USAARL-TECH-FR--2023-03

Preliminary Evaluation of an Osteopathic Manipulative Treatment (OMT) to Prevent Motion Sickness Symptoms

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This study, USAARL log number 2022-019, was approved by the Medical Research and Development Command Institutional Review Board on 15 September 2022.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
27-10-2022	Final Report	

4. TITLE AND SUBTITLE

Preliminary Evaluation of an Osteopathic Manipulative Treatment (OMT) to Prevent Motion Sickness Symptoms

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Aeromedical Research Laboratory
P.O. Box 620577
Fort Rucker, AL 36362

8. PERFORMING ORGANIZATION REPORT NUMBER

USAARL-TECH-FR--2023-03

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Medical Research and Development Command
Military Operational Medicine Research Program
504 Scott Street
Fort Detrick, MD 21702-5012

10. SPONSOR/MONITOR'S ACRONYM(S)

USAMRDC MOMRP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A. Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

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14. ABSTRACT

Motion sickness directly impacts the readiness of the Army's aviation units. Severe motion sickness results in the dismissal of pilot and aircrew candidates during initial training, while minor to moderate symptoms can be distracting during flight. The current medications on the market that target motion sickness symptoms are prohibited for use before flight. Osteopathic manipulative techniques are a low to no cost option, which lacks side effects, that allows Doctor of Osteopathic Medicine flight surgeons the opportunity to treat crew members without the use of pharmaceuticals. If effective, these techniques could be used along side current desensitization training in order to ensure more pilot and crew candidates are eligible for flight. Given the paucity of research on such a technique, we conducted a small pilot study to to evaluate the effectiveness of a novel osteopathic manipulative treatment to prevent motion sickness symptoms whilst controlling for motion sickness susceptibility. The results of this study suggest that OMT may be effective at preventing motion sickness symptoms, specifically gastrointestinal (e.g., nausea) and sopite-related (e.g., drowsiness) symptoms. The effects observed were moderated by motion sickness susceptibility but not to the extent to suggest limited utility. The limitations of the study, however, preclude firm recommendations for operational use at this time.

15. SUBJECT TERMS

motion sickness, osteopathic manipulative treatment

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Loraine St. Onge, PhD
UNCLAS	UNCLAS	UNCLAS	SAR	14	19b. TELEPHONE NUMBER *(Include area code)* 334-255-6906

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Acknowledgements

The authors graciously thank the U.S. Army Aeromedical Research Laboratory Warfighter Performance Group members, Alabama College of Osteopathic Medicine, and the Department of Aviation Medicine, U.S. Army Medical Center of Excellence, for support of this project.

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Introduction

Motion sickness is widely believed to be a discrepancy between perceived and actual motion that results in a range of symptoms to include nausea, vomiting, drowsiness, and excessive salivation. While the exact mechanisms of motion sickness are undefined, the sensory conflict etiology and resulting symptoms indicate dysfunction in the communication between the vestibular, visual, and somato/visceral-sensory systems of the body (e.g., Takov & Tadi, 2021). Aircrew can experience motion sickness resulting from various maneuvers performed in the aircraft. Typically, this results in minimal impact for flight operations, but could yield an aircrew member unfit for duty. Also, advancements in the next fleet of rotary-wing aircraft anticipate increased maneuverability and speeds which may lend towards increased incidence of motion sickness.

While many medications currently exist in the marketplace, they vary dramatically in reported effectiveness. Additionally, most of the medications indicated for motion sickness treatment and prevention are listed as Do Not Issue/Do Not Fly by the Federal Aviation Administration (FAA; Guide for Aviation Medical Examiners, 2022). Guidance from the FAA regarding these medications prohibits aviators from flying for at least five times the maximum half-life of the drug after the last dose is administered. The list includes, but is not limited to, anticholinergics (such as scopolamine for inhibition of vestibular system stimulation), antihistamines, and muscle relaxants. In Army aviation, rated aviators and many aircrew are disqualified if motion sickness is unmanageable. However, desensitization training through repeated stimuli exposure is often sufficient to resolve motion sickness issues. Other treatment options include biofeedback training, relaxation training, and psychological counseling. Pharmaceutical treatment options are allowed on a limited basis including: “Promethazine (Phenergan) 25 milligrams (mg) combined with ephedrine 25 mg or L-scopolamine hydrobromide alone or in combination with dextroamphetamine (Scop/Dex) taken one hour prior to flight is permitted for up to three flights during training or for re-acclimatization of a rated aviator provided the patient is accompanied in flight by an instructor pilot. The scopolamine transdermal patch achieves peak blood levels 8-12 hours after application, but peak levels may not be needed to achieve symptom control” (U.S. Army Aeromedical Activity, 2021, pp. 140).

Given the limitations on pharmaceutical options for pilots and the severity of consequences regarding continued motion sickness, this study aimed to demonstrate an alternative approach that could be implemented in operational settings. Specifically, we aimed to utilize osteopathic manipulative treatment (OMT) to alleviate the neuromuscular components of the impacted systems. OMT is often used to alleviate symptoms associated with similar illness including tension headaches (Whalen, 2018), nausea and vomiting (Schrick-Senasac, 2008), post-concussion symptoms (Baltazar, 2020), dizziness, and vertigo (e.g., Fraix et al., 2021; Roberts et al., 2022). OMT is performed by a licensed physician and utilizes a mechanical, hands-on approach to treat symptoms related to neuromuscular and skeletal dysfunction. This is done by the physician addressing tissue texture changes, asymmetry, restriction of motion, and tenderness of fascia, muscle, and skeletal structures, which can in turn alleviate pressure and friction on nerves, vasculature, or lymph structures. Similar mechanisms have been proposed for the use of OMT for tension headache relief, where hypertrophy and asymmetry of the rectus capitis posterior major and obliquus capitis superior and inferior muscles compress the occipital nerve. The muscle energy technique and myofascial release are OMT methods that are believed

to activate the Golgi tendon reflex, allowing for complete muscle relaxation (Chin, 2020). One of the most widely accepted treatments for vertigo, the Epley maneuver, utilizes a mechanical approach to symptom alleviation, showing promise for the use of physical correction (Braschi, Ross, & Korownyk, 2015).

While the foundation is present with respect to vertigo, there is a need for more evidence with regard to the use of OMT, specifically as it applies to motion sickness. No research studies or defined guidance regarding the use of OMT for motion sickness could be found by the authors.

The primary objective of this study was to evaluate the efficacy of OMT for prevention of motion sickness symptoms. We hypothesized that symptom presence and severity (measured by the Motion Sickness Assessment Questionnaire [MSAQ] score) and heart rate (shown to correlate with sickness and severity) (e.g., Holmes & Griffin, 2001) would be lower following the target OMT treatment compared to sham.

Methods

A novel Osteopathic Manipulative Treatment protocol for the reduction of motion sickness symptoms and severity was evaluated using a sham-controlled, counter-balanced, between-subjects study design. The study was reviewed and approved by the U.S. Army Medical Research and Development Command prior to conduct. The independent variable was OMT treatment administered prior to the motion sickness inducing procedure (target treatment vs. sham treatment). The primary dependent measures were total and sub-scale scores from the MSAQ and heart rate.

Subjects

Twelve healthy adults participated in the study, of which 5 were male (7 female). The mean age was 29.33 years (*SD* = 5.57). All participants were screened for medical history (e.g., vestibular disorders) or current use of medications/supplements that could negatively impact the scientific integrity of the data or pose a safety threat to them.

Procedure

Participants provided written informed consent prior to study enrollment. Once determined to be eligible by a study physician, participants first completed the Motion Sickness Susceptibility Questionnaire (MSSQ), a valid and reliable measure of one's propensity towards motion sickness symptoms (Golding, 1998). Next, participants received either the sham or target treatment, administered by a licensed Doctor of Osteopathic Medicine in a private room (to preserve blinding to research team). The sham treatment did not include maneuvers that address the cervical region where the targeted anatomical structures are located. Instead, the sham maneuver treatment addressed soft tissue tension, restriction of motion, and tenderness of the lower thoracic and lumbar regions (Appendices A and B). Finally, participants were escorted to a testing room where they were instrumented the Biopac Bionomadix system (electrodes placed on the collarbone and the side) which measured electrocardiogram data that served as an objective manipulation check measure (i.e., the Barany chair procedure should cause spikes in heart rate if effective as a manipulation). Subjects completed the MSAQ, a valid and reliable measure of the

four dimensions of motion sickness: gastrointestinal (e.g., nausea), central (e.g., dizzy), peripheral (e.g., sweaty), and sopite-related (e.g., drowsy) (Gianaros, et al., 2001) to gather a baseline. Participants were seated, and secured using the safety restraint, in a Barany chair. The procedure to induce motion sickness symptoms mimics the protocol used by U.S. Army Flight Surgeons to desensitize aircrew susceptible to motion sickness (over repeated administrations) (Personal communication; Program Director, Occupational Medicine Residency, School of Army Aviation Medicine; 12 July 2022). Specifically, participants rotated (manually) at approximately 20 revolutions per minute (rpm) for 10 minutes varying the angle of their head to the ground and closing their eyes (similar to that successfully implemented by Russomano, 2003). Participants completed a final MSAQ and then were given adequate time to recover before release.

Statistical Approach

All data were inspected for impossible values and technical errors prior to analyses. Heart rate was calculated in 30-second intervals. Coefficients of variance were then calculated across the twenty 30-second intervals per participant. Difference scores (between pre- and post-procedure) were calculated for each MSAQ subscale (gastrointestinal, central, peripheral, and sopite-related) scores and total score.

Group differences in motion sickness susceptibility (MSSQ score) and age were evaluated with an independent-samples *t*-test. Group difference in gender was evaluated using a Chi-square test of independence.

The effects of the treatment condition (target, sham) on the difference (from pre- to post-procedure) in MSAQ subscale (gastrointestinal, central, peripheral, and sopite-related) scores and total score (from pre- to post-procedure) were then evaluated using five separate between-subjects analyses of covariance (ANCOVAs). Additionally, a between-subjects ANCOVA was conducted to evaluate the effect of treatment on heart rate variability (coefficients of variation). MSSQ score was included as a covariate in all analyses in order to control for motion sickness susceptibility.

Results

Summary statistics for each treatment group with respect to demographics (age and gender) and motion sickness susceptibility (MSSQ scores) are presented in Table 1. The results of the independent-samples *t*-tests do not support any differences in age ($t(10) = 1.04$, $p = 0.32$) or MSSQ ($t(10) = -0.20$, $p = 0.84$) between groups. Gender was equally distributed across groups ($\chi^2(1, 12) = 0.34$, $p = 0.56$) (Table 2).

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Table 1. Summary Statistics for Age and Motion Sickness Susceptibility by Treatment Group

Variable	Treatment Group	Mean (SD)
Age	Sham	31.00 (5.78)
	Target	27.67 (5.28)
Motion Sickness Susceptibility	Sham	12.15 (10.51)
	Target	13.64 (14.74)

Note. SD indicates standard deviation.

Table 2. Gender Distribution by Treatment Group

Treatment Group	Male	Female
Sham	3	3
Target	2	4

Summary statistics were calculated for all outcome variables (Table 3). For the gastrointestinal subscale scores, there was a significant main effect of treatment condition such that scores significantly increased in the sham group but not the treatment group, $F(1, 9) = 5.33$, $p = 0.04$. This effect was moderated by MSSQ scores, $F(1, 9) = 6.15$, $p = 0.03$ (Figure 1).

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Table 3. Summary Statistics for All Outcome Variables

Measure	Time	Sham Condition Mean (SE)	Target Condition Mean (SE)
Gastrointestinal score	Pre	12.52 (0.69)	11.09 (7.49)
	Post	46.71 (7.49)	20.42 (7.49)
Central score	Pre	11.58 (0.49)	11.57 (0.49)
	Post	41.7 (7.95)	24.04 (7.95)
Peripheral score	Pre	11.11 (0.00)	11.11 (0.00)
	Post	42.89 (9.13)	36.74 (9.13)
Sopite-related score	Pre	12.96 (0.77)	11.58 (0.77)
	Post	26.08 (3.82)	12.81 (3.80)
Total score	Pre	12.16 (0.33)	11.33 (0.33)
	Post	39.33 (6.37)	22.71 (6.39)
Heart rate coefficient of variation	Not Applicable (N/A)	0.05 (0.02)	0.06 (0.03)

Note. SE is standard error of the mean.

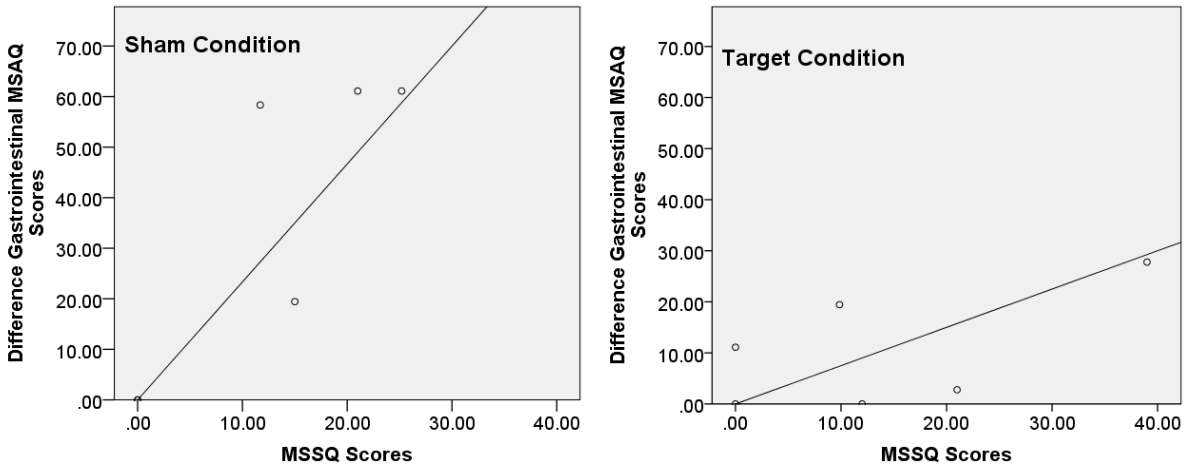

Figure 1. Relationship between difference (pre- to post-procedure) in MSAQ gastrointestinal subscale scores and MSSQ scores by treatment condition.

For the central subscale scores, treatment condition did not significantly impact difference scores, $F(1, 9) = 2.49$, $p = 0.15$. There was not a significant relationship between MSSQ scores and the difference in MSAQ central subscale scores, $F(1, 9) = 1.92$, $p = 0.20$ (Figure 2).

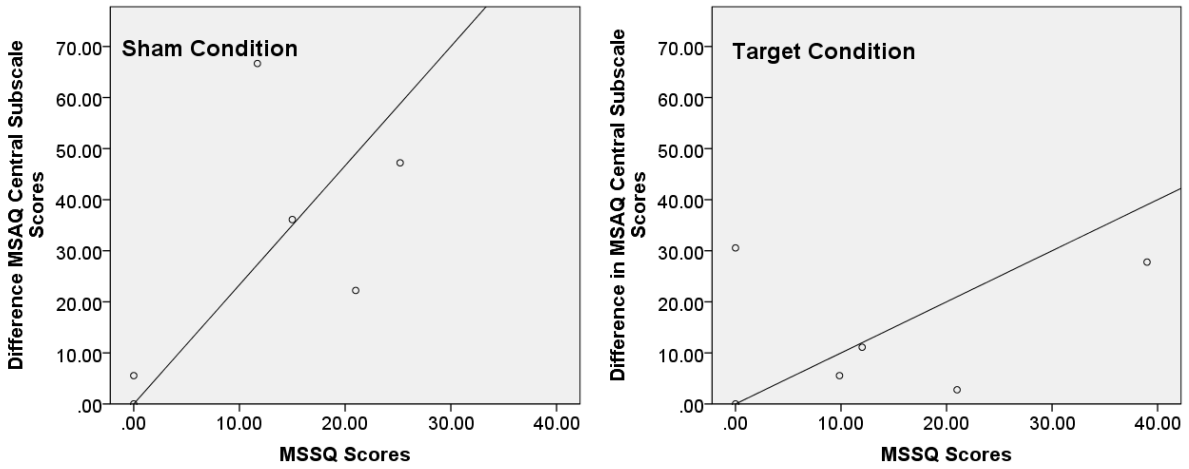

Figure 2. Relationship between difference (pre- to post-procedure) in MSAQ central subscale scores and MSSQ scores by treatment condition.

For the peripheral subscale scores, treatment condition did not significantly impact difference scores, $F(1, 9) = 0.23$, $p = 0.65$. There was a significant relationship between MSSQ scores and the difference in MSAQ peripheral subscale scores, $F(1, 9) = 4.90$, $p = 0.05$ (Figure 3).

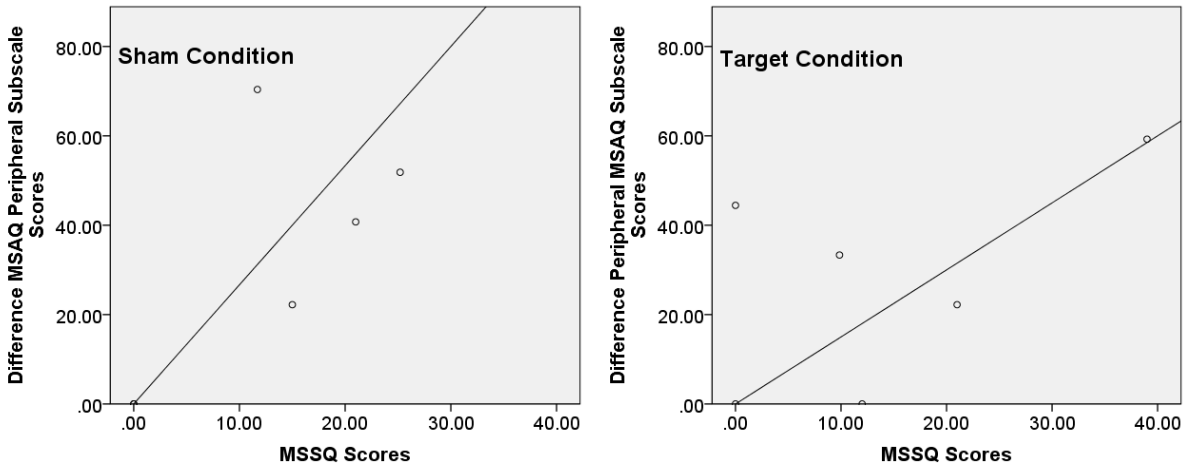

Figure 3. Relationship between difference (pre- to post-procedure) in MSAQ peripheral subscale scores and MSSQ scores by treatment condition.

For the sopite-related subscale scores, there was a significant main effect of treatment condition such that scores significantly increased in the sham group but not the treatment group, $F(1, 9) = 5.72$, $p = 0.04$. This effect was not moderated by MSSQ scores, $F(1, 9) = 0.93$, $p = 0.36$ (Figure 4).

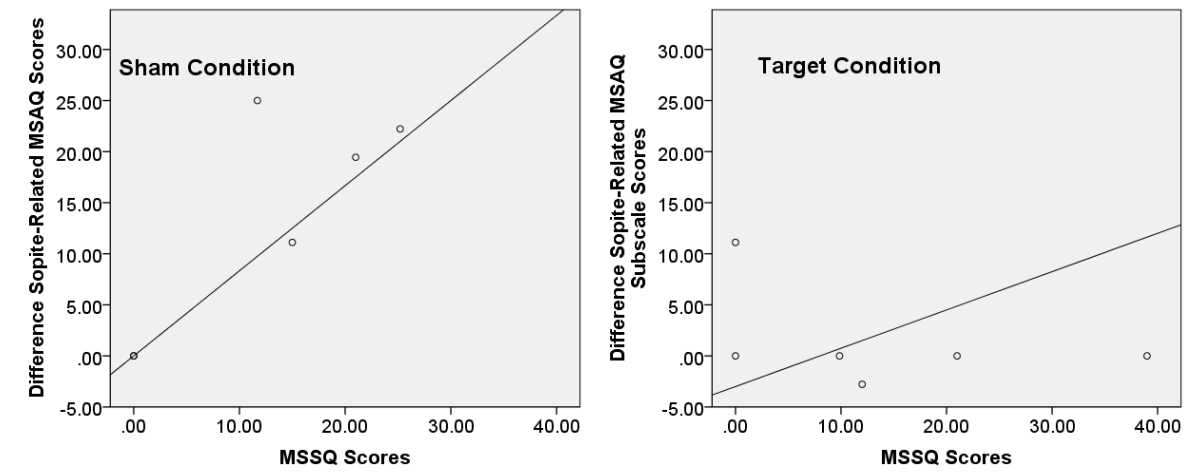

Figure 4. Relationship between difference (pre- to post-procedure) in MSAQ sopite-related subscale scores and MSSQ scores by treatment condition. Negative score indicates lower value at post- than pre-procedure.

For the total MSAQ scores, treatment condition did not significantly impact difference scores, $F(1, 9) = 3.13$, $p = 0.11$. There was not a significant relationship between MSSQ scores and the difference in total MSAQ scores, $F(1, 9) = 3.72$, $p = 0.09$ (Figure 5).

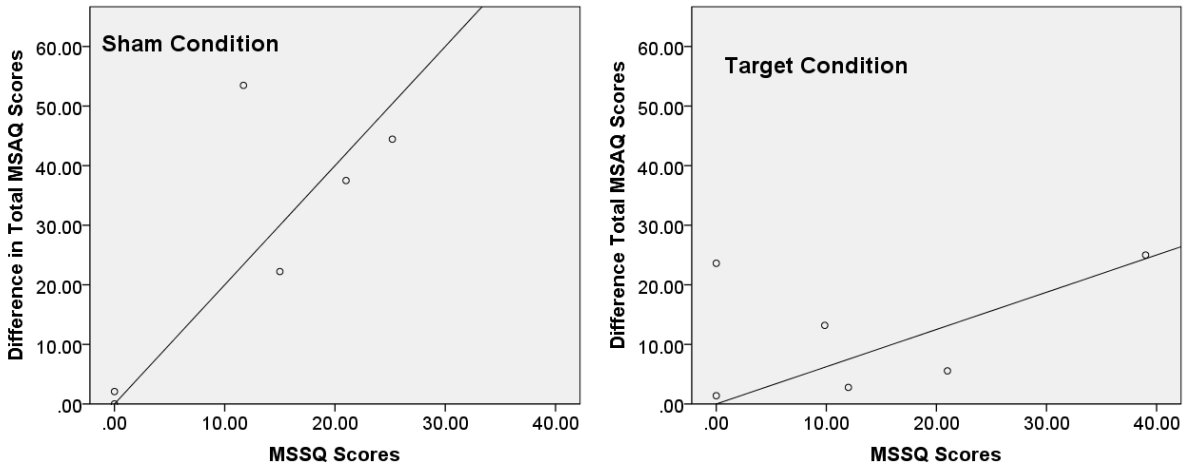

Figure 5. Relationship between difference (pre- to post-procedure) in total MSAQ scores and MSSQ scores by treatment condition.

For the coefficients of variation in heart rate, treatment condition was not significant, $F(1, 9) = 0.77$, $p = 0.40$. There was not a significant relationship between MSSQ scores and coefficients of variation in heart rate, $F(1, 9) = 0.59$, $p = 0.46$ (Figure 6).

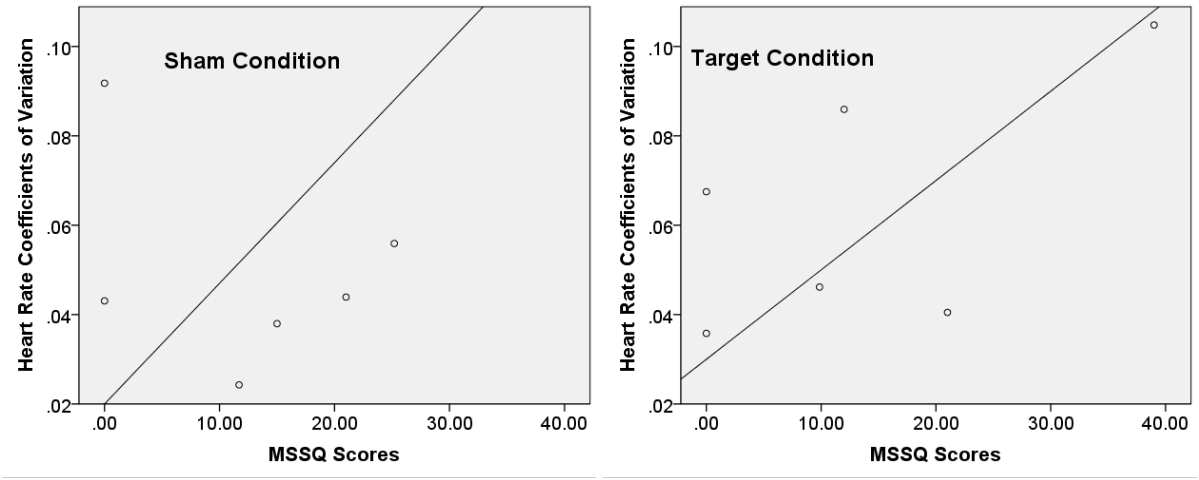

Figure 6. Relationship between heart rate coefficients of variation and MSSQ scores by treatment condition.

Discussion

This study was designed to evaluate the effectiveness of a novel osteopathic manipulative treatment to prevent motion sickness symptoms whilst controlling for motion sickness susceptibility. The findings, overall, suggest that the novel treatment shows promise for this purpose. Specifically, the results suggest that the treatment may reduce gastrointestinal and sopite-related symptoms.

The OMT target treatment group experienced significantly less gastrointestinal symptoms than the sham group whilst controlling for motion sickness susceptibility. Nausea is considered the main, or most commonly experienced, motion sickness symptom (Leung & Hon, 2019). In this study, gastrointestinal symptoms were the most highly reported in the sham group and one of the least reported in the target treatment group. In fact, in the sham group, those who scored relatively low on motion sickness susceptibility reported high levels of gastrointestinal symptoms with the exception of one individual who reported no change in symptoms from pre- to post-procedure. Similarly, the target group experienced significantly fewer sopite-related symptoms compared to the sham group. These subscale scores were lower overall than the other subscale scores suggesting they were less severe and less common. In the motion sickness literature, sopite-related symptoms are often overlooked due to the lack of specificity with their occurrence (Leung & Hon, 2019). We did not measure fatigue levels, or previous night's sleep information to control for whether individuals were rested, which presents a challenge in interpreting the true nature of this finding.

Treatment received (target or sham) did not significantly impact scores for the central or peripheral symptoms subscales, or the total scores. For the central symptoms subscale score, two participants in the treatment group reported central symptoms at a roughly equivalent level as the sham group. The extent to which individuals are more or less susceptible to experiencing these types of symptoms was not measured and would likely aid in interpretation of the result. Similarly, most participants in both groups reported experiencing peripheral symptoms at a comparable level. Given that the total score is composed of the subscale scores, it is expected that no effect was seen. The importance of distinguishing between symptom types is highlighted

in the conflicting findings between subscales. It is possible that the treatment is effective at preventing some symptom types and not others. It is also possible that likelihood of symptom type (e.g., nausea being the most common symptom, (Leung & Hon, 2019)) also contributed to these findings.

The purpose of measuring heart rate was to include a potentially objective measure of experienced physiology during the procedure. The comparable pattern seen in both groups is likely reflective of the manipulation's utility as a stimulus. The procedure is widely used for desensitization purposes and its validity has been previously established, thus we expected this finding.

Our study had several limitations worth noting. In order for recommendations regarding the utility of the OMT for this purpose to be confidently prepared, these findings need to be replicated with a larger and more diverse sample of participants. In order to fully understand the role that motion sickness susceptibility plays in moderating the treatment effect, a wider range of susceptibility levels will need to be represented. A possible solution is to include this measure in the inclusion criteria and implement quota sampling. Additionally, while we did control for motion sickness susceptibility, a case-controlled or matched procedure would more clearly isolate the effect of treatment.

While our findings did not result in specific, implementable recommendations, they did provide a more-focused direction for future investigations. Specifically, this study provides preliminary support for further evaluation. More precise evaluation of the mechanism of action is needed. In terms of practicality and applicability, the treatment needs to be tested with a variety of providers, using a variety of motion sickness inducing stimuli. Also, the duration of the effect needs to be established. Ultimately, OMT could provide a no-cost solution to motion sickness symptoms appropriate for aircrew in operations and in training, increasing readiness, vigilance, and safety.

Conclusion

The results of this study suggest that OMT may be effective at preventing motion sickness symptoms, specifically gastrointestinal and sopite-related symptoms. The effects observed were moderated by motion sickness susceptibility but not to the extent to suggest limited utility. The limitations of the study, however, preclude firm recommendations for operational use at this time.

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Appendix A. Sham Treatment

Anatomical Structure Targeted	Technique Used	Justification
Thoracic Paraspinal Muscles	Soft tissue inhibition/Stretching/Kneading/ counterstrain (CS)	Non-targeted region.
Lumbar Paraspinal Muscles	Soft tissue inhibition/Stretching/Kneading/CS	Non-targeted region.
Lower Trapezius Muscles	Soft tissue inhibition/Stretching/Kneading/CS	Non-targeted region.
Sacrum	Muscle Energy (ME)	Non-targeted region.
Supraspinatus	Soft tissue/CS	Non-targeted region.
T5-T12	ME/ Facilitated Positional Release (FPR)	Non-targeted region.
Rib 2-12	ME/Still Technique	Non-targeted region.
Rib 2-12	Balance Ligamentous Tension	Non-targeted region.
L1-L5	MET	Non-targeted region.

Appendix B. Target Treatment

Anatomical Structure Targeted	Technique Used	Justification
Scalene Muscles (Anterior/Middle/Posterior)	Soft tissue inhibition/CS	Relax hypertonicity on the muscles which may biomechanically stress the vertebral arteries.
Sternocleidomastoid Muscles (SCM)	Soft tissue inhibition/stretching/CS	Relax hypertonicity on the muscles which may biomechanically stress the vertebral arteries indirectly. SCM attaches to mastoid process, has a known affiliation with the vestibular system.
Suboccipital region	Suboccipital Myofascial Release/Soft tissue inhibition	Relax hypertonicity on the muscles which may biomechanically stress the vertebral arteries indirectly.
Cervical Paraspinal Muscles	Soft tissue inhibition/Stretching/Kneading/CS	Relax hypertonicity on the muscles which may biomechanically stress the vertebral arteries.
Levator Scapulae Muscles	Soft tissue inhibition/CS	Relax hypertonicity on the muscles which may biomechanically stress the vertebral arteries.
Upper Thoracic Paraspinal Muscles	Soft tissue inhibition/Stretching/Kneading/CS	Tie down muscles for the cervical spine. May cause tension in the cervical paraspinal musculature.
Upper Trapezius Muscles	Soft tissue inhibition/Stretching/Kneading/CS	Attaches to the occipital region and may influence hypertonicity of the suboccipital region and cervical paraspinal

		muscles.
Atlanto-occipital (OA)	ME/FPR	Any articular problem may affect proprioception and muscle hypertonicity.
Atlanto-axial (AA)	ME/FPR	Any articular problem may affect proprioception and muscle hypertonicity.
C2-C7 vertebrae	ME/FPR	Any articular problem may affect proprioception and muscle hypertonicity.
T1-T4 vertebrae	ME/FPR	Any articular problem may affect proprioception and muscle hypertonicity.
Rib 1 bilaterally	ME/Still Technique	Any articular problem may affect proprioception and muscle hypertonicity.

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