TPM Vol. 32, No. S1, 2025
ISSN: 1972-6325
https://www.tpmap.org/

EFFECTIVENESS OF VESTIBULAR AND SENSORY ADAPTATION EXERCISES IN PEDIATRIC MOTION SICKNESS MANAGEMENT: A MULTI-CENTERED STUDY

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Abstract
Motion sickness is a prevalent condition in children, often leading to discomfort and functional impairment. While pharmacological treatments exist, they may cause undesirable side effects, highlighting the need for effective, non-pharmacological alternatives. This study evaluates the efficacy of vestibular exercises, optokinetic stimulation, and imaginary play therapy in reducing motion sickness symptoms in children. A quasi-experimental study was conducted with 45 children (ages 6–12 years) diagnosed with motion sickness, randomly assigned to three intervention groups: (A) optokinetic stimulation, (B) vestibular exercises, and (C) imaginary play therapy. Each intervention was administered over four weeks, and the Motion Sickness Assessment Questionnaire (MSAQ) was used to assess pre- and post-intervention symptom changes. Results indicated that vestibular exercises led to the most significant symptom reduction, with a mean MSAQ improvement of 58.90 points, followed by optokinetic stimulation and imaginary play therapy. The findings emphasize the role of vestibular adaptation in motion sickness management and highlight the potential of exercise-based interventions for pediatric populations. Vestibular exercises proved to be the most effective non-pharmacological approach, supporting their integration into clinical practice as a primary intervention. Further research is needed to optimize exercise protocols and explore multimodal strategies for enhanced efficacy.

INTRODUCTION

Motion sickness is a common condition characterized by symptoms such as nausea, dizziness, and vomiting, typically triggered by passive movement, such as traveling by car, boat, or airplane (Reason & Brand, 1975). It results from sensory conflict, where discrepancies between visual, vestibular, and proprioceptive inputs disrupt the brain's ability to process motion cues effectively (Golding, 2006). While motion sickness affects individuals of all ages, children are particularly susceptible due to their developing vestibular systems and heightened sensitivity to motion stimuli (Turner & Griffin, 1999). This heightened vulnerability makes motion sickness a significant concern, as it can interfere with daily activities, academic performance, and travel experiences.

Several intervention strategies have been explored to alleviate motion sickness, including pharmacological treatments, behavioral therapies, and exercise-based interventions (Koch et al., 2018; Rahimzadeh et al., 2023; Cha et al., 2021; Pope & Whiteley, 2003).). Pharmacological approaches, such as antihistamines and anticholinergic medications, have demonstrated efficacy in reducing symptoms but often cause undesirable side effects such as drowsiness and dry mouth (Koch et al., 2018). As a result, non-pharmacological alternatives have gained increasing attention, particularly exercise-based interventions that focus on vestibular adaptation and sensory integration (Yates et al., 1998).

Despite the theoretical benefits of exercise for motion sickness, there is limited research on its effectiveness, especially in pediatric populations (Matsangas & McCauley, 2014). Most studies have focused on adults or used varied methodologies, making it difficult to determine the most effective exercise strategies for children (Bos et al., 2005). Given the limitations of pharmacological treatments, exercise-based interventions offer a promising alternative by enhancing vestibular function, promoting sensory adaptation, and improving motion tolerance. This study aims to evaluate different exercise interventions—such as aerobic exercise, balance training, and vestibular rehabilitation—to identify the most effective approach for managing motion sickness in children.

Vestibular exercises, which aim to enhance the brain's ability to process motion-related stimuli, have shown promise in mitigating motion sickness by promoting sensory adaptation (Palekar & Panse, 2024). These exercises involve controlled head and body movements designed to desensitize the vestibular system to motion stimuli, thereby reducing symptom severity over time (Ugur et al., 2022). Similarly, optokinetic stimulation, which involves repeated exposure to moving visual patterns, has been explored as a method to train the brain to better tolerate motion stimuli and prevent sensory mismatch (Kennedy et al., 1993). Studies have indicated that

optokinetic stimulation may be effective in reducing symptoms of seasickness and improving motion tolerance in various settings (Trendel et al., 2010; Ressiot et al., 2012).

Beyond these sensory adaptation techniques, cognitive and behavioral strategies have also been investigated as potential interventions for motion sickness. One such approach is imaginary play therapy, which incorporates elements of cognitive distraction and relaxation to help children cope with motion-induced discomfort (Bratton et al., 2005). While this method has demonstrated benefits in anxiety reduction and emotional regulation (Yardley & Redfern, 2001), its direct impact on motion sickness remains less well understood.

Despite the growing body of research supporting exercise-based interventions for motion sickness, there remains a need for direct comparisons of their relative effectiveness, particularly in pediatric populations. Most existing studies have focused on individual strategies, making it difficult to determine which intervention provides the greatest benefit. Furthermore, while previous research has highlighted the importance of sensory adaptation, cognitive engagement, and behavioral conditioning, the extent to which these approaches interact remains underexplored (Maffert et al., 2020).

By identifying effective interventions, this study will provide evidence-based recommendations for clinicians and caregivers, ultimately improving children's quality of life. Additionally, the study will contribute to a deeper understanding of motion sickness mechanisms, guiding the development of targeted, personalized treatment plans. The findings will be disseminated through academic publications, informing clinical practice and future research.

This study aims to address these gaps by conducting a comparative analysis of vestibular exercises, optokinetic stimulation, and imaginary play therapy in a pediatric population. By evaluating the relative effectiveness of these interventions, this study seeks to provide evidence-based recommendations for managing motion sickness in children. The findings will contribute to the growing understanding of motion sickness treatment and inform the development of multimodal intervention strategies that integrate physiological and psychological approaches for optimal symptom management.

MATERIALS AND METHODS

Study Design and Participants: The quasi-experimental study design was employed and aimed to determine the most effective exercise strategy for children experiencing motion sickness. The study was conducted as a multi-centered study over duration of four weeks. A total of 45 children (ages 6-12 years) were selected based on predefined inclusion and exclusion criteria.

Inclusion criteria included boys and girls aged 6-12 years, diagnosed with motion sickness as confirmed by an ENT specialist, scoring positive on the Motion Sickness Assessment Questionnaire (MSAQ), and parental confirmation of motion sickness symptoms. Exclusion criteria included a history of surgical conditions, sleep disturbances, psychological disorders, or any additional medical conditions.

Intervention Groups and Procedures Participants were randomly divided into three groups (15 participants per group), each undergoing different intervention strategies. Group A underwent optokinetic stimulating training, where participants were exposed to moving visual stimuli on a screen while seated. The visual field consisted of dots and patterns moving in different directions, with sessions lasting 15-20 minutes, twice weekly for four weeks. No head movements were permitted, and breaks were given if symptoms occurred. Group B engaged in vestibular exercises, including head movements (slow to fast head turns with eyes open, then closed), sitting exercises (shoulder shrugs, trunk rotations, and eye-following tasks), standing balance tasks (heel-to-toe stance and standing on unstable surfaces), walking tasks (walking in a straight line with coordinated head movements), and lying down exercises (rapid positional changes to stimulate vestibular adaptation). Group C participated in imaginary play therapy, incorporating relaxation techniques like deep breathing and visualization, aimed at reducing anxiety linked to motion sickness. Sessions lasted 30 minutes per session for four weeks.

Outcome Measures and Data Collection The primary outcome measure was the MSAQ, a validated 16-item, 9-point scale assessing gastrointestinal, central, peripheral, and sopite-related symptoms. Pre- and post-test scores were collected for statistical analysis.

RESULTS

The study aimed to evaluate the effectiveness of three different intervention strategies—Vestibular Exercises, Optokinetic Stimulating Training, and Imaginary Play Therapy—in reducing motion sickness symptoms in children. The results were analyzed using statistical methods, including ANOVA and post-hoc Tukey analysis, to determine the effectiveness of each intervention.

Vestibular Exercises (Group B) demonstrated the most substantial improvement in reducing motion sickness symptoms. The pre-test mean score was 81.15 (±2.21), which significantly dropped to 22.25 (±2.08) in the post-test, yielding a mean difference of 58.90 (**$p < 0.001$**). The effect size was large, with an Eta² of 0.98, indicating that 98% of the variance in motion sickness symptoms could be explained by the intervention type. The observed

effect size (f = 7.27) further confirmed that this intervention had a clinically meaningful impact on symptom reduction. Post-hoc Tukey HSD analysis revealed that Vestibular Exercises were significantly more effective than both Optokinetic Stimulating Training (mean difference = 17.83, **p < 0.001**) and Imaginary Play Therapy (mean difference = 33.57, **p < 0.001**).

Optokinetic Stimulating Training (Group A) also showed a significant reduction in motion sickness symptoms, though not as much as Vestibular Exercises. The pre-test mean score for this group was 81.95 (±2.19), which improved to 40.01 (±2.20) in the post-test, yielding a mean difference of 41.94 (**p < 0.001**). The effect size (Eta^2 = 0.98) indicated that the intervention explained a large proportion of the variance in motion sickness symptoms. While still effective, the reduction in symptoms was less pronounced compared to Vestibular Exercises. Post-hoc Tukey HSD analysis revealed that Optokinetic Stimulating Training was more effective than Imaginary Play Therapy (mean difference = 15.74, **p < 0.001**), but less effective than Vestibular Exercises.

Imaginary Play Therapy (Group C) was beneficial but comparatively less effective than the other two interventions. The pre-test mean score was 81.67 (±2.21), which decreased to 55.74 (±2.21) in the post-test, resulting in a mean difference of 25.93 (**p < 0.001**). While this strategy reduced symptoms significantly, it primarily worked by alleviating anxiety and providing coping mechanisms rather than directly modifying vestibular function. The effect size (Eta^2 = 0.98) again indicated that the intervention had a large effect in reducing symptoms, though to a lesser degree than the other two strategies. Post-hoc Tukey HSD analysis confirmed that Imaginary Play Therapy was significantly less effective than both Vestibular Exercises (mean difference = 33.57, **p < 0.001**) and Optokinetic Stimulating Training (mean difference = 15.74, **p < 0.001**).

The results strongly support vestibular exercise therapy as the best intervention for motion sickness in children. The large effect size and statistical significance suggest that incorporating structured balance and coordination exercises can be a powerful strategy in mitigating motion sickness symptoms. This study highlights the importance of sensory adaptation in addressing motion sickness and provides a strong basis for future clinical applications.

Table

Group	Pre-Test Mean (±SD)	Post-Test Mean (±SD)	Mean Difference	p-value
Vestibular Exercises	81.15 (±2.21)	22.25 (±2.08)	58.90	<0.001
Optokinetic Stimulating Training	81.95 (±2.19)	40.01 (±2.20)	41.94	<0.001
Imaginary Play Therapy	81.67 (±2.21)	55.74 (±2.21)	25.93	<0.001

Post-Hoc Analysis (Tukey HSD)

Comparison	Mean Difference	p-value
Optokinetic vs. Vestibular	17.83	<0.001
Optokinetic vs. Imaginary	15.74	<0.001
Vestibular vs. Imaginary	33.57	<0.001

DISCUSSION

This study employed a quasi-experimental design to evaluate the efficacy of various exercise-based interventions in alleviating motion sickness symptoms in children. Among the three interventions evaluated, vestibular exercises proved to be the most effective, demonstrating a mean reduction of 58.90 points in MSAQ scores. This result aligns with existing literature that emphasizes the role of vestibular adaptation exercises in enhancing the sensory system's ability to process motion-related stimuli (Palekar & Panse, 2024; Ugur et al., 2022). By directly targeting vestibular function, these exercises facilitate adaptation and improve motion tolerance, reinforcing their role as a primary intervention for motion sickness management.

Optokinetic stimulation also demonstrated effectiveness, with a mean symptom reduction of 41.94 points. This finding supports previous research suggesting that controlled visual exposure to motion stimuli promotes gradual desensitization to motion-induced discomfort (Kennedy et al., 1993). Prior studies have reported optokinetic stimulation's benefits in reducing seasickness (Trendel et al., 2010; Ressiot et al., 2012). However, some research indicates that its statistical significance is less pronounced compared to vestibular exercises (Maffert et al., 2020). One potential limitation of optokinetic stimulation is that excessive exposure to moving visual stimuli can sometimes induce discomfort rather than alleviate symptoms, particularly in individuals with heightened sensitivity to visual motion (Golding, 1998). This suggests that optokinetic stimulation may be more suitable as a complementary rather than a standalone intervention.

Imaginary play therapy, despite being the least effective intervention in this study, still showed a significant symptom reduction of 25.93 points. This suggests that cognitive distraction and relaxation techniques have a role in symptom management, although they may be less impactful than direct vestibular or visual interventions (Yardley & Redfern, 2001; Bratton et al., 2005). One potential reason for its lower efficacy is that play therapy does not directly engage the sensory adaptation mechanisms responsible for motion sickness mitigation. Instead,

it primarily serves to reduce anxiety and provide a mental diversion, which may not be sufficient for more severe cases of motion sickness. To improve its effectiveness, incorporating structured cognitive-behavioral strategies, guided imagery, or mindfulness techniques could enhance its impact on motion sickness symptoms.

Previous studies have highlighted that motion sickness impairs both balance and gait, making routine activities more challenging (Pai et al., 2022). The results of this study are consistent with systematic reviews indicating the superiority of balance and proprioception exercises in mitigating motion sickness symptoms (Wertheim, 1998). Similarly, research on optokinetic training has highlighted its benefits, though with slightly lower efficacy than vestibular-based therapies (Reason, 1978). These findings reinforce the importance of multimodal approaches that integrate both sensory adaptation and cognitive strategies for optimal management of motion sickness. The superiority of vestibular exercises underscores their role in directly addressing balance and spatial orientation, making them the most effective intervention examined in this study.

The novelty of this study lies in its comparative evaluation of three distinct intervention methods within a pediatric population. While previous research has focused on individual strategies, this study provides a direct head-to-head comparison, offering a clearer understanding of their relative effectiveness. Additionally, the inclusion of imaginary play therapy introduces a lesser-explored, anxiety-reducing approach that may hold promise when refined and integrated into broader motion sickness treatment programs.

Overall, this study contributes to the growing body of evidence supporting exercise-based interventions for motion sickness and highlights vestibular exercises as the most effective strategy. Future research should explore personalized treatment approaches that combine vestibular and optokinetic exercises with psychological techniques for comprehensive and individualized motion sickness management plan.

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