic review aimed to review the effectiveness of physiotherapy interventions for motion sickness, which helps sum up the existing information on countermeasures for the treatment of motion sickness.

2. MATERIALS AND METHODS

The systematic review was conducted between 2000 and 2021 when most articles were published on this topic. The search strategy included relevant articles from PubMed, Pedro, Cochrane, and Google Scholar databases with 2000–2021 publication dates using the following MeSH terms: 'motion sickness', 'exercise', 'physiotherapy', or 'physical therapy'. Articles published other than in English were excluded. Additional articles were searched by reviewing the references of relevant studies. Duplicate studies were removed manually by the authors.

Eligibility criteria consisted of the study design, dates, and P (population), I (intervention), C (comparator), and O (outcomes) approach. Exclusion criteria were primarily based on irrelevant, duplicate articles and full texts that were not available. The inclusion criteria included articles with the target patients, randomized control trials (RCT), observational studies, and case-control studies. To summarize, the study consisted of articles that had information answering our research question.

- (P)population: Patients with motion sickness
- (I)intervention: Exercise, physiotherapy, gaze stability exercise, eye exercise
- (C)comparator: Reduce sensitivity of motion sickness
- (O)outcomes: Sensitivity of motion sickness
- Study designs: Clinical trials, RCT, review, case reports, pilot study and review, meta-analysis

2.1 Inclusion criteria

- RCTs, case-controlled studies, and observational studies
- Published in the English language
- Articles from 2000 to 2021
- Both male and female

2.2 Exclusion criteria

- Seasickness, simulator sickness
- blindness
- primary diagnosis of BPPV, migraine, central vestibular disorder, or central nervous system pathology (e.g., Parkinson's disease, multiple sclerosis, stroke, mild brain injury [concussion], and cerebellar ataxia)

2.3 Search strategy

- The search strategy was standardized as used in PubMed. Later, the strategy was modified specifically to the database to get the best relevant articles to optimize results as shown in Table 1. Formulation of the strategy was based upon the research question, i.e., PICO approach. Search strategies were developed to include free-text terms, namely text and abstracts, manuscripts, title searches, and subject-appropriate indexing (e.g., MeSH terms), with an expert opinion in the field to clear any ambiguities.
- Databases other than PubMed included Cochrane, CTRI platform, EMBASE, Google Scholar, and clinicaltrials.gov.

Table 1. Search strategy used in PubMed

#1 "motion sickness" [Mesh] OR (motion sickness) OR (sickness, motion)
#2 "physical therapy" [Mesh] OR (physical therapy) OR (therapy, physical) OR (physical intervention)
#3 "exercise" [MeSH] OR (exercise) OR (exercises)
#4 "physiotherapy" [Mesh] OR (physiotherapy) OR (physiotherapy in motion sickness) OR (motion sickness, physiotherapy)

3. RESULTS

3.1 Study selection

The preferred reporting items for systematic reviews and meta-analyses (PRISMA) flow chart refers to the steps of study selection, as shown in Figure 1. The search strategy yielded a total of 41,789 articles from 2 databases. A total of 41,767 articles were excluded after the first screening because of irrelevance to the topic, and only 18 articles were saved for further screening. After reviewing these 18 articles, investigators selected 7 articles for the review.

3.2 Data synthesis and analysis

The studies included in this review had varied outcome measures and comparator interventions. A meta-analysis was supposed to be conducted for this study but was not performed due to heterogeneity within the study. Therefore, narrative and descriptive findings are explained from the articles included in this review in Table 2.

3.3 Breathing exercises for motion sickness

Russell et al. (2014) performed a study to find out the effect of diaphragmatic breathing on motion sickness in a virtual reality environment. Subjects (n=60) were divided into 2 two groups: one experimental group performed diaphragmatic breathing exercises, and the other control group performed control breathing. Both groups were given 10 min of virtual reality exposure. The difference was not significant between the average motion sickness susceptibility questionnaire scores of the diaphragmatic breathing exercise group (μ = 25.8) and the control condition (μ = 22.9 with p = .90). The self-regulating strategies suggest that apart from medications, activation and stimulation of the parasympathetic nervous system can reduce motion sickness. For example, performing diaphragmatic breathing exercises at a rate of 3–7 breaths/min minimizes symptoms of motion sickness. This breathing rate is optimal because as it slows down, it increases parasympathetic nervous system tone, preventing motion sickness. Another reason such methods are helpful is that they activate the vagus nerve, which has many fibers in the heart, helping to slow the heart rate and reduce motion sickness. The study suggests that combining both may have increased the parasympathetic tone and prevented motion sickness. Breathing training can be used to reduce motion sickness symptoms. The combination of diaphragmatic breathing exercises and slowing of respiratory rate per minute is effective in increasing parasympathetic tone and preventing motion sickness signs and symptoms with prolonged exposure to motion sickness-inducing stimuli.

Stromberg et al. (2015) performed a study (n=43) about diaphragmatic breathing and its effectiveness on individuals with motion sickness. The experimental group was trained to perform diaphragmatic breathing at 6 breaths/min, and the control group breathed naturally at a normal pace. The mean respiration rate from the pre-baseline of the diaphragmatic breathing group and the control group were 15.74±2.91, 14.67±2.60, respectively. After virtual reality exposure, the mean respiration rate for the diaphragmatic breathing group and control group were 8.54±2.75 and 14.40±1.53, respectively, significant at $p<0.001$. This showed a decrease in the rate, thus reducing the severity of motion sickness. Studies have shown that diaphragmatic breathing activates the peripheral nervous system at a higher rate, alleviating motion sickness symptoms in a virtual reality environment. The study concluded that diaphragmatic breathing can be used as an effective strategy to increase the tone of the peripheral nervous system and reduce symptoms related to motion sickness.

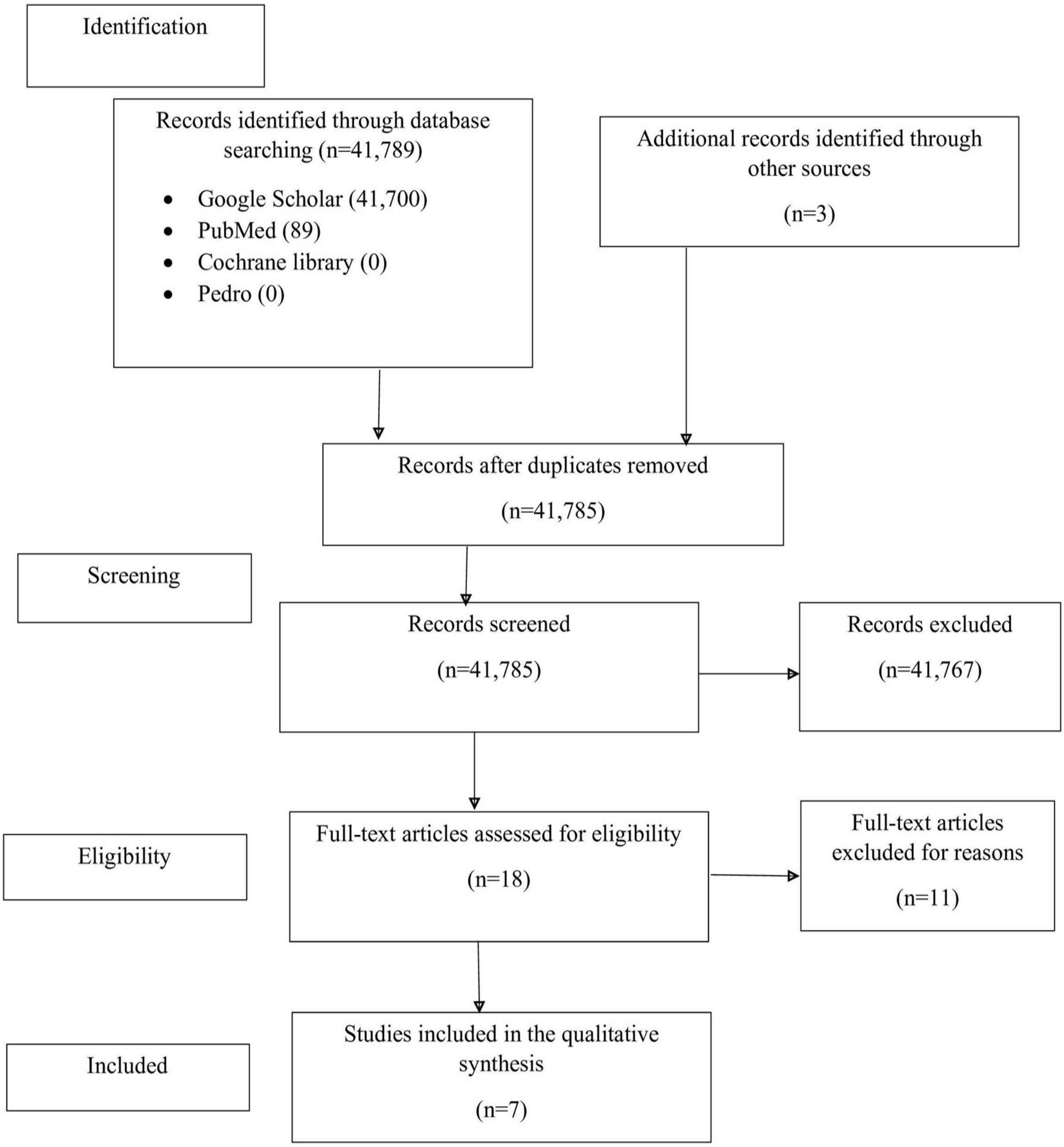

Figure 1. Preferred reporting items for systematic review (PRISMA) flow diagram showing the flow of information through the review

Table 2. The main characteristics of the studies included

Number	Title Author(s) Year of publication	Study design	Outcome measure	Intervention	Conclusion
	Vestibular adaptation exercises intervention for motion sickness.				
1	Effect of gaze stability on chronic motion sensitivity: A randomized controlled trial. Gaikwad SB, Johnson EG, Nelson TC, Ambode OI, Albalwi AA, Alharbi AA, Daher NS. 2018	A single-blinded randomized controlled trial n=41	1) Computerized dynamic posturography with virtual reality (CDP-VR) 2) MSSQ-short form	1) Gaze stability exercises (n=21) performed daily for 6 weeks. 2) Sham exercises, i.e., saccadic eye movement exercise, performed for 6 weeks daily.	The study concludes that gaze stability exercises produced a greater reduction in perception of motion sensitivity in young adults.
2	Role of vestibular adaptation exercises on motion sickness. Singh A, Sanjai K, Meena RK. 2016	Quasi-experimental study n=25	The effect was recorded on the motion sickness susceptibility questionnaire.	Vestibular adaptation exercises for 40 min per session, twice a day, i.e., a total of 80 min every day for 12 weeks.	The vestibular adaptation exercises effectively reduce signs and symptoms of motion sickness. Therefore, vestibular exercises can be used to decrease motion sickness in clinical and hospital settings and also for home-based programs.
3	Visual, vestibular habituation, and balance training for motion sickness. Rine R, Schubert MC, Balkany TJ. 2000	Case report n=1	Test for balance, coordination, vision, posturography and vestibular system status.	A 34-year-old female was given an exercise regimen that included visual-vestibular habituation exercises and balance training with speed, duration, and activity alteration. It was followed by 10 weeks of a home-based exercise program.	It showed that her symptoms were alleviated, and she could resume back to her work-related activities.
4	Effectiveness of visual-vestibular habituation and controlled breathing for motion sickness Lad M, Singh N, Bhalerao S. 2018	Experimental study n=30	Motion sickness assessment questionnaire.	It included visual-vestibular exercises for 30 minutes and controlled diaphragmatic breathing for 15 minutes for 5 days/week for 2 weeks, and then a home exercise program for 8 weeks.	It concluded that the combined effect of both techniques improved symptoms and reduced sensitivity for motion sickness at 2 weeks and was effective for as long as 8 weeks. $P<0.0001$ with 95% confidence interval.
5	A systemic review of applicability and efficacy of eye exercises. Rawstron JA, Burley CD, Elder MJ. 2020	Systemic review		43 referred studies were obtained.	Eye exercises have been seen to improve a wide range of conditions, including myopia, dyslexia, motion sickness, visual field deficits, and general well-being.

Table 2. The main characteristics of the studies included (Continued)

Number	Title Author Year of Publication	Study design	Outcome measure	Intervention	Conclusion
	Breathing exercises for motion sickness				
6	Use of controlled diaphragmatic breathing for the management of motion sickness in a virtual reality environment Russell ME, Hoffman B, Stromberg S, Carlson CR. 2014	Experimental study n=60	1) MSSQ-short form 2) Heart rate-BioPac ECG100C electrocardiogram module 3) Respiration rate using BSL-SS5LB 4) Motion sickness assessment questionnaire	1) The experimental group performed deep breathing with 3–7 breaths/per min. 2) The control group was exposed to 10 min of virtual reality, then checked for symptoms.	Slow diaphragmatic breathing along with a virtual reality environment helped reduce motion sickness.
7	Diaphragmatic breathing and its effectiveness for the management of motion sickness. Stromberg SE, Russell ME, Carlson CR. 2015	Experimental study n=43	1) Heart rate-BioPac ECG100C electrocardiogram module. 2) Respiration rate using BSL-SS5LB 3) Motion sickness assessment questionnaire	1) The experimental group performed deep breathing with 6 breaths/min 2) The control group performed control breathing at 12 breaths/min Both groups were exposed to VR.	The subjects learned new breathing skills, namely diaphragmatic breathing and slow-paced pattern. The results indicated that the alteration in breathing rate and pattern prevented the development of motion sickness symptoms.

3.4 Vestibular adaptation exercises intervention for motion sickness

Physical therapy in the form of vestibular rehabilitation therapy (VRT) specializes in exercises that result in gaze and gait stabilization. These exercises focus on head movement, crucial in stimulating and retraining the vestibular system. The fundamental mechanism behind the exercise is using neural mechanisms in the CNS for adaptation, plasticity, and compensation.

Habituation due to these VRT exercises reduces or prevents motion sickness in professionals like pilots and astronauts. Thus, these exercises can be used safely at clinics and hospitals and are effective in home-based therapy (Singh et al., 2016).

Motion sickness sensitivity is a consequence of vestibular disorders commonly treated by neuro-physiotherapists during vestibular rehabilitation. Therefore, rehabilitation targets impairments associated with motion sickness. These exercises include Gaze stabilization exercises, which are fundamental to vestibular rehabilitation therapy. The adaptation or substitution of the vestibular system is the main mechanism behind the use of gaze stabilization exercises. Therapists usually include gaze stabilization exercises as part of an intervention to reduce motion sickness with habituation as the principal mechanism behind it. Neurological physical therapists tend to use habituation as an approach with visual motion or optokinetic stimulation and balance activities under various sensory conditions to resolve visually induced instability in postural. These interventions are believed to be used to decrease visual dependence, thus reducing motion sensitivity (Gaikwad et al., 2018).

Motion sensitivity, also known as motion sickness, is often accompanied by postural instability and anxiety, as both symptoms are related to the vestibular system. Limited research is available on interventions like optokinetic training, including postural stabilization and gaze stability; however, it proves that it minimizes motion sensitivity and related anxiety. Studies have shown that a small repetition of gaze stability exercises, one session per day for 5 min, helps in motion sensitivity. This exercise involves 3 min of eye movement, first horizontally and then with eyes focused over an object, followed by about one minute's rest after each set of exercises, helps in chronic motion sensitivity in young adults (Gaikwad et al., 2018).

Singh et al. (2016) studied the impact of vestibular adaptation exercises on subjects (n=25) suffering from motion sickness. The subjects were taught the exercises involving head and eye movements and were asked to perform them twice daily for 12 weeks. After the pre- and post-experimental data were examined, the mean difference between 0–12 weeks was 1.14±2.29, significant with a t-value of 2.48, suggesting vestibular adaptation exercises can safely decrease motion sickness. The motion sickness susceptibility questionnaire score clearly shows that the vestibular adaptation exercises reduce motion sickness, and these interventions are safe to be used for reducing signs and symptoms of motion sickness in clinical and hospital settings and for home-based programs. The study can be done for a longer duration using the advanced regime of vestibular adaptation exercises.

Gaikwad et al. (2018) investigated the intervention, i.e., gaze stability exercises, to improve stability in posture and sensitivity to movement in young adults (n=41), between the ages of 20 and 40 years, with chronic motion sensitivity. Two interventional groups were made, of which one group was prescribed gaze stability exercises while the other group (control group) performed saccadic eye movement for 6 weeks. The study showed the mean significant improvement of motion severity quotient from baseline to 6 weeks post-intervention to be 1.9±0.9, significant at $p=0.004$, The control group's mean was 35.8±2.2, significant at $p=0.03$. This suggests that gaze stability exercises had a greater effect than the control group. The study showed that gaze stability exercises and saccadic eye movement exercises were equally effective in improving postural stability; in addition, there was a higher reduction in the perception of motion sickness due to the gaze stability exercise, which was based on the habituation approach.

Rawstron et al. (2005) conducted a systemic review to investigate the applicability and efficacy of eye exercises. The study also reported improving many conditions, including myopia, dyslexia, motion sickness, visual field deficits, and general well-being. Forty-three studies were analyzed: 14 were clinical trials (10 controlled studies), 18 were review articles, 2 were historical articles, 1 was a case report, 6 were editorials or letters, and 2 were position statements from professional colleges. The study concluded that the efficacy of eye exercises was also reported to improve a wide range of conditions, including motion sickness.

3.5 The combined effect of vestibular adaptation exercises and controlled breathing exercises

Lad et al. (2018) conducted a study to explore the effects of habituation on the visual-vestibular system and controlled breathing exercises in individuals (n=30) with motion sickness related to road travel. These interventions are a non-pharmacological treatment and an alternative to medication for reducing signs and symptoms of motion sickness. The individuals were given the visual, vestibular habituation exercises and breathing techniques for 2 weeks with a total protocol of 45 min. The study concluded that the combined effect of both visual-vestibular habituation and control breathing exercises caused habituation and/or adaptation of the vestibular and visual system for motion sickness. This improved symptoms and decreased sensitivity for motion sickness at a faster rate, and it showed a carryover effect up to the 8th week of intervention. This research concluded that the vestibular system is crucial in stimulating motion sickness; vestibular habituation exercises will suppress symptoms of motion sickness. This repetitive stimulation can, therefore, decrease sensitivity to motion sickness. These exercises cause a habituation effect within 2 weeks but can sometimes extend to 6 months (Lad et al., 2018).

3.6 The combined effect of vestibular adaptation exercises and balance training

Rine et al. (1999) studied the effect of habituation on the visual-vestibular system by targeting exercises. In addition, balance training was given to a 34-year-old female marine biologist with moderate to severe visually induced motion sickness, affecting her functional abilities and work. She was taught the visual-vestibular habituation exercises and was asked to continue for the next 10 weeks with a follow-up schedule at 2-week intervals. After 10 weeks, it was observed that her symptoms were alleviated, and she could resume all her work-related activities. Although she was not completely cured, her symptoms were mild. Although this case cannot be generalized to all individuals, there is a need for further investigations for appropriate interventions. Since the intervention focuses on habituation and training for vision and vestibular function, their combined conflicting input was provocative to motion sickness symptoms. Step by step, activities were added. Moreover, the patient could resume activities after habituation exercises via central mechanisms, leading to adaptation at the peripheral level, requiring repeated stimulation to maintain the outcomes (Rine et al., 1999).

Although research has been focused on habituation training using visual or vestibular stimuli, the results suggest that evidence supports the concept that habituation is usually stimuli-specific. Evidence from previous research on vestibular stimulation has shown habituation of the nystagmus response and the perception of motion. Habituation is majorly seen if visual stimulation is used, dramatically affecting habituation (Rine et al., 1999).

4. DISCUSSION

After an extensive search on different electronic databases like PubMed, Pedro, and Google Scholar, a total of 41,789 articles were identified, and a total of 41,767 articles were excluded after the first screening because of irrelevance to the topic. Only 18 articles were subjected to further screening. After extensively reviewing these 18 articles, only 7 articles were selected to determine the effectiveness of physiotherapy intervention on motion sickness. These 7 studies included RCTs, experimental observational, and case studies. Evidence was identified to be strong for 2 strategies used for individual treatment for having symptoms of motion sickness. These strategies included the use of breathing techniques (with or without the use of virtual reality) and vestibular adaptation exercises (with or without gaze stabilization exercise, i.e., eye movement exercise).

Motion sickness can be decreased, and treatment can be focused on using strategies, specifically nonpharmacologic treatment, some medicines, and therapies targeting adaptation. Pharmacologic treatments are generally prescribed medications targeted to suppress the functioning of the vestibular pathway, reducing the sensory input, and resolving conflicts between the vestibular, visual, and other proprioceptive systems. Antihistamines, anticholinergics, and antidopaminergics medicines are the most common pharmacologic line of treatments used for motion sickness. Of these, anticholinergics are some of the most used medications for motion sensitivity in children and adults. Scopolamine is considered the most effective pharmacological medication for motion sickness (Castillo-Bustamante et al., 2022).

However, non-pharmacological treatment is also commonly used. Research has shown repetitive exposure to sickness-inducing stimuli to be one of the most effective methods for preventing motion sickness in the long term. It results in a reduced response to such stimuli called habituation. It is considered the most effective intervention used in vestibular rehabilitation in children with motion sickness and has long-term effects with continued follow-up. Habituation strategies are effective treatments used in reducing symptoms of motion sickness. Vestibular rehabilitation is commonly used to achieve self-confidence in short and long trips, preserve the vestibule-ocular reflex, and maintain adequate movements on the horizontal plane. Optokinetic exercises are commonly used to achieve this goal (Castillo-Bustamante et al., 2022).

Another research supports the evidence that non-pharmacological treatment, including behavioral strategies, helps prevent motion sickness. Newer forms of transport services have increased the risk of motion sickness. Non-medicinal countermeasures would outweigh the merits to people who suffer from motion sickness because antiemetic drugs have lots of side effects on the human body (Yen Pik Sang et al., 2003).

A trial was reported on behavioral methods for suppression of motion sensitivity by using intervention, which showed the effectiveness of subtly maintaining regular breathing and listening to music that is claimed to reduce motion sickness symptoms. The gentle use of the breathing exercise was prompted by anecdotal reports of student naval aviators and experienced pilots, which suggest that controlled breathing helps suppress motion sickness (Yen Pik Sang et al., 2003).

Modification in breathing techniques has been studied previously and found to help decrease motion sickness symptoms in a subject who felt nausea. Deep diaphragmatic breathing, or evenly paced breathing technique, has been used as one method of desensitization training and autogenic feedback treatments for chronic motion sickness in pilots and astronauts. These indicate that controlled respiration could be a useful behavioral strategy for managing motion sickness-related malaise. Subsequently, these behavioral countermeasures were estimated to be as effective as half of the typical protection given by one of the best-proven antiemetic drugs used during actual traveling conditions by various transportation methods (Yen Pik Sang et al., 2003).

Motion sickness prevented by gently paced breathing exercises demonstrated consistent results concerning the effective treatment of airsickness in trainee pilots using deep diaphragmatic breathing exercises in combination with motion desensitization training. A suggested advantage of the breathing exercise method was that it was gentle with a regularly paced rhythm to avoid the risk of hyperventilation that occurs while performing the deep breathing technique (Yen Pik Sang et al., 2003).

Findings in research concerning music with breathing exercises were the first to report from this controlled trial for its effectiveness as a motion sickness countermeasure. The mechanism of action is unknown and may involve distraction or a placebo as a suggested hypothesis for decreasing symptoms of motion sickness. Music might have physiologic effects that cannot be discarded simply as a placebo/distraction. Music may influence central physiological systems, easing pain, anxiety, and nausea-like symptoms (Yen Pik Sang et al., 2003).

To sum up, motion sickness is one of the most common vestibular disorders, but it still poses a challenge for clinicians regarding diagnosis, therapeutics, and rehabilitation. The involvement of the central nervous and vestibular systems seems critical in developing symptoms from the first years of life. Vestibular rehabilitation and pharmacologic strategies are still being researched and are focused on symptom relief. Further experimental and prospective studies are needed to better understand motion sickness in children (Castillo-Bustamante et al., 2022).

Some researchers have shown that using distractions like controlled breathing and listening to music may help reduce motion sickness. Some other researchers have discovered habituation is the most effective non-pharmacological treatment for most people and will reduce symptoms over time. They can be time-consuming and may not be practical for managing infrequent motion sickness, but they are an effective treatment option if motion sickness significantly affects the person's quality of life or capacity to perform their job (Bentley and Fitzsimmons, 2023).

Diaphragmatic breathing exercises, vestibular habituation or adaptation exercises, gaze stabilization exercises, eye exercises, and combination vestibular exercises with controlled breathing, with or without virtual reality, are a few interventions used as behavioral strategies other than pharmacological treatment for motion sickness (Zhang et al., 2016).

Various interventions like VRT, visual-vestibular habituation, gaze stabilization exercise, and balance and gait training have been experimented, but no solid evidence was demonstrated by these interventions in alleviating symptoms of motion sickness. Of these various treatments, visual-vestibular habituation training is considered one of the most effective non-pharmacological treatments based on repeated exposure to stimuli that reproduce the sensory conflict, like the environment-inducing symptoms, helping to reduce motion sickness (Zhang et al., 2016).

Due to the complexity of the neuronal structures involved in the development of the symptoms of motion sickness, a variety of treatment options of different ideologies and methodologies may nevertheless achieve success. They range from pharmacological treatments proven effective, which are based mainly on H1-antihistamines and anticholinergics, behavioral measures for symptom relief like taking vitamin C and ginger, measures for desensitizing or improving habituation through physiotherapeutic exercises, or habituation to stimuli that trigger motion sickness which have all proved effective (Koch et al., 2018).

4.1 Limitations and future scope

Major limitations in all the above studies showed that the sample sizes were too small to conclude the studies. It is known that the female population has a higher predominance of motion sickness, yet few studies focus on gender. There is also a shortage of literature on standardized protocols for the nonpharmacological treatment of motion sickness. Very few randomized control trials related to motion sickness are conducted. In addition, measuring the severity of motion sickness does not include objective assessment methods. Therefore, future studies should focus more on randomized control trials, with follow-ups of longer durations, to see the carry-over effect as well as to assess the effectiveness of the treatment. The sample size should also be adequate to generalize the results to the general population. These interventions should be experimented in various ethnicities, geographical locations, climatic conditions, and age groups to conclude their effectiveness. Another important aspect is the quantification of sopite symptoms of motion sickness, which is the subject of ongoing research.

5. CONCLUSION

From the findings of this systemic review, it can be concluded that physiotherapy interventions play an important role for individuals with motion sickness by alleviating the symptoms and improving their functional well-being, but more RCTs need to be conducted in this field of research.

REFERENCES

Anuradha, P., and Mishra, G. (2010). Travel (motion) sickness: A review. *Journal of Indian Association of Public Health Dentistry*, 8(16), 39–43.

Bentley, J., and Fitzsimmons, L. (2023). Motion sickness: Causes, prevention and management. *The Pharmaceutical Journal*, 310(7971).

Brainard, A., and Gresham, C. (2014). Prevention and treatment of motion sickness. *American Family Physician*, 90(1), 41–46.

Castillo-Bustamante, M., Sommerfleck, P. A., Madrigal, J., and Cid, C. D., Bello, L., Aud, M. V., and Baez, M. (2022). Motion sickness in children: an update from its origins to nowadays a narrative review. *International Journal for Research Trends and Innovation*, 7(11), 782–787.

Cha, Y.-H, Golding, J. F., Keshavarz, B., Furman, J., Kim, J.-S., Lopez-Escamez, J. A, Magnusson, M., Yates, B. J., Lawson, B. D., Staab, J. A, and Bisdorff, A. (2021). Motion sickness diagnostic criteria: Consensus document of the Classification Committee of the Bárány Society. *Journal of Vestibular Research*, 31(5), 327–344.

Chen, L. H. (2009). Travel medicine. In *Emerging Infectious Diseases* (Keystone, J. S., Kozarsky, P. E., Freedman, D. O., Nothdurft, H. D., and Connor, B. A., Eds.), 2nd, Philadelphia: Elsevier.

Gaikwad, S. B., Johnson, E. G., Nelson, T. C., Ambode, O. I., Albalwi, A. A., Alharbi, A. A., and Daher, N. S. (2018). Effect of gaze stability exercises on chronic motion sensitivity: A randomized controlled trial. *Journal of Neurologic Physical Therapy*, 42(2), 72–79.

Green, P. (2016). *Motion sickness and concerns for self-driving vehicles: A literature review Technical Report UMTRI–2016*, University of Michigan Transportation Research Institute, USA, pp. 1–83.

Henriques, I. F., de Oliveira, D. W. D., Oliveira-Ferreira, F., and Andrade, P. M. O. (2014). Motion sickness prevalence in school children. *European Journal of Pediatrics*, 173(11), 1473–1482.

Koch, A., Cascorbi, I., Westhofen, M., Dafotakis, M., Klapa, S., and Kuhtz-Buschbeck, J. P. (2018). The neurophysiology and treatment of motion sickness. *Deutsches Ärzteblatt International*, 115(41), 687–996.

Krueger, W. W. O. (2011). Controlling motion sickness and spatial disorientation and enhancing vestibular rehabilitation with a user-worn see-through display. *The Laryngoscope*, 121(S2), S17–S35.

Lad, M., Mandade, N. S., Bhalerao, S., Babila, B. A., and Panchal, G. (2018). Effectiveness of visual vestibular habituation and controlled breathing for motion sickness. *International Journal of Yoga, Physiotherapy and Physical Education*, 3(5), 17–25.

Rawstron, J. A., Burley, C. D., and Elder, M. J. (2005). A systematic review of the applicability and efficacy of eye exercises. *Journal of Paediatric Ophthalmology & Strabismus*, 42(2), 82–88.

Rine, R. M., Schubert, M. C., and Balkany, T. J. (1999). Visual-vestibular habituation and balance training for motion sickness. *Physical Therapy*, 79(10), 949–957.

Russell, M. E. B., Hoffman, B., Stromberg, S., and Carlson, C. R. (2014). Use of controlled diaphragmatic breathing for the management of motion sickness in a virtual reality environment. *Applied Psychophysiology and Biofeedback*, 39(3–4), 269–277.

Singh, A., Kumar, S., and Meena, R. K. (2016). Role of vestibular adaptation exercises on motion sickness. *Physiotherapy and Occupational Therapy Journal*, 9(3), 95–101.

Stromberg, S. E., Russell, M. E., and Carlson, C. R. (2015). Diaphragmatic breathing and its effectiveness for the management of motion sickness. *Aerospace Medicine and Human Performance*, 86(5), 452–457.

Yates, B. J., Miller, A. D., and Lucot, J. B. (1998). Physiological basis and pharmacology of motion sickness: An update. *Brain Research Bulletin*, 47(5), 395–406.

Yen Pik Sang, F. D., Billar, J. P., Golding, J. F., and Gresty, M. A. (2003). Behavioural methods of alleviating motion sickness: Effectiveness of controlled breathing and a music audiotape. *Journal of Travel Medicine*, 10(2), 108–111.

Zhang, L.-L., Wang, J.-Q., Qi, R.-R., Pan, L.-L., Li, M., and Cai, Y.-L. (2016). Motion sickness: Current knowledge and recent advance. *CNS Neuroscience and Therapeutics*, 22(1), 15–24.