Electroacupuncture Could Reduce Motion Sickness Susceptibility in Healthy Male Adults: A Double-Blinded Study

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ABSTRACT

Objective: Motion sickness is the main cause of nausea-related symptoms during passive motion in transportation. The aim of this study was to evaluate the effects of electroacupuncture (EA) for the reduction of motion sickness symptoms.

Materials and Methods: Study participants were randomly assigned into three groups: Group A, therapeutic EA; Group B, sham EA; and group C, a control group. After an EA session, participants were exposed to a motion stimulus, using a rotating chair. Their symptoms were measured using the Greek version of the Gianaros Motion Sickness Assessment Questionnaire (MSAQ).

Results: In this study 20 volunteers participated. All 3 groups of subjects showed increases in their motion sickness symptoms after exposure to the motion stimulus. The mean total symptom score for Group A was 59,375, for Group B it was 74,333, and in Group C was it 93,166. This difference is partially statistically significant when comparing Group A with Group C, especially in a peripheral group of symptoms, as measured by the Gianaros MSAQ.

Conclusions: The results of the present study suggest that participants who received therapeutic EA prior to motion stimulation tended to have fewer motion sickness symptoms in comparison with their counterparts, who were not given any therapy.

Keywords: motion sickness, electroacupuncture, questionnaire, Coriolis stimulation

INTRODUCTION

MOTION SICKNESS IS A SYNDROME caused when a person is exposed to certain types of motion and often occurs during passive motion in vehicles that are means of transport. Body acceleration applied to a person not accustomed to it is considered a main eliciting factor. The cause, according to the prevailing hypothesis,¹ is ambivalent stimuli sent to the brain by the body's sensory receptors, the vestibular and visual

systems. Major signs and symptoms of motion sickness include nausea, vomiting, pallor, cold sweating, drowsiness, headache, increased salivation, and hyperventilation.^{1,2}

Acupuncture is a type of therapy that involves applying mechanical stimulation to various body points using needles. Electroacupuncture (EA) entails the application of an electric current to the fitted needles by means of a special device. Previous studies have shown benefits from the application of acupuncture and EA for prevention of and

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therapy for nausea from other causes, such as chemotherapy-induced nausea,^{3,4} postoperative nausea,⁵⁻⁷ and pregnancy-related nausea in the first semester.^{4,8} The present study was designed to research the effect of EA on the symptoms of motion sickness.

MATERIALS AND METHODS

The sample in this study consisted of asymptomatic young males of the Hellenic Air Force, ages 18–30. The sample consisted of 20 people. The study took place in the 120 Flight Training Wing Medical Service (in Kalamata, Greece). Participation in the study was voluntary, according to the World Medical Association Declaration of Helsinki. All participants signed informed consent for their participation in the study. Ethical approval was obtained by the Hellenic Air Force Directorate of Health and University of Thessaly Ethics Committee.

The following staff categories were excluded from the study:

- (1) Pilots of any experience level, because they are considered already adapted to complex motion sickness stimuli
- (2) Subjects who had received acupuncture or EA treatment in the past for any reason
- (3) People who had medical histories active diseases that could affect their tolerance to motion sickness (e.g., chronic gastrointestinal or ear–nose–and–throat problems)
- (4) Subjects who had consumed alcohol within the last 24 hours prior to the examination
- (5) Subjects who reported <6 hours sleep the night before.

The participants were randomly assigned into 1 of 3 groups:

- (1) Group A, who were subjected to verum EA
- (2) Group B, who were subjected to sham EA and were used as a first control group
- (3) Group C, who did not receive any therapy and were used as the second control group.

Prior to each session, the medical history of each participant was taken. In cases of drug use, illness, or any other pathologic conditions, the procedure was postponed for the particular participant until resolution of the condition occurred.

Application of verum EA and sham EA to the participants in Groups A and B, respectively, was performed by acupuncture trained Investigator A (O.F.) and took place half an hour prior to the motion-exposure procedure.

The acupuncture points used were PC 6 (Pericardium 6), ST 36 (Stomach 36), and LI 4 (Large Intestine 4) bilaterally. EA was applied on needles in PC 6 and ST 36 bilaterally, while, in the LI 4 point only manual acupuncture was applied. The aforementioned protocol is compatible with the

recent study of Han et al., who studied the effectiveness of EA treatment for gastroesophageal disease.⁹

Sterile, disposable, stainless-steel needles were used, with a gauge that was 0.25 × 0.25 mm. They were inserted ~1 cm below the skin surface. Once the needles were positioned at points PC 6 and ST 36, they were connected to a pair of cables of an EA device on the same side to complete the electrostimulation. EA was applied via an ES-160 EA device (ITO Co., Ltd., Tokyo, Japan) for 20 minutes at preset program 1. In the selected electrostimulation program, the frequency ranges between 1 and 6 Hz, while the phase durations of the electrical waves are between 50 and 300 μ s. There are 5 different consecutive modes used in this program: (1) constant; (2) fast + slow; (3) burst; (4) sweep; and (5) constant. The maximum output current used was low, between 1 and 16 mA (the peak output current of the device is 32 mA) and the stimulation intensity was adjusted depending on the degree of each participant's tolerance (mean level of 10–14 mA). This is according to the practice of Han et al.'s study, in which the same EA device and the same method for the current were used.⁹ However, Han et al. preferred to use a mixed electric current at a frequency of 2–6 Hz and the “fast + slow” mode of the ES-160 of ITO.⁹

Sham acupuncture is nontherapeutic acupuncture at nontherapeutic points, but using the same needles as when applying verum acupuncture. The participants were not able to distinguish the difference between conventional and sham EA, despite the fact that no electricity ran through the needles for the latter. In the present study sham acupuncture was applied to nontherapeutic points through superficial needling near acupuncture points LI 13 (Large Intestine 13) and GB 32 (Gall Bladder 32). When applying sham acupuncture, the EA device's cables were connected to the placed needles; yet, no electrical stimulation was applied.

Half an hour after the end of the EA procedure, the participants were exposed to a Coriolis-type stimulus to induce motion sickness by using a rotating chair under the supervision of Investigator B (P.K.). Coriolis stimulation simultaneously engages two of the three semicircular canals of the ears and occurs when there is a sudden movement of the participant's head on one axis in space, while the participant is in rotation on another axis. This illusion gives the impression that there is rotation on the third axis in space. It has been shown that this Coriolis illusion can disorientate a participant easily and generate motion sickness.¹⁰

In the present study, the rotation of the motor-driven chair was always clockwise, stable, and preset at 10 revolutions per minute. The head of each participant was aligned with the rotation axis, after the adjustment of the seat and the headrest, as was described in a previous study.¹¹ There was a type of seatbelt used for the protection of the volunteers. During the rotation, the participants were exposed to limited visual stimuli; the participants were placed in a barely lit room and were asked to keep their eyes shut. This practice enhanced the disorientation of the volunteers, as vision is

the major input for orientation. The participants followed computer-recorded commands to make specific head movements (right roll, front pitch, left roll, and back pitch) every 30 seconds.

Before the start of the session and immediately after its end, motion sickness symptoms were measured using the Greek version of the Gianaros Motion Sickness Assessment Questionnaire (MSAQ),¹² which had been translated and validated in a previous study.¹¹ The MSAQ is comprised of 16 questions, covering four clusters of symptoms: (1) gastrointestinal (GSTR); (2) central nervous system (CNS); (3) peripheral nervous system (PNS); and (4) sopite (SOP)-related symptoms. Each symptom was given ratings of 1 (not at all) to 9 (severe). A total score is produced (MSAQ-Total) and four subscale scores (MSAQ-GSTR, MSAQ-CNS, MSAQ-PNS and MSAQ-SOP). Two types of measures of motion sickness severity were used for the present study:

- (1) MSAQ scores (total and subscale scores) after motion exposure
- (2) The difference in MSAQ scores before and after the exposure.

In addition, during the rotation and after each head movement, total subjective motion sickness symptoms were measured based on a scale from 1 to 7, according to the practice of Golding and Kerguelen (1=no symptoms and 7=maximum nausea-vomiting intensity).¹³ The session ended either when the participant reached maximum intensity of nausea symptoms or vomiting level, or wished to interrupt the process (7 in the Kerguelen scale) or had completed 20 minutes of motion exposure. The times reached by the volunteers in the rotating procedure was assessed and compared among the 3 groups.

RESULTS

The sample of this study consisted of 20 subjects, 8 of whom were assigned to Group A, 6 to Group B, and 6 to Group C.

All participants completed the Greek version of the Gianaros MSAQ¹² without any need for assistance. The mean time required to complete the questionnaire was ~3 minutes (range: 2–4 minutes).

The variables that were researched—GSTR, CNS, PNS, SOP, and TOTAL—result from summing up the responses to the relevant questions of the Gianaros questionnaire.¹² In the current analysis, the reliability of the scales (Likert scales) was tested with a Cronbach's α statistic. After motion exposure, the statistics were estimated at levels ranging from 0.74 (SOP) to 0.93 (TOTAL), implying that the internal consistency of the data was at least satisfactory.

The basic descriptive measures of the variables showed that their mean values, as well as their ranges and disper-

sions (standard deviations), increased considerably after application of the motion procedure.

To further this analysis, the increase in the symptom severity in the total score and in all subscale scores was compared by comparing Group A versus Group B, Group A versus Group C, and Group B versus Group C. The bi-group differences were evaluated on the basis of a nonparametric Mann-Whitney *U*-test (for two independent samples). No statistically significant differences were found at baseline before motion stimuli was applied. However, after motion exposure, when comparing Group A to Group C, it was found that the differences in the elevated values of the variables TOTAL, PNS, and SOP were statistically significant (with the last one marginally so). With respect to SOP, a statistically significant difference at level 0.01 was also found when comparing Group A to Group B. The results of the analysis are presented in Table 1.

As the motion sickness symptoms of each person was measured twice (i.e., before and after exposure; paired observations), the significance of the changes was evaluated on the basis of a Wilcoxon test for two related samples. The results are presented in Table 2 and show that, in all cases (i.e., all variables and all groups), the changes are statistically significant at the level of 0.05.

The average times of exposure to motion stimulus by group are shown in Table 3. The greatest mean time (17.5 minutes) appeared to be achieved by the participants in Group B. To test for the differences in the mean times of exposure among the 3 groups, the *F*-test (one-way analysis of variance; ANOVA) was used. The assumptions of the

TABLE 1. MANN-WHITNEY NONPARAMETRIC U TEST FOR TWO INDEPENDENT SAMPLES

	GSTR	CNS	PNS	SOP	TOTAL
<i>Test statistics for Group A vs. Group C</i>					
Mann-Whitney- <i>U</i>	13.000	13.000	8.000	9.500	7.000
<i>Z</i>	-1.425	-1.423	-2.079	-1.884	-2.197
Asymp. sig. (2-tailed)	0.154	0.155	0.038	0.060	0.028
Exact sig.	0.181	0.181	0.043	0.059	0.029
<i>Test statistics for Group A vs. Group B</i>					
Mann-Whitney- <i>U</i>	21.000	14.500	19.500	10.500	15.500
<i>Z</i>	-0.389	-1.232	-0.582	-1.754	-1.100
Asymp. sig. (2-tailed)	0.698	0.218	0.560	0.079	0.271
Exact sig.	0.755	0.228	0.573	0.081	0.282
<i>Test statistics for Group B vs. Group C</i>					
Mann-Whitney- <i>U</i>	8.500	16.500	8.500	17.500	11.500
Wilcoxon <i>W</i>	29.500	37.500	29.500	38.500	32.500
<i>Z</i>	-1.529	-0.241	-1.537	-0.080	-1.043
Asymp. sig. (2-tailed)	0.126	0.810	0.124	0.936	0.297
Exact sig.	0.132	0.818	0.132	0.937	0.31

Asymp., asymptomatic; sig., significance; GSTR, gastrointestinal; CNS, central nervous system; PNS, peripheral nervous system; SOP, sopite.

TABLE 2. SIGNIFICANCE OF CHANGES IN VALUES OF THE VARIABLES BEFORE AND AFTER MOTION EXPOSURE: WILCOXON NONPARAMETRIC TEST FOR PAIRED SAMPLES

	Test statistics ^a				
	GSTR	CNS	PNS	SOP	TOTAL
Group A					
Z	-2.524 ^b	-2.201 ^b	-2.521 ^b	-2.032 ^b	-2.521 ^b
Asymp. sig. (2-tailed)	0.012	0.028	0.012	0.042	0.012
Group B					
Z	-2.201 ^b	-2.214 ^b	-1.826 ^b	-1.997 ^b	-2.201 ^b
Asymp. sig. (2-tailed)	0.028	0.027	0.048	0.046	0.028
Group C					
Z	-2.207 ^b	-2.201 ^b	-2.207 ^b	-1.992 ^b	-2.207 ^b
Asymp. sig. (2-tailed)	0.027	0.028	0.027	0.046	0.027

^aWilcoxon signed-rank test.

^bBased on negative ranks.

Asymp., asymptomatic; sig., significance; GSTR, gastrointestinal; CNS, central nervous system; PNS, peripheral nervous system; SOP, sophite.

techniques (homogeneity of variances and normality of variables) were evaluated on the basis of the Levene test and Shapiro–Wilk statistics, respectively. Examination of the mean differences between groups in A versus B, in A versus C, and in B versus C was carried out using a Tukey posthoc multiple comparison test. The results of the whole procedure are presented in Table 4. These findings indicated that the assumptions of the one-way ANOVA were fulfilled and the estimated *F*-statistic (7.036) was statistically significant (at a level of 0.006). However, the difference in the mean times between groups A and B was not statistically significant ($P=0.575$); on the contrary, comparisons between Group C and each of the other two groups (A and B) showed that the relevant differences were statistically significant.

DISCUSSION

The main purpose of this study was to evaluate EA pretherapy as a beneficial nonpharmaceutical method for the treatment of motion sickness. The initially recorded differences are relatively small and partially statistically significant.

TABLE 3. TIME OF EXPOSURE TO MOTION STIMULUS: DESCRIPTIVE STATISTICS BY GROUP

	N	Mean	SD	SE	95% CI	
					Lower bound.	Upper bound.
Group A	8	14.938	6.050	2.1390	9.880	19.995
Group B	6	17.500	3.209	1.3102	14.132	20.868
Group C	6	7.833	3.488	1.4240	4.173	11.494
Total	20	13.575	5.954	1.3314	10.788	16.362

SD, standard deviation; SE, standard error; CI, confidence interval; bound., boundary.

TABLE 4. TEST FOR DIFFERENCES IN THE MEAN TIMES OF EXPOSURE TO MOTION STIMULUS AMONG GROUPS

<i>Test of homogeneity of variances</i>				
<i>Levene statistic</i>	<i>df 1</i>	<i>df 2</i>	<i>Sig.</i>	
3.067	2	17	0.073	
<i>Test of normality: Shapiro–Wilk statistic</i>				
	<i>Statistic</i>	<i>df</i>	<i>Sig.</i>	
Group A	0.827	8	0.055	
Group B	0.807	6	0.068	
Group C	0.938	6	0.647	
<i>One-way ANOVA: F-test</i>				
	<i>Sum of squares (df)</i>	<i>Mean square</i>	<i>F</i>	<i>Sig.</i>
Between-groups	305.085 (2)	152.543	7.036	0.006
Within-groups	368.552 (17)	21.68	–	–
Total	673.637 (19)	–	–	–
<i>Tukey test: Posthoc multiple comparisons</i>				
<i>(I) Group</i>	<i>(J) Group</i>	<i>Mean df (I–J)</i>	<i>SE</i>	<i>Sig.</i>
A	B	–2.5625	2.5146	0.575
	C	7.1042	2.5146	0.030
B	A	2.5625	2.5146	0.575
	C	9.6667	2.6882	0.006
C	A	–7.1042	2.5146	0.030
	B	–9.6667	2.6882	0.006

df, difference; Sig., significance; ANOVA, analysis of variance; SE, standard error. Comparisons of all possible pairs of sub-groups (I and J) of the factor variable under investigation include tests of mean differences between groups (A,B), (A,C), (B,A), (B,C), (C,A), (C,B).

cant. However, promising findings were observed. No difference was found in the gastrointestinal and central nervous systems. A statistically significant difference was observed in the peripheral and total symptoms in the comparison between Group A and Group C, while the difference in SOP-related symptoms was only marginally significant. The volunteers in Group A mentioned less sweating or cold sweating symptoms, as well as less flashing and heat sensations in comparison to their Group C counterparts. Given that peripheral symptoms are attributed to sympathetic nervous system activation, it is possible, that acupuncture alters autonomic nervous system activity in a certain way. The difference in total symptoms was mainly attributed to the peripheral subtotal.

The results of this study cannot be clearly understood, because the pathophysiology mechanisms of acupuncture are still in debate. Tjen-A-Looi et al. studied cats and found that EA at PC 6 and LI 4 decreased premotor sympathetic cardiovascular neuronal activity in the rostral ventral lateral medulla by 41% and 12%, respectively.¹⁴ Yang et al. suggested that manual and laser acupuncture at PC 6 and ST 36

in rats enhanced gastric motility and increased heart rate, while EA in the former induced an increase in low-frequency/high-frequency in heart rate variability (HRV).¹⁵ Those results were attributed to sympathetic nerve activity and were partially compatible with the results found in a study by Hideaki et al. The latter studied 16 healthy individuals using HRV testing and found that EA at LI 4 and LI 11 bilaterally increased sympathetic nerve activity immediately, while parasympathetic nerve activity was induced 20 minutes later.¹⁶ However, although there have been efforts to identify the accurate mechanism of acupuncture in several studies, this field remains unclear and more studies are needed.

The acupuncture points used in the present study (PC 6, ST 36, and LI 4) were selected because they had been used in the past for treatment of nausea. Dundee et al., in a review article, proposed the PC 6 antiemetic action in postoperative morning sickness, cancer chemotherapy, and travel sickness,⁴ and Alizadeh et al. discussed the use of points for preventing postoperative nausea and vomiting (PONV).⁶ ST 36 is a point that is thought to promote the regulation of the gastric activity. Sallam et al. studied rats with the aim of finding a potential treatment for chemotherapy-induced delayed emesis; the treatment proposed was EA via chronically implanted electrodes, and the researchers found that a combination of EA of PC 6 and ST 36 points was superior to PC6 only.³ LI 4 is one of the most-researched and significant acupuncture points. It has analgesic and spasmolytic effects and it is frequently used in combination with ST 36 or PC 6.^{6,9}

In previous studies, acupuncture or EA produced relief of nausea symptoms.^{4,5,7} For example, Dundee et al, in a series of studies with more than 500 female patients, found a significant reduction in PONV only by stimulating PC 6.⁴ The lack of antinausea effect of EA in the present study, which is effective for the treatment of nausea of other causes, such as chemotherapy-induced and postoperative nausea, might indicate that there are different pathophysiology mechanisms in the development of nausea in motion sickness.

One major concern of the present investigators was to ensure proper study blinding. Investigator A (O.F.) conducted the EA procedure and investigator B (P.K.) supervised the motion exposure procedure. Investigator B (P.K.) was not aware of the participants' division into groups. Group A and B participants were not able to distinguish whether they were subjected to verum or sham EA, because both were applied with the same method. For the above reasons, the comparison between Groups A and B was, in effect, a double-blinded study. Group C participants were aware that they had not received any therapy prior to the motion exposure. They were used as a control group in order to research the possibility of a placebo effect of sham EA. Every effort was made to ensure that the participants did not inform Investigator B about which groups they were in. Thus, the comparison between Groups A or B with Group C, also, was in effect, a single-blinded study.

The MSAQ scores and subscores before the exposure were similar in all 3 groups, indicating that all subjects had the same starting point, with respect to their motion sickness symptoms. This was expected, as the experiment was conducted under appropriate conditions (double-blinded study) to safeguard the random sample selection. Any slight differentiations noticed could have resulted from the small sample. Therefore, any differences in the MSAQ scores observed had to be attributed to the exposure to rotating motion and the influence of the EA therapy. The MSAQ scores increased in a statistically significant way after the procedure in all 3 groups of participants. This meant that all 3 groups were exposed to a stimulus of adequate intensity to produce measurable physiologic effects.

Quantifying the physiologic effects and the motion sickness symptoms is inherently difficult and this might contribute to the variable results seen in motion sickness studies. Scientists generally rely on subjective measures and questionnaires for these studies.⁶ Motion sickness has usually been assessed with a questionnaire by Graybiel et al., which ranges the symptoms from slight malaise (1–2 points) up to frank sickness (> 16 points).² Muth et al. proved that there was no correlation of high doses of ondansetron and dimenhydrinate with prevention of motion sickness,¹⁷ using the same MSAQ as in the present study. It is worth mentioning that this is the first time that the Greek-validated version of MSAQ was used in a study.¹¹

Regarding the time spent by the participants on the rotating chair being submitted to the Coriolis stimuli, the comparison among the 3 groups was interesting. Group B tended to be more resistant to nausea stimuli, while Group A was the second more durable group. However, there was no statistically significant difference between Groups A and B. On the contrary, Group C spent statistically significant less time being rotated in comparison with both Groups A and B. This result reinforces the suggestion that EA and EA procedures affect and reduce motion sickness symptoms. The lack of a statistically important difference between the first two groups might have been the result of a placebo effect or the consequence of the small sample size of the participants.

Therefore, a major limitation of reporting results of this study was the small sample size. The small sample reflected a difficulty in recruiting, which could be attributed to the lack of information of Greek citizens about EA procedures. Moreover, the inclusion criteria were relatively strict, and only young adult males were allowed to take part in the study.

CONCLUSIONS

The results of this study suggest that individuals who were subjected to therapeutic EA prior to motion stimulation tended to have fewer motion sickness symptoms in comparison with their counterparts who were not subjected to the same therapy.

Indeed, this tendency showed, in some cases, a statistically significant result, especially with regard to peripheral symptoms. The small sample size and the marginal statistical significance point toward the need for further research.

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AUTHOR DISCLOSURE STATEMENT

The authors declare that they have no conflict of interest.

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