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# Transfer of NASA Technology to the DoD: Mitigating Motion Sickness with Autogenic Feedback Training Exercise

## Final Report

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# Acronyms and Definitions

AETC....................................Air Education Training Command
AFTE ....................................Autogenic Feedback Training Exercise
AFTECH...............................Autogenic-Feedback Training Exercise Technology
ANS ......................................autonomic nervous system
AQS ......................................Additional Qualifying Symptoms
ARC ......................................Ames Research Center
AT .........................................Autogenic Therapy
DIZ........................................dizziness
DoD.......................................Department of Defense
DRZ ......................................drowsiness
EA .........................................epigastric awareness
ED .........................................epigastric discomfort
HAC ......................................headache
HR.........................................heart rate
HRP.......................................Human Research Program
min ........................................minute
NAMRU-D ............................Naval Medical Research Unit-Dayton
NASA ...................................National Aeronautics and Space Administration
NSA ......................................nausea
PAL.......................................facial pallor
PI...........................................Principal Investigator
rad .........................................angular rotational speed in radians per second
rpm........................................revolutions per minute
RR .........................................respiration rate
SAL.......................................salivation
SCL .......................................skin conductance level
sec .........................................second(s)
SWT......................................sweating
TMP ......................................temperature
VMT .....................................vomiting
WPAB...................................Wright Patterson Air Force Base

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Allison Ludwig[3], Mary Nimmer[4], Tayton Hess[4], Mariateresa Sestito[4], Kevin Novak[5]

*Abstract*

*Motion sickness poses a significant safety risk, particularly in the context of aviation. Given its prevalence among aviators and its detrimental impact on performance, researchers have attempted to identify effective mitigation strategies for motion sickness. Currently, many of the existing interventions are pharmacological, and while effective, they present a problem due to their associated adverse side effects. The primary goals of the current research were: 1) demonstrate the value of the application of Autogenic-Feedback Training Exercise (AFTE), a physiological training program developed by the National Aeronautics and Space Administration (NASA) to mitigate the impact of operational stressors such as motion sickness and spatial disorientation on human physiology and performance; and 2) evaluate a new enhanced version of AFTE training software and demonstrate the ability to apply it remotely and train other personnel to administer it.*

*AFTE combines principles of autogenic therapy, and biofeedback in training individuals to control their physiological reactions through a series of relaxation and arousal exercises. This study included twenty-six participants, 17 men and 9 women. On day 1 participants were tested in a rotating chair (pre-test) to determine their motion sickness tolerance (measured as minutes of rotation); days 2-5 consisted of four AFTE training sessions, each 30-min. in duration for a total of 2 hours; and on day 6 the participants were re-tested in the rotating chair. Results revealed a significant increase in motion sickness tolerance with AFTE on the post-test when compared to pre-test, participants had significantly lower symptom diagnostic scores post-test, and there was no significant gender effect. In addressing the first goal it was concluded that the modified 2-hour version of AFTE significantly improved motion sickness tolerance with participants experiencing fewer symptoms. A second goal of this research was to refine and transfer a NASA technology, software, and methods for applications within the Department of Defense (DoD) by training other personnel to administer AFTE. A comparison of NASA and Naval Medical Research Unit-Dayton (NAMRU-D) trainers on AFTE outcome for improving participants' motion sickness tolerance revealed no significant difference indicating the successful transfer of methods to DOD. In addition, remote AFTE training of military aviators at distant sites was feasible. A third goal was to identify individual patterns of interoceptive abilities and related autonomic metrics able to predict stress response and training outcome. These data included measures of personality traits obtained from questionnaires and specific autonomic measures (e.g., heart rate variability) collected by NAMRU-D investigators. These results will be reported in a separate paper.*

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## 1. Introduction

This study was a research collaboration between the National Aeronautics and Space Administration's (NASA) Ames Research Center (ARC) and the Naval Medical Research Unit-Dayton (NAMRU-D) at Wright Patterson Air Force Base (WPAFB) in Dayton, Ohio. Funding for this work was provided by the Air Force Research Laboratory, 711th Human Performance Wing, United States Air Force School of Aerospace Medicine. NAMRU-D researchers and test participants were in Dayton, Ohio. Ames researchers' involvement included remote training via the internet of participants in the administration of Autogenic Feedback Training Exercise (AFTE), data processing and analyses, and remotely instructing Navy personnel on how to administer the training. This work was performed under a Memorandum of Agreement between ARC and NAMRU-D. The primary purposes of the research were to determine if AFTE, a physiological training program developed at ARC, would be beneficial for applications within the Department of Defense (DoD) and to demonstrate that Navy personnel could be instructed to administer it.

This work supports NASA's Human Research Program (HRP) objectives of: (1) determining methods for facilitating adaptation to space, thereby improving crew health, safety, and performance; and (2) transferring NASA technology to Earth-based applications. This research also provides data to NASA for the purpose of evaluation and validation of AFTE in a unique operational environment (e.g., aviators in military aircraft) and these data are relevant to future potential tests of AFTE in space. This research also addresses the military's 2019 Air Education Training Command (AETC) capability gaps: (1) Gap 11: Lack of capability to standardize, implement, and measure air sickness best practices across the enterprise; and (2) Gap 6: Lack of an evidence-based approach to human performance, sustainment, optimization, and enhancement, which includes customized solution sets based on operational mission sets.

The new enhanced hardware and software—Autogenic-Feedback Training Exercise Technology (AFTECH)—including an operator's manual [14] and AFTE training methods, provide DoD investigators who have been instructed with a means to perform comprehensive assessments of military and civilian personnel physiological status. A training guide, video recordings of AFTE sessions, and observing the NASA trainer during sessions provided a means to standardize AFTE methods and data collection procedures. The present study included documenting baseline physiological responses and responses to motion sickness induced by a rotating chair stimulus. It also established operating procedures for using AFTECH software to perform remote monitoring and AFTE training. Weekly meetings were scheduled with Navy personnel to discuss study progress and address specific questions and/or concerns on administering AFTE training and rotating chair test procedures. Remote training and monitoring capabilities are essential to the potential future use of AFTE with astronauts to improve operational readiness during long-duration space flights. It is further anticipated that medical, commercial, and military personnel will utilize remote training methods for the application of AFTE in other operational environments.

## 2. Background

AFTE is potentially a viable nonpharmacologic countermeasure to motion sickness and spatial disorientation. It was originally developed by NASA as a method for enhancing adaptation to extreme environments. The rationale for using AFTE to treat motion sickness was based in part on the assumption that there are profound autonomic nervous system (ANS) changes associated with this disorder [1]. The importance of ANS responses in the development of motion sickness has been demonstrated in both laboratory and operational environments [12–13]. Observations of increased motion sickness tolerance after AFTE support the notion that the treatment effect is due to learned self-regulation of ANS activity [5–7].

Adaptation to extreme environments differs from habituation in that the former involves an individual's ability to change (e.g., learn physiological control) to better fit varying conditions, while habituation is when an individual is less responsive to a repeated stimulus and responses do not transfer to other environments. Although both learning processes may reduce symptoms and diminish impacts on performance, AFTE has been shown to improve tolerance with fewer symptoms in much less time and the training effects transfer across different motion sickness stimuli induced in both laboratories (e.g., rotating chair, vertical acceleration, visual stimuli) [5] and field studies (e.g., high-performance aircraft, space) [6–9].

NASA research with over 300 test subjects has demonstrated no significant gender effects in motion sickness susceptibility during initial test exposures (i.e., duration tolerated in a rotating chair, vertical acceleration, and a rotating visual surround). In addition, there were no significant gender differences in the ability to learn sufficient physiological control with AFTE needed to reduce symptoms and increase tolerance. However, physiological responses to motion stimuli are highly idiosyncratic. Therefore, AFTE was tailored for everyone with emphasis on training control of those physiological variables that changed the most when symptoms increased. AFTE is presented to subjects as a method for learning a skill, not just relaxation. The word "exercise" in AFTE refers to exercising smooth muscles where subjects learn to control specific physiological parameters by both increasing and decreasing levels (see bidirectional training below).

AFTE combines the application of several physiological and perceptual training techniques that include Autogenic Therapy [10] and biofeedback [11]. Autogenic Therapy (AT) is a self-regulatory technique that has been shown to have wide effects on autonomic reactivity. When used alone, AT has been reported to take between 1 year and 18 months before treatment (e.g. anxiety) becomes effective. It involves the use of self-suggestion exercises that are designed to induce bodily sensations (e.g., warmth in the hands) that are highly correlated with specific physiological responses such as peripheral vasodilation. When these exercises are practiced in series, the result is a relaxed (i.e., parasympathetic-like) physiological profile within the subject that prevents the emergence of behavioral and physiological reactions to stress. Biofeedback decreases the time for the treatment to become effective by providing subjects with augmented sensory information about the ongoing activity of some physiological response (e.g., a numeric display of heart rate). In addition, auditory tones can be set by the trainer to reward subjects whenever response levels fluctuate in the desired direction (e.g., operant conditioning). After decades of work, NASA researchers have developed effective techniques to decrease the amount of training required. The result is an enhanced ability of the trainee to self-regulate physiological parameters on demand for sustained periods of time.

Previous studies have demonstrated the utility of AFTE to improve tolerance to motion sickness and improve cognitive performance [2]. More importantly, the results of these studies indicate that the effects of AFTE on motion sickness tolerance have advantages over medication [3]. While the full AFTE protocol stipulates six hours of training, existing research and preliminary data from ongoing research indicate that applying AFTE with AFTECH software is effective at significantly increasing tolerance to motion sickness with only two hours of training [2].

Specific Aims:

1. Refine and transfer NASA technology, AFTECH software, and training methods to NAMRU-D for applications within DoD (e.g., military aviators in the Airsickness Management Program). In this study, NASA researchers remotely trained 16 test participants while NAMRU-D personnel observed. The remaining 10 participants were trained by NAMRU-D personnel while NASA investigators provided oversight.
2. Evaluate the effects of 2-hours of AFTE on motion sickness tolerance and symptom mitigation.

## 3. Methods

### 3.1 Subjects

Twenty-six men and women were recruited from the general population of off-duty military or contractual personnel. Six participants were active-duty military pilots on temporary assignment to NAMRU-D. Prospective participants were screened to exclude those who reported histories of unmanaged high blood pressure, heart disease, or pregnancy. Participants were excluded if they had undergone surgery or been hospitalized within the previous 90 days. Participants were medically qualified to participate via medical screening at NAMRU-D and a medical monitor was on call during the study if needed. Voluntary consent of all participants was obtained following a briefing in which all procedures and potential risks were explained to them by the NASA Principal Investigator (PI) and/or NAMRU-D Co-PI. Subjects were compensated for their participation.

### 3.2 Test Schedule

Day 1.............Participant briefing; pre-test rotating chair (1.5 hr.)
Days 2–5 ........AFTE sessions 1–4 consecutive days (2 hr. per day)
Day 6.............Post-test rotating chair (1.5 hr.)

### 3.3 AFTE Training:

The current study protocol shortened the 6-hours of AFTE used in previous studies and followed a new 2-hour training schedule developed as this technology was transferred to NAMRU-D. Training included 4 AFTE sessions given to participants over 4 days. AFTE sessions were 30 minutes in duration consisting of ten, 3-minute trials alternating between relaxation (e.g., heart rate decreases) and arousal states (e.g., heart rate increases)—referred to as bidirectional training. Relaxation trials focused on the introduction of AT self-suggestion exercises. AT exercises were combined with AFTECH visual and/or audio feedback to assist trainee learning. The trainee repeats the mental exercises in a specific sequence with the goal of becoming self-aware of bodily sensations associated with a relaxed physical and mental state. The emphasis was on passive volition with focused attention but maintaining complete indifference to the external feedback cues (if I am succeeding or failing). The trainer provided verbal feedback to direct the subject’s attention (close your eyes, pay attention to your right arm). Arousal trials focused on the introduction of mental imagery to elicit bodily sensations (feelings) associated with highly emotional physical and mental states, such as anxiety, anger, or fear. The emphasis was on active volition instead of passive where motivation is on the desire to obtain incentives from external cues (if I am succeeding or failing). The trainer also provided verbal feedback. The goal of bi-directional training was to enable trainees to better discriminate the different bodily sensations associated with relaxed and arousal states (warm vs cool hands, heartbeat slow vs heartbeat fast).

## 3.4 Rotating Chair Tests

The initial symptoms of motion sickness were induced using a standard rotating chair test [5]. Physiological responses were monitored during the test and the subject's symptom characteristics were documented. Following a 10-minute resting baseline (no rotation), the chair was initially rotated to 6 rpm (0.628 rad/sec.) and then incremented by 2 rpm (0.219 rad/sec.) every 5-minutes. The maximum velocity was 30 rpm (3.142 rad/sec.). During each 5-minute interval at a constant rotational velocity, subjects made 150 head movements at 45-degree angles in four randomized directions (front, back, left, and right). Instructions for making head movements were at 2-second intervals and delivered to subjects by a computer-generated voice. There were 30-second rests between each 5-minute period (no head movements but continued rotation) during which a diagnostic symptom scale was administered by the investigator. Rotating chair tests were terminated at 30 rpm (65 minutes of rotation), or at any time the subject requested termination, or the investigator determined from the standard symptom diagnostic scale that the subject was experiencing severe malaise. Tests were followed by a 10-minute post-test baseline recovery period.

## 3.5 Symptom Diagnostic Scale

Motion sickness symptoms were assessed using the Miller and Graybiel Diagnostic Criteria [4] as shown in Table 1. This scale is based on self-report and experimenter observations with respect to vomiting, subjective body temperature, dizziness, headache, drowsiness, sweating, pallor, salivation, and nausea. A single global motion sickness score can be derived using a complex scoring and weighting system. The symptom of vomiting (VMT) is pathognomonic motion sickness under the conditions of the test and as such receives the maximum number of points (16). On the other end of the motion sickness spectrum, very minor symptoms of motion sickness are listed in this scale as Additional Qualifying Symptoms (AQS). Included in this symptom category are increased body temperature (TMP), dizziness (DIZ), and headache (HAC). The subject has the option of reporting two levels of increased temperature and dizziness (mild-moderate "I" or moderate-severe "II"). The level of headache is not differentiated with respect to point value. The remaining symptoms of motion sickness (not including nausea) are drowsiness (DRZ), sweating (SWT), facial pallor (PAL), and increased salivation (SAL). Each of these symptoms can be described as mild, moderate, or severe ("I," "II," or "III"), respectively. Symptoms of nausea or any sensations associated with the "gut" can be reported as five separate levels: epigastric awareness (EA), described as increased sensations in the stomach but not considered uncomfortable is rated as mild "I;" epigastric discomfort (ED), described as *not* nausea but becoming uncomfortable (e.g., lump in the throat, knot in the stomach), is rated as moderate "II;" and nausea (NSA) reported as mild, moderate, or severe, ("I," "II," or "III"), respectively.

Table 1. Miller and Graybiel Diagnostic Criteria

| *Malaise Category* | *Point* | *VMT* | *TMP* | *DIZ* | *HAC* | *DRZ* | *SWT* | *PAL* | *SAL* | *NSA* | *ED* | *EA* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pathognomonic | 16 | | | | | | | | | | | |
| Major | 8 | | | | | III | III | III | III | II, III | | |
| Minor | 4 | | | | | II | II | II | II | I | | |
| Minimal | 2 | | | | | I | I | I | I | | I | |
| AQS | 1 | | I, II | I, II | I | | | | | | | I |

## 3.6 Physiological Measures

Data were collected and displayed on monitors using new and improved AFTECH software which was integrated with commercially available self-contained battery-operated biomonitoring equipment (Figure 1). Physiological measures are listed in Table 2. The software can receive 16 input variables. It processes these data and can display up to 27 output variables in numeric format and/or analog waveforms (Figure 2) and based on selectable parameters provides audible feedback tones, as well as voice commands and tones for pacing respiration.


*Figure 1. AFTECH software display of physiological parameters during AFTE.*

| *Table 2. Physiological Measures.* | |
|---|---|
| *Display Label: Measure* | *Display Label: Measure* |
| SCL: skin conductance level | LL EMG: left leg muscle activity |
| RESP RATE CHEST: respiration rate chest | RL EMG: right leg muscle activity |
| RESP RATE ABD: respiration rate abdomen | SYS: systolic blood pressure |
| HR: heart rate | DIA: diastolic blood pressure |
| LF BVP: left finger blood volume pulse | MAP: mean arterial pressure |
| RF BVP: right finger blood volume pulse | Z0: thoracic impedance |
| LL BVP: left leg blood volume pulse | SV: stroke volume |
| RL BVP: right leg blood volume pulse | CO: cardiac output |
| LF TEMP: left finger skin temperature | TPR: total peripheral resistance |
| RF TEMP: right finger skin temperature | DZDT: 2nd derivative thoracic impedance |
| LT TEMP: left toe skin temperature | LVET: left ventricular ejection time |
| RT TEMP: right toe skin temperature | RESP VOL CHEST: respiration volume chest |
| LA EMG: left arm muscle activity | RESP VOL ABD: respiration volume abdomen |
| RA EMG: right arm muscle activity | |

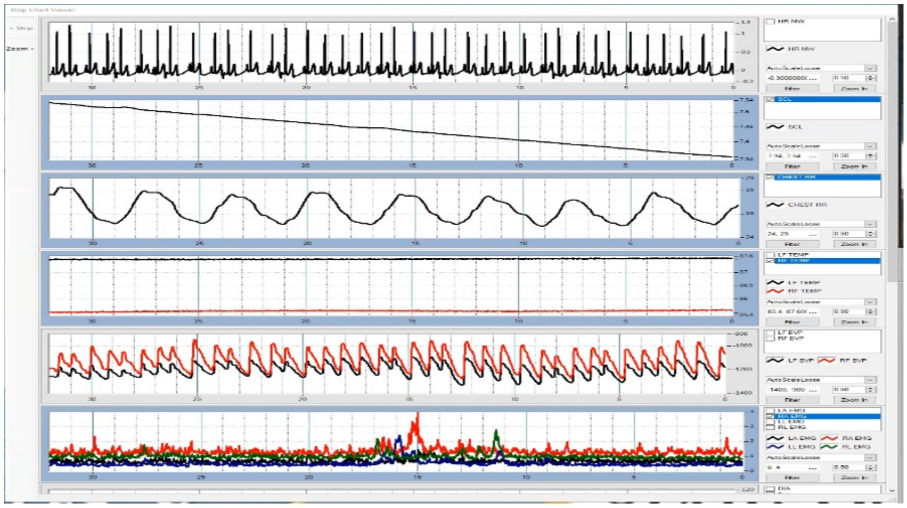

*Figure 2. Example of analog waveforms displayed on the monitor during AFTE.*

## 4. Results

### 4.1 Motion Sickness Tolerance

Twenty-six participants (17 men and 9 women) between the ages of 22 and 45 (M = 30.8, SD = 6.7) completed the study. Three subjects withdrew from the study and their data were not included in subsequent analyses. Motion sickness tolerance, measured as minutes of rotation, was recorded on each participant during their pre-test (no training) and post-test (after 2-hrs of AFTE). Figure 3 (on the left) shows mean and SEM of minutes of rotation tolerated for men and women on their pre-test (men: 14.18 ± 2.77; women: 12.78 ± 3.79) and post-test (men: 21.82 ± 4.66; women: 21.33 ± 6.32). A 2-way mixed factor ANOVA involving Gender (men vs. women) and Test (pre-test vs. post-test) on minutes of rotation tolerated was performed. The results revealed no significant effects of gender and gender x test interaction, however, there was a significant effect of test ($F(1, 24) = 17.97$, $p = .0003$) on motion sickness tolerance with a medium effect size, $\eta p^2 = .43$). Figure 3 (on the right) shows mean and SEM of minutes of rotation tolerated on the pre-test (13.75 ± 2.3, 13.6 ± 3.76) and post-test (20.93 ± 4.01, 22.8 ± 6.0). Sixteen participants were remotely trained by a NASA trainer and 10 participants were locally trained by a NAMRU-D trainer. A second 2-way ANOVA examined effects of Trainer and Test factors, and the results revealed a significant effect for test ($F(1,24) = 18.14$, $p = .0002$), while trainer and interaction effects were not significant.

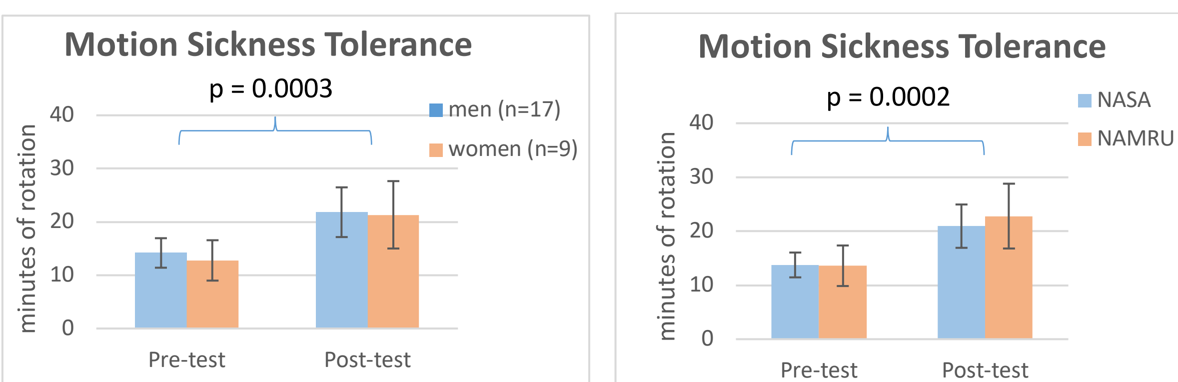


*Figure 3. Motion sickness tolerance of men and women (left) and trainer effect (right).*

Changes in motion sickness tolerance of individual participants on their pre-test (no training) and post-test (2 hrs. AFTE) are shown in Figure 4. Difference scores on minutes tolerated (post-test – pre-test) were calculated for each participant and ranked from highest (left) to lowest (right) in the figure. The difference scores were then divided into four categories based on minutes tolerated: ≥24 min. = 5 participants; 8–23 min. = 6 participants; 3–7 min. = 11 participants; and <1 min. = 4 participants. Although susceptibility to motion sickness is highly idiosyncratic, most participants (22 of 26), after receiving AFTE, improved their motion sickness tolerance on the post-test.

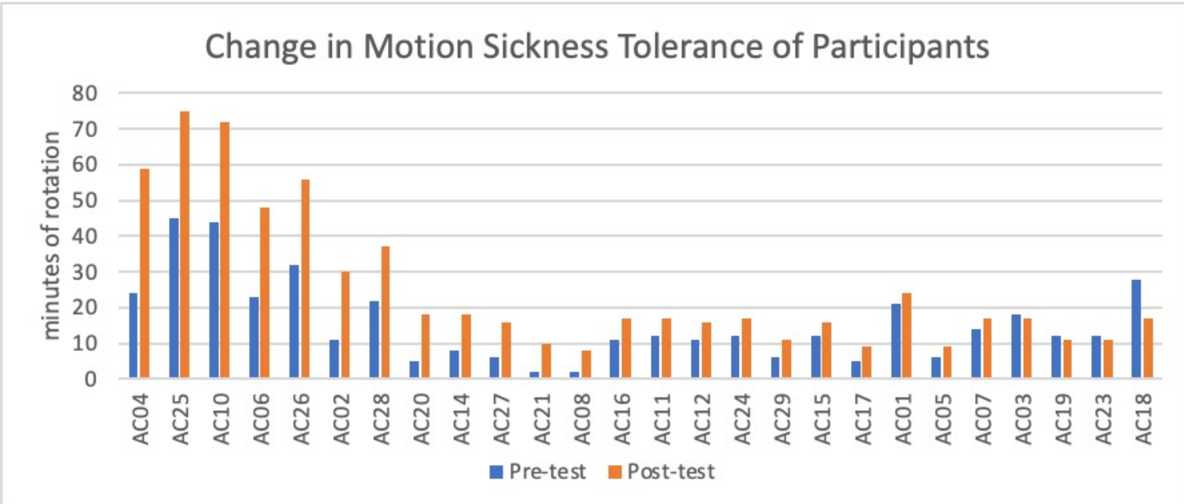


*Figure 4. Motion sickness tolerance of individual participants on pre- and post-test.*

## 4.2 Motion Sickness Symptoms

A non-parametric Wilcoxon Signed-Rank Test with Yates Continuity Correction for small samples was conducted to compare median symptom diagnostic scores (combined sample of 26 participants) on the pre- and post-tests. Figure 5 shows the median and SE (median) diagnostic points of all participants on their pre-test (8.0 ± .92) and post-test (5.6 ±.75). The test revealed significantly lower diagnostic scores on the post-test compared to the pre-test, Z = 3.18, p = .0015).

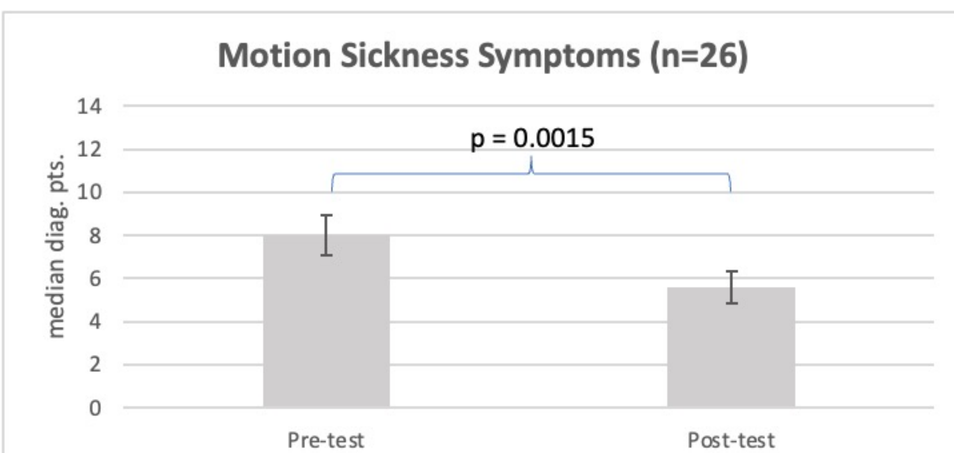


*Figure 5. Motion sickness symptoms of all participants on pre- and post-tests.*

## 4.3 Physiological Data

Analyses of physiological measures collected during AFTE training sessions and rotating chair tests and their relationship to minutes of rotation tolerated during pre- and post-tests is currently in progress and the results will be reported in a separate publication. Examples of the physiological data of one participant during the last AFTE training session and rotating chair tests are shown in Figures 6–8. Figure 6 shows normalized data (Z-scores) reduced to 15-second averages. Z-scores were calculated from the mean and standard deviation (shown in the legend) of the first 6 minutes of baseline. Both skin conductance levels and heart were lower in relaxation trials and higher in arousal trials, while respiration rate was kept at a constant pace. This graph shows that the largest magnitude changes during training were for skin conductance level and that the subject had reliable control of heart rate. Respiration data indicate that these changes were not due to hyper- or hypoventilation. Muscle activity of arms and legs (not shown) was also monitored to ensure that the observed changes in heart rate and skin conductance were not influenced by muscle contractions during trials.

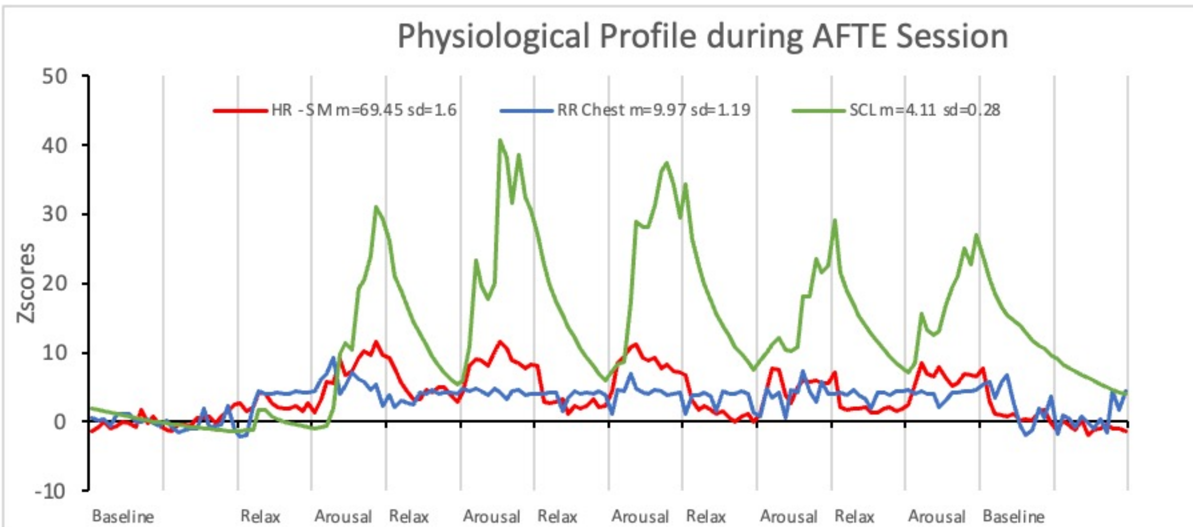


*Figure 6. Example of AFTE training session of one participant shows learned control of heart rate, respiration rate, and skin conductance level.*

Figures 7 and 8 show the same subject skin conductance level (SCL) and heart rate (HR) responses during rotating chair tests before and after receiving 2 hours of AFTE. These figures show normalized data (Z-scores) based on the mean and standard deviation (shown in the legend) of the first 10 minutes of baseline. SCL (Figure 7) showed the largest change at the start of rotation and increased as the rotational velocity increased. While HR (Figure 8) was higher before training it also showed a sudden increase (startle response) as the chair velocity increased to higher speeds. In the post-test, HR was lower with fewer startle responses. The data demonstrate that as the subject gained better control of their physiological responses they were able to tolerate the test at higher rotational velocities.

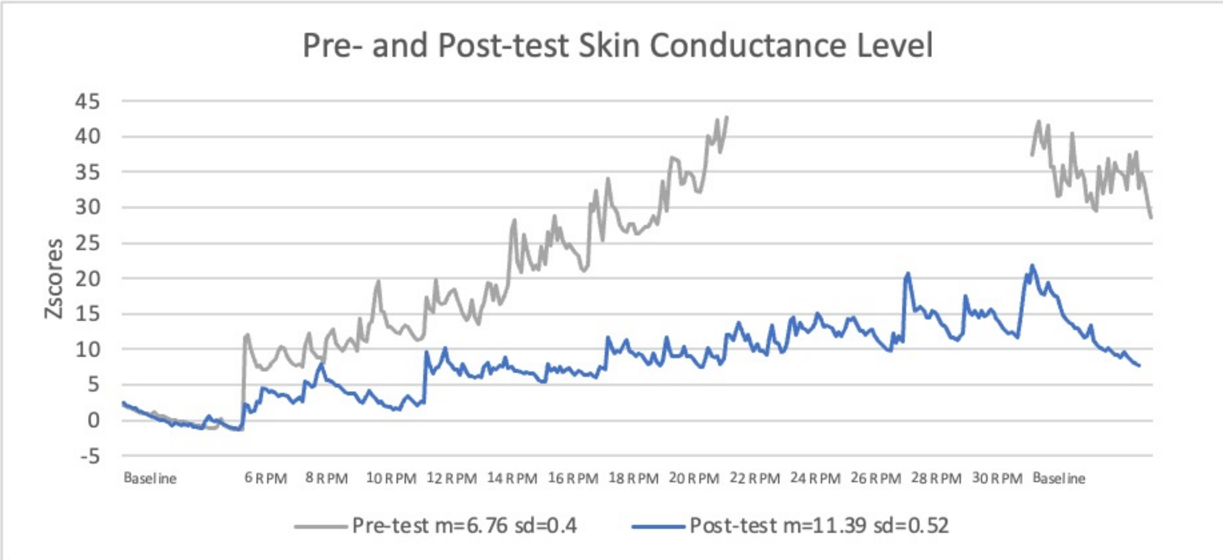


*Figure 7. Skin conductance level during rotating chair tests before and after training.*

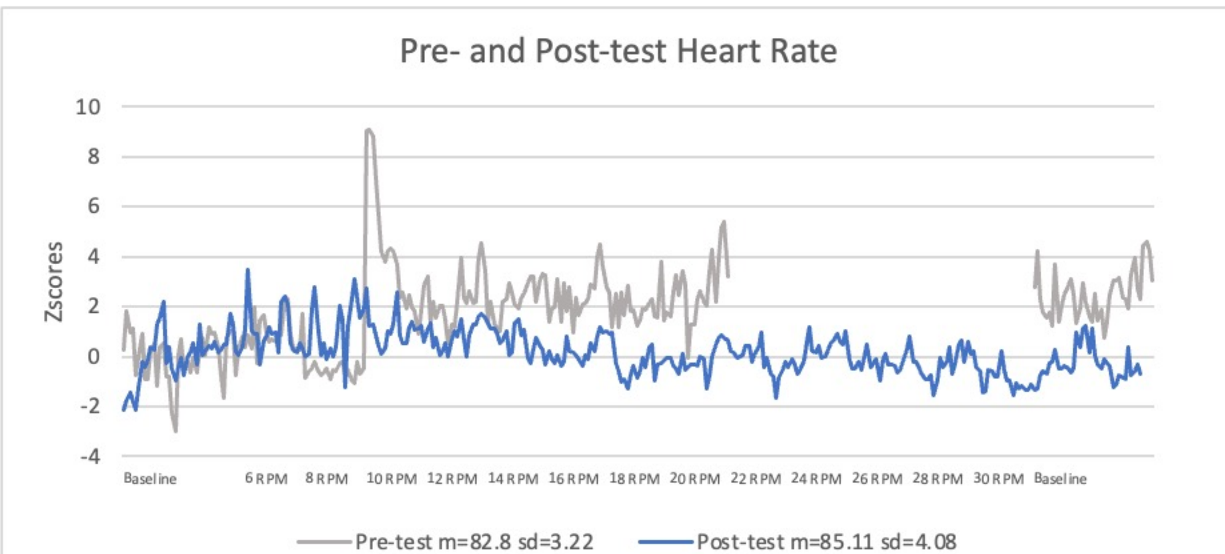


*Figure 8. Heart rate during rotating chair tests before and after training*

## 5. Discussion and Conclusions

The specific aims of this collaboration were to:

1. Refine and transfer NASA technology to NAMRU-D to address the military's 2019 AETC capability gap: 1. Gap 11: Lack of capability to standardize, implement, and measure air sickness best practices across the enterprise. The delivery of new hardware and software provided DoD investigators with a means to perform comprehensive assessments of military and civilian personnel's physiological status, standardization of AFTE training methods, and data collection procedures. The present study included documenting baseline physiological responses and responses to motion sickness induced by a rotating chair stimulus. It also established procedures for using AFTECH software to perform remote monitoring and AFTE training. Software upgrades, manuals, and training on operating procedures were developed and provided to NAMRU-D personnel. During the initial phase of the study NASA researchers administered AFTE training remotely (via the internet) to 16 participants while NAMRU-D researchers observed and learned AFTE methods. In phase two, NAMRU-D researchers administered AFTE training locally to 10 participants while NASA researchers provided oversight. The study results revealed no significant difference between trainers in administering AFTE; the observed increases in motion sickness tolerance were similar. Transfer of AFTE training methods and use of AFTECH software were successfully provided to NAMRU-D investigators.
2. Evaluate the effects of AFTE on motion sickness tolerance and symptom mitigation. In previous NASA research [2, 5–7] AFTE was administered over 12 days for a total of 6 hours of training, while in the current study using the AFTECH software, AFTE was reduced to 4 days with participants receiving only 2 hours of training. Although there were fewer hours of training in this study a significant increase in motion sickness tolerance was observed with a medium effect size. It was noted that some individuals (e.g., military pilots who were highly susceptible to motion sickness) would likely benefit from additional hours of training. Two pilots received an additional 2 hours of training (4 hours total) and their motion sickness tolerance increased significantly when compared with 2 hours of training. Other mitigation strategies for motion sickness (e.g., habituation through repeated exposure) require significant time commitment and do not fully negate all adverse symptoms (drowsiness). Moreover, habituation through gradual desensitization incurs a significant cost in terms of loss of valuable training time. Considering this, pharmacological interventions have been identified and used as a possible countermeasure to motion sickness. However, pharmacotherapies are often associated with adverse side effects—unlike AFTE where there are no side effects [3].

In addressing the limitations of this study, there were several methodological constraints and technical issues. The study did not exclude individuals with a recent history of motion sickness. As noted above, highly susceptible pilots who were given additional training were able to significantly improve their motion sickness tolerance. These results were consistent with earlier research demonstrating the benefit of providing additional AFTE training (4 and 6 hours) specifically for highly susceptible individuals [2].

Another important goal of this collaboration was to establish procedures for the use of AFTECH software and its training manual to administer remote monitoring and AFTE training. Remote training and monitoring capabilities are essential to the potential future use of AFTE in other operational applications within DoD (e.g., Air Force and Navy training wings). One technical issue with the current study was the low network bandwidth that occurred during remote training and resulted in some interruptions to training sessions. Maximizing bandwidth between training sites should be a high priority in future work involving remote AFTE training.

Because AFTE and the related software address multiple autonomic measures, real-world applications of AFTE can provide symptom mitigation not only for motion sickness (commercial and private vehicles) but for other conditions that induce nausea (e.g., virtual reality, morning sickness, chemotherapy) or other clinical disorders (e.g., gastrointestinal, cardiovascular, hypotension in spinal cord injury patients), emotional trauma (e.g., post-traumatic stress disorder, attention deficit disorder), or autonomic dysfunction. Future research should be conducted in other environments providing data for both NASA and DoD such as cybersickness in virtual reality simulators and g-tolerance and sensorimotor adaptation following chronic centrifugation.

In conclusion, the specific aims of this study were met successfully. The training approach with new trainers was effective and efficient, providing a means to train future DoD or other trainers. This approach provided new trainers with knowledge on how to direct a subject's attention to physiological responses most in need of correction.

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