NPS-OR-20-001

NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

ASSESSMENT OF STRESS INOCULATION TRAINING AT THE US NAVY SURFACE WARFARE OFFICER SCHOOL

by

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July 2020

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Prepared for: Surface Warfare Officer School Command; Naval Station Newport; 446 Cushing Road, Newport, RI 02841 and Naval Advanced Medical Development Program; Naval Medical Research Center; 503 Robert Grant Avenue, Silver Spring, MD 20910.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE ***(DD-MM-YYYY)***
07-09-2020

2. REPORT TYPE
Technical Report

3. DATES COVERED ***(From-To)***
May 2019 – May 2020

4. TITLE AND SUBTITLE
Assessment of Stress Inoculation Training at the US Navy Surface Warfare Officer School

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Heather L. Clifton, Panagiotis Matsangas, and Nita Lewis Shattuck

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) AND ADDRESS(ES)
Operations Research Department, Naval Postgraduate School, Monterey, CA 93943

8. PERFORMING ORGANIZATION REPORT NUMBER
NPS-OR-20-001

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Surface Warfare Officer School Command; Naval Station Newport; 446 Cushing Road, Newport, RI 02841.

Naval Advanced Medical Development Program; Naval Medical Research Center; 503 Robert Grant Avenue, Silver Spring, MD 20910.

10. SPONSOR/MONITOR'S ACRONYM(S)

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

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES
The views expressed in this report are those of the author(s) and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

14. ABSTRACT
Naval Officers face dynamic and challenging situations as part of their daily operations. These warfighters must be able to perform complex tasks and make critical decisions under high stress conditions. Stress Inoculation Training (SIT) utilizes controlled stress exposure during training to enhance expertise, adaptability, confidence, resilience, and performance under high stress conditions.
In 2019, the Surface Warfare Officer School (SWOS) expanded their Surface Commanders Course (SCC) from the previous standard 9-week training program to an enhanced 10-week training program that implemented a SIT component (a briefing on stress and a week of exercises designed specifically to induce stress in the students). This study assessed and compared stress levels between the standard and the enhanced training program. SWOS students (N=40) participated in the study, 21 in the standard program (the "Control" group) and 19 students in the enhanced program (the "SIT" group). Measurements included assessments of life stress (Cohen Perceived Stress Scale, PSS), mood (Profile of Mood States, POMS), physical exertion (Modified Borg Rating of Perceived Exertion, RPE), cognitive workload (Bedford Workload Scale, BWS), salivary biomarkers for stress (α-amylase, cortisol, C-reactive protein), and heart rate (HR).
Our results showed that stress levels during the classroom period were in general low. In terms of the Fire Trainer evolution, the training was stressful, both in terms of the subjective assessments of stress and in terms of the psychophysiological metrics we collected. There were no differences in stress metrics between groups during the Fire Trainer.
During week 10, students experienced an incremental pattern of pre-evolution α-amylase activity. This pattern suggests an accumulative effect of the training activities, and indicates that the autonomic nervous system was remaining activated. C-reactive protein did not accumulate during week 10, and the levels of the protein did not show any notable spikes that would point to an inflammatory response associated with injury or overload. Also, the Battle Stations event with three consecutive evolutions in the same day was stressful as evidenced by the peak heart rate metrics.
Overall, our results suggest that the inclusion of week 10 in the training regime can be considered successful from a stress perspective. The addition of week 10 with high intensity training evolutions did succeed in evoking moderate levels of stress in the SWOS students but was able to do so without causing overload or injury.

15. SUBJECT TERMS
Stress, Stress Inoculation Training, Training, Surface Warfare Officer School

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			
Unclassified	Unclassified	Unclassified	Unclassified	70	Nita Lewis Shattuck
					19b. TELEPHONE NUMBER ***(include area code)*** 831-656-2281

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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NAVAL POSTGRADUATE SCHOOL
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Ann E. Rondeau
President

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Provost

The report entitled "Assessment of Stress Inoculation Training at the US Navy Surface Warfare Officer School" was prepared for the Surface Warfare Officer School Command and funded by the Surface Warfare Officer School and the Naval Advanced Medical Development Program.

Further distribution of all or part of this report is authorized.

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ABSTRACT

Naval Officers face dynamic and challenging situations as part of their daily operations. These warfighters must be able to perform complex tasks and make critical decisions under high stress conditions. Stress Inoculation Training (SIT) utilizes controlled stress exposure during training to enhance expertise, adaptability, confidence, resilience, and performance under high stress conditions.

In 2019, the Surface Warfare Officer School (SWOS) expanded their Surface Commanders Course (SCC) from the previous standard 9-week training program to an enhanced 10-week training program that implemented a SIT component (a briefing on stress and a week of exercises designed specifically to induce stress in the students). This study assessed and compared stress levels between the standard and the enhanced training program. SWOS students (N=40) participated in the study, 21 in the standard program (the "Control" group) and 19 students in the enhanced program (the "SIT" group). Measurements included assessments of life stress (Cohen Perceived Stress Scale, PSS), mood (Profile of Mood States, POMS), physical exertion (Modified Borg Rating of Perceived Exertion, RPE), cognitive workload (Bedford Workload Scale, BWS), salivary biomarkers for stress (α-amylase, cortisol, C-reactive protein), and heart rate (HR).

Our results showed that stress levels during the classroom period were in general low. In terms of the Fire Trainer evolution, the training was stressful, both in terms of the subjective assessments of stress and in terms of the psychophysiological metrics we collected. There were no differences in stress metrics between groups during the Fire Trainer.

During week 10 of the SCC, students experienced an incremental pattern of pre-evolution α-amylase activity. This pattern suggests an accumulative effect of the training activities, and indicates that the autonomic nervous system was remaining activated. C-reactive protein did not accumulate during week 10, and the levels of the protein did not show any notable spikes that would point to an inflammatory response associated with injury or overload. Also, the Battle Stations event with three consecutive evolutions in the same day was stressful as evidenced by the peak heart rate metrics.

Overall, our results suggest that the inclusion of week 10 in the training regime can be considered successful from a stress perspective. The addition of week 10 with the high intensity training evolutions did succeed in evoking moderate levels of stress in the SWOS students but was able to do so without causing overload or injury.

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I. INTRODUCTION

You are standing the mid watch on the bridge – it has been a long day and you are pretty tired. The night is dark, the weather is overcast, the seas are choppy and there are few surface contacts to demand your attention as you stand bridge watch. The deployment is finally coming to an end and you will be pulling into home port in just a couple of days. The cruise has been a tough one with limited port calls, long hours of watch, and weeklong bouts without internet connectivity. You can't wait to get home and see your family. Suddenly, your thoughts are jolted back to the present with the sound of five blasts on the ship's whistle and people yelling orders as a huge contact looms just off the starboard bow. There is a loud crash and you are thrown to the floor, then you regain your footing. As you rush to take charge of the emergency, you notice that not everyone on the bridge is taking action. You are surprised to see some of the crew frozen in place, some are even crouching down as if to hide from the chaos. You begin shouting orders, encouraging the crew to resume their duties and fight to save the ship. You recognize that the stress of the emergency has rendered a number of your crewmembers practically helpless. It looks like that stress inoculation training you received paid off. You were able to anticipate your own and your team's reactions to extreme stress and were able to continue performing in the midst of the crisis.

Stress is a term used across multiple domains. The word stress, as it relates to human behavior, can be a noun, a verb or an adjective, further confusing the issue. For the purposes of this report, we will define ***stress*** as the reaction to or response to a stressful event or condition which can be called a ***stressor***. Stress can manifest itself in a variety of ways; individuals may exhibit idiosyncratic responses to stressors, complicating the definition even more. In particular, stress may be observed in cognitive, emotional, behavioral, or physiological measures – which allows it to be quantified.

The military operational environment is full of stressors. These stressors include temperature extremes and harsh physical environments, sensory stimuli such as noise, motion and vibration, crowding or isolation, fatigue, lack of sleep, uncertainty or lack of control, time pressures, heavy tasking, increased task complexity, information overload, and threat to one's physical safety (Driskell & Salas, 1996). Along with these combat stressors are also high pressure to perform and escalating severity of consequences when that performance falls short. Even with advancing technologies and increasing automation, the warfighter still remains the linchpin of any military operation. The ability to maintain emotional, cognitive, and behavioral control in challenging and stressful conditions is essential to survival, maintaining safety, and maximizing operational effectiveness (Driskell, Carson, & Moskal, 1986; Driskell & Salas, 1996; Thompson & McCreary, 2006). Providing military personnel with the skills and tools needed to perform under stress is therefore a key element to operational success.

A. TYPES OF STRESS

Sources of stress in the operational environment vary considerably. Some sources of combat stress are sudden, novel, or unpredictable, but generally brief or temporary (*acute stress*). Other sources are constant or recurring, and often thought of as daily or background annoyances (*chronic stress*). Stress may also come from the surroundings (*physical or environmental stress*) or from interpersonal interactions or perceptions (*psychological or emotional stress*). Stress can even be categorized as being engaging and beneficial (*eustress*) or counterproductive and harmful (*distress*). Military service members will encounter all of these types of stress, and many times they will encounter multiple stressors simultaneously. In some cases, the physiological response to stressors can itself become a source of stress (Driskell & Salas, 1996).

B. RESPONDING TO STRESS

When confronted with a stressor, several response systems within the body become activated, most notably the autonomic nervous system (ANS), the hypothalamic-pituitary-adrenal (HPA) axis, and the immune system (Figure 1). The activation of these systems results in changes to various signaling factors, proteins, and enzymes (biomarkers) leading to a number of physiological responses across multiple organ systems. Following an acute stress exposure, the timing for the onset and the peak of the various biomarkers differs. Changes in salivary α-amylase, which is associated with activation of the sympathetic branch of the ANS, occur within the first minute, and peak around 5 minutes after the stress exposure (Engert et al., 2011; Thoma, Kirschbaum, Wolf, & Rohleder, 2012). The cortisol response, which reflects activation of the HPA system, is slightly delayed relative to α-amylase, but still occurs rather quickly, with onset starting within the first 5 minutes and levels peaking around 20 minutes (Engert et al., 2011). Immune system responses occur more slowly. One key protein associated with immune system activation is C-reactive protein, which is produced following the release of other pro-inflammatory signaling factors (cytokines). The onset generally takes around 4 hours, with the peak occurring sometime over the following 24-36 hours - in some cases peaking as long as 48 hours - after the stress exposure (Pick, 2013; Salazar et al., 2014).

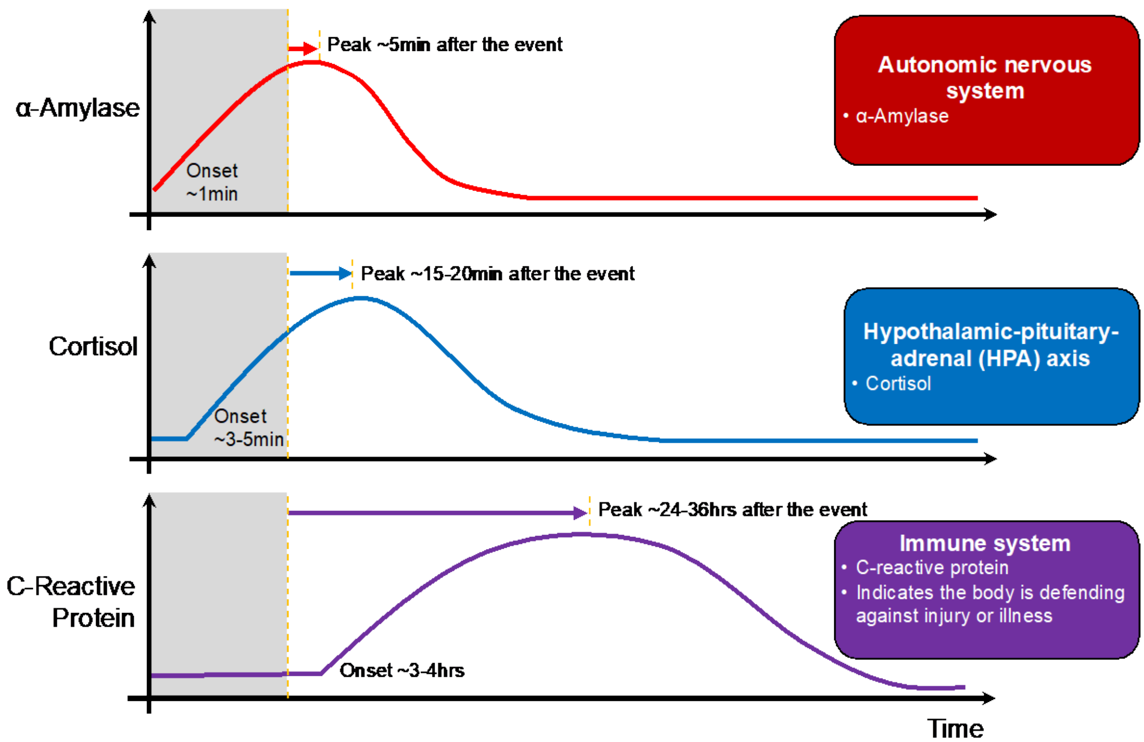


Figure 1. Time course for the onset and peak of key biomarkers associated with the three major stress response systems.

The neurohormonal and physiological responses to stressors are “nonspecific”, meaning that once the presence of a stressor has been identified and the stress response has been initiated, the signaling pathway and the resultant end-organ responses do not distinguish or change due to the type of stressor. This nonspecific or generalized response phenomenon can be leveraged in military training to safely expose individuals to stress. Recreating combat stress in a training environment is inherently difficult. The scenarios may be seen as contrived and lack the real-world consequences that are characteristic of a true operational environment, and thus fail to elicit the same degree of stress. However, other stressors may be applied during training to provoke similar physiological responses, enabling the warfighter to experience these changes and become adept at mitigating or working through them.

A well-recognized model describing the process of responding to a potential source of stress is the Lazarus appraisal theory (Lazarus & Folkman, 1984). In their theory, the stress response process begins with the initial perception or appraisal of the stressor. During this first phase, the individual assesses the severity and nature of the demand or threat. This initial phase is followed by a secondary appraisal, where the individual assesses the resources available to meet the demand or neutralize the threat. If the resources available to meet the demand or combat the threat are considered to be sufficient, then there will be little to no stress response. If the resources are deemed to be insufficient, then the stress response systems will become activated.

This appraisal-based model was later expanded into a military stress-performance model (Kavanagh, 2005). In this model, the warfighter's performance under stress is adjusted by two sets of moderators. Type 1 moderators influence the warfighter's physiological response to the stress and include personality type and individual characteristics, outlook and experiences, anticipation, and training. Type 2 moderators impact the individual's performance or behavior in the presence of stress and include self-efficacy, sense of control, and training. To put it another way, Type 1 moderators determine whether or not the person feels stressed, and Type 2 moderators determine what they do about it. Kavanagh's military stress-performance model points out two key principles: the significance of training (it appears as both a Type 1 and Type 2 moderator) and the importance of how these elements ultimately impact the final outcome – performance.

C. EFFECTS OF STRESS ON PERFORMANCE

The effects of combat stress on performance are complex and difficult to predict. As previously discussed, the operational environment contains a large number of stressors, including extreme temperatures, noise, motion, vibration, lack of sleep, heavy or complex tasking, time pressure, and imminent threat. These various stressors will impact individuals differently depending on their appraisal of the situation and their Type 1 and 2 moderators. Predicting the impact of stress in a military context is further complicated by the fact that multiple stressors are likely to exist at the same time. When several stressors are present simultaneously, the net effect is not necessarily the sum of the parts. Two stressors, both with negative effects on performance, when combined could result in little performance decrement or even improved outcomes (Driskell & Salas, 1996). Or they could combine in a multiplicative manner and have catastrophic effects. Additionally, the susceptibility of a task to degradations in performance with stress depends on factors like the complexity of the task, level of task mastery, and the presence of additional tasking.

A substantial body of literature documents many of the potentially negative effects of stress on performance. These include perceptual narrowing, impaired concentration, focusing on fewer or inappropriate cues, less time spent on decision making or changes in decision making strategies, limited information scanning, greater reliance on heuristics, impaired memory, degradation in psychomotor skills, and increased reaction time (Driskell & Salas, 1996; Kavanagh, 2005). These cognitive changes increase the likelihood of errors, lapses, and performance decrements, and in an operational environment, may result in dire consequences. Providing the training and tools that enable the warfighter to maintain optimal performance under stress is of critical importance.

D. STRESS INOCULATION TRAINING

Military training aims to prepare the warfighter to perform in evolving, demanding, and often life-threatening conditions. Stress Inoculation Training (SIT) uses controlled stress exposure during training to improve future performance under high stress conditions, and has been cited as the most important moderator of the impact of stress on performance in the military context (Kavanagh, 2005). SIT has been used in law enforcement (Andersen, Pitel, Weerasinghe, & Papazoglou, 2016), emergency medicine (DeMaria et al., 2010), disaster response (Hytten, Jensen, & Skauli, 1990), and a number of different military populations (McClernon, 2009; McClernon, McCauley, O'Connor, &

Warm, 2011; Robson & Manacapilli, 2014; Taylor, Schatz, Marino-Carper, Carrizales, & Vogel-Walcutt, 2011). The controlled application of stress during training has also been shown to improve learning and performance (Vogel & Schwabe, 2018), and strengthen resilience (Crane, Searle, Kangas, & Nwiran, 2018).

SIT programs are designed to familiarize the individual with their own physiological and psychological responses to stressors, improve their appraisal of the situation, reduce the physiological and psychological disruptions caused by stress, and improve performance outcomes. SIT has been described as a three phase process (Figure 2). The first phase consists of providing instruction on the physiological and psychological effects of stress, and on techniques for mitigating the negative effects of stress on performance. The second phase involves practicing the stress mitigation techniques in a controlled training environment with guidance and feedback. In the third phase, stress is delivered in training environments to facilitate mastery of stress mitigation techniques and promote confidence, self-efficacy, adaptability, and optimized performance under high stress conditions (Driskell & Salas, 1996; Kavanagh, 2005).

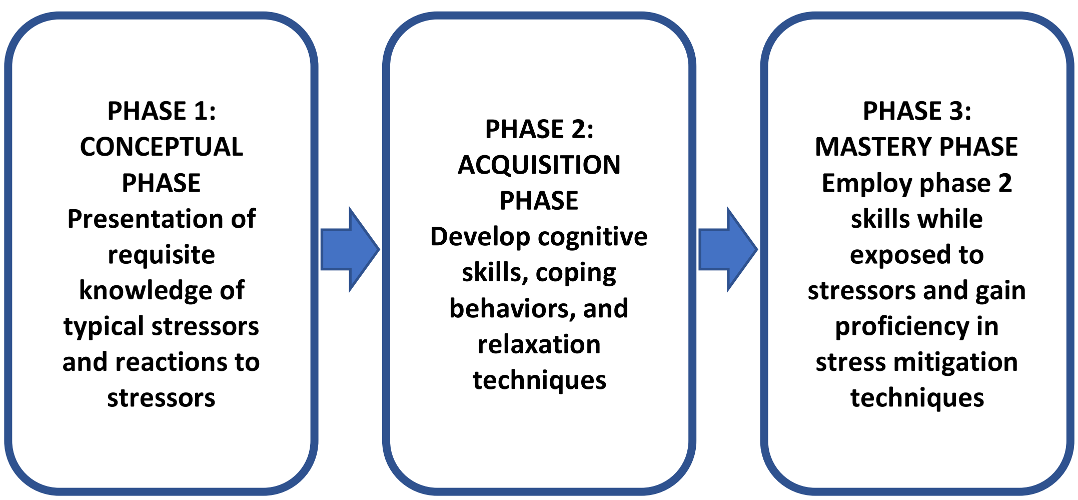


Figure 2. Design and phases of a Stress Inoculation Training (SIT) program.

E. THE SURFACE WARFARE OFFICER SCHOOL (SWOS) SURFACE COMMANDERS COURSE (SCC)

Surface Warfare Officers face unique and evolving challenges and situations as part of their daily operations. These warfighters must be able to stay alert, continue to operate, make critical decisions, and lead their crew under conditions of high stress. Anticipating and training for all possible scenarios is neither practical nor feasible. Instead, they must develop the physiological and psychological tools to adapt to and cope with these high stress situations while maintaining the highest possible level of performance.

In 2019, the Surface Warfare Officer School (SWOS) expanded their Surface Commanders Course (SCC) from the previous standard 9-week training program to an enhanced 10-week training program that implemented a SIT component. The standard course included classroom-based instruction five days per week, as well as a half-day training evolution in a live fire-fighting training facility ("Fire Trainer") during the last week of instruction. With the enhanced 10-week program, the course also included an instructional briefing on stress and several additional high-stress training evolutions during the final week of the program. In addition to the Fire Trainer, the expanded training regimen consisted of a half-day scenario-based training of a ship taking on water ("Wet Trainer", a.k.a. "Buttercup"), a jump from a high platform into a pool followed by a swim to a lifeboat, representing an abandon ship scenario ("Pool Trainer"), a fast-paced combination of the Fire Trainer, Wet Trainer, and Pool Trainer scenarios ("Battle Stations"), and two high-difficulty ship driving tasks in a fully immersive Bridge simulator, a high-traffic ship handling task ("Traffic"), and an *extremis* extraction ship handling task ("Extraction"). During this final week of the enhanced program when SCC students were not performing the training evolutions, they were undergoing high-stress testing and evaluations in the classroom.

F. PROJECT SCOPE AND OBJECTIVES

The mission of the Surface Warfare Officer School (SWOS) is to ready sea-bound warriors to serve on surface combatants. This training includes the SCC course which all prospective commanding officers and executive officers attend. At the request of SWOS, the Naval Postgraduate School team was asked to assess the stress loads of two cohorts of SWOS students, one cohort in the standard 9-week SCC course and the other cohort in an expanded 10-week course which included the implementation of a SIT program. The specific aims of this study were to:

- Assess stress and mood in the classroom portion of the curriculum;
- Assess and compare stress levels in the Fire Trainer evolution between participants in the standard training regimen and participants in the enhanced training regimen.
- Assess and compare stress levels between participants in the standard training regimen (experiencing only the Fire Trainer evolution) and participants in the enhanced training regimen (experiencing a multi-day series of training evolutions).

II. METHODS

A. EXPERIMENTAL DESIGN

This study was quasi-experimental and longitudinal in nature.

B. PARTICIPANTS

Active duty service members (N = 40) attending the Surface Warfare Officer School (SWOS) in Newport, RI, volunteered to participate in the study. The study protocol was approved by the Naval Postgraduate School Institutional Review Board (NPS.2019.0031) and all participants provided written informed consent.

C. EQUIPMENT AND INSTRUMENTS

1. Questionnaires

Information regarding participant demographics, service history and health behaviors were collected by means of the Enrollment questionnaire (Appendix A). The Cohen Perceived Stress Scale (PSS) was used to assess nonspecific appraised stress over the past month (Cohen & Janicki-Deverts, 2012; Cohen, Kamarck, & Mermelstein, 1983). As shown in Appendix B, the current version consists of ten questions that are scored on a five-point scale ranging from 0 (Never) to 4 (Very often). Responses are summed for a possible total score of 40 (Cohen, 1994).

To measure mood states and assess changes in mood, participants filled out the Profile of Mood States (POMS) (McNair, Lorr, & Droppelman, 1971). The POMS is a standardized, 65-item inventory originally developed to assess mood state in psychiatric populations (Appendix C). The questionnaire assesses the dimensions of the mood construct using six subscales: Anger-Hostility (12 items; range 0-48), Confusion-Bewilderment (7 items; range 0-28), Depression (15 items; range 0-60), Fatigue (7 items; range 0-28), Tension-Anxiety (9 items; range 0-36) and Vigor-Activity (8 items; range 0-32). Total Mood Disturbance (TMD) score is derived by adding the five subscales and subtracting the score for Vigor (range 0-200). Normalized T-scores are based on norms for adults (Nyenhuis, Yamamoto, Luchetta, Terrien, & Parmentier, 1999). The POMS was administered using the instruction “Describe how you felt during the past week.” Positive mood has been associated with better within-team communication behaviors and enhanced team awareness (Pfaff, 2012).

A modified version of the Borg Rating of Perceived Exertion (RPE) scale was used to assess perceived physical demand (Borg, 1982; Zamunér et al., 2011). The scale rates physical effort from 1 (Very low) through 10 (Maximal) (Appendix D). The RPE was administered using the instruction “Please rate your level of physical exertion during the previous activity.”

A modified version of the Bedford Workload Scale (BWS) was used to assess cognitive workload (Roscoe & Ellis, 1990). As shown in Appendix E, the BWS scale rates task workload on the basis of spare capacity to perform additional tasks from 1 (Workload insignificant) to 10 (Task abandoned. Unable to apply sufficient effort). The BWS was administered using the instruction “Please rate the cognitive workload you experienced during the previous activity.”

2. Salivary Biomarkers

Three biomarkers were used to assess the body’s responses to stress, i.e., α-amylase, cortisol, and C-reactive protein. All biomarkers were measured from saliva samples.

Salivary α-amylase is associated with the activation of the sympathetic branch of the autonomic nervous system under times of stress. In addition to stress, α-amylase can be influenced by smoking, caffeine use, and recent food or beverage intake (Salimetrics, 2019c). Salivary α-amylase activity was assessed by kinetic enzyme assay kit (Salimetrics, LLC).

Salivary cortisol increases with activation of the hypothalamic-pituitary-adrenal (HPA) axis under times of stress. Cortisol levels also fluctuate over the course of the day following a circadian rhythm, with levels peaking in early morning and dropping at night (Salimetrics, 2019a). Cortisol was assessed by enzyme immunoassay kit (Salimetrics, LLC).

Salivary C-reactive protein increases with activation of the immune system, and indicates a response to inflammation, infection, or injury. C-reactive protein levels can increase dramatically during acute stress, but are also elevated by chronic stress, as well as several chronic health conditions (Salimetrics, 2019b). C-reactive protein was assessed by enzyme-linked immunosorbent assay (ELISA) (Salimetrics, LLC).

Samples of whole saliva were collected by the passive drool technique. The samples were immediately frozen and then transported to the Crew Endurance and Stress Laboratory at the Naval Postgraduate School. Once in the laboratory, the samples were stored at -80°C. The samples were later thawed, centrifuged, and divided into aliquots. The aliquots were stored at -80°C until they were assayed for α-amylase, cortisol, and C-reactive protein.

3. Sleep assessment

Sleep was assessed by wrist-worn actigraphy, a validated method to collect objective sleep data in field studies (Meltzer, Walsh, Traylor, & Westin, 2012; Rupp & Balkin, 2011). In general, the use of actigraphy followed existing recommendations (Ancoli-Israel et al., 2015; Morgenthaler et al., 2007) with one exception. Specifically, we decided not to ask the participants keep a sleep log because they had a normal work/rest schedule during the data collection (i.e., working during the day, sleeping at night).

We used the Spectrum Plus (Philips-Respironics Inc.; Bend, Oregon) actigraph. Collected in 1-minute epochs, data were scored using Actiware software version 6.0.0 (Phillips Respironics; Bend, Oregon). The medium sensitivity threshold (40 counts per epoch) was used, with 10 immobile minutes the criterion for sleep onset and sleep end (all values are default for this software).

4. Heart rate

Heart rate was measured during training exercises using the Blink 24 armband and the Heart Zones heart rate monitoring system (Heart Zones, Inc.). Individual heart rates could be monitored in real-time, and the peak heart rates were logged by the system for later analysis.

D. PROCEDURES

All data collection took place at the Surface Warfare Officer School in Newport, RI, and all data analysis was performed at the Naval Postgraduate School in Monterey, CA.

Data collection occurred in two phases. In the first phase (May 2019 to June 2019), the SWOS Surface Commanders Course (SCC) used the standard 9-week training regimen. During this phase we recruited participants for the study from the cohort of students attending the course during that period. All volunteers from this cohort were considered as the Control group. The second phase was from July 2019 to September 2019. Before the second phase, SWOS leadership introduced changes to the SCC to include additional SIT components. For this reason, training in the SCC was conducted over a 10-week period which included a briefing on stress and an additional week of exercises designed specifically to induce additional stress in the students. During the second phase, we recruited participants from the cohort of students attending the course during that period. Therefore, all volunteers from the second cohort were considered the treatment group, or SIT group.

The basic procedures in both study phases were the same. Within each phase, data were collected during three on-site visits (Control group: weeks 1, 5 and 9; SIT group: weeks 1, 6 and 10). The first two site visits occurred during the classroom portion of the training, whereas the third site visit occurred during the training evolutions.

At the beginning of the first visit, students were briefed on the study. Volunteers signed informed consent documents, completed the Enrollment questionnaire to include the POMS and the PSS scales, and provided a saliva sample. During the second visit, participants completed again the POMS and PSS scales, and provided a saliva sample. These sessions all occurred about the same time of day (approximately 1330).

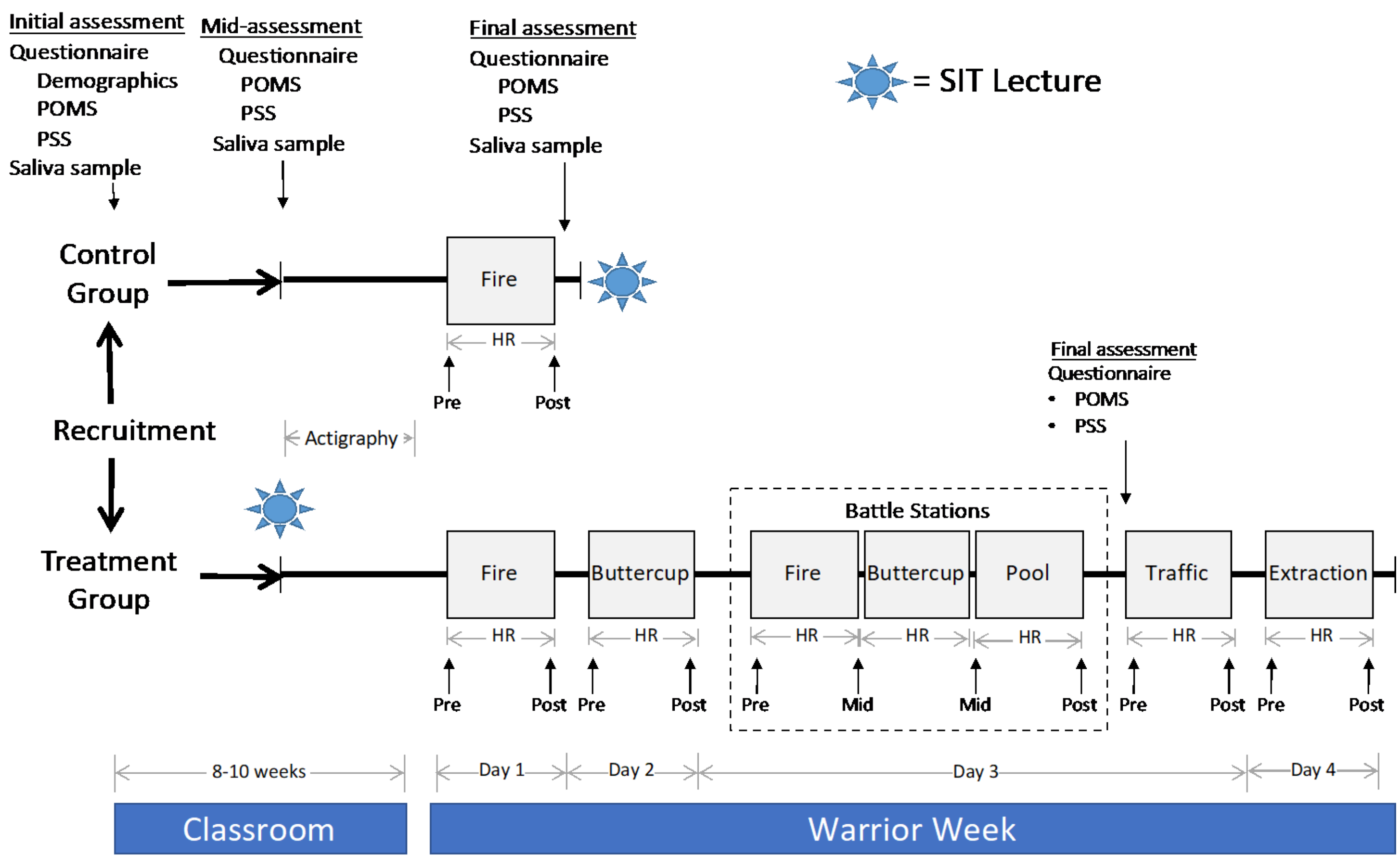
At the end of the second visit, participants were issued an actigraph and were instructed to wear the device on their non-dominant hand continuously for the 4-week period between the second and third study visits. Also, participants in the SIT group attended a one-hour lecture on stress effects during the second visit.

Participants in the Control group repeated the procedure (POMS, PSS, saliva sample) at the end of the third visit. Due to time constraints, however, participants in the

SIT group repeated the procedure (POMS, PSS, saliva sample) one day before the end of the study, during the training evolutions.

During the third visit, data were also collected during the training evolutions. Specifically, before and immediately after each evolution, participants completed the RPE scale to assess overall physical demand, the BWS scale to assess task load, and provided saliva samples. Also, participants wore heart rate monitors during the evolutions to assess cardiac activity.

Due to different training regimens, the specific evolutions differed between the two participant groups. The Control group went through the Fire Trainer ("Fire") evolution only. In contrast, the SIT group had four days of training evolutions. Specifically, the first day included the Fire Trainer and the second day included the Wet Trainer ("Buttercup"). The third day included the Battle Stations training scenario which was comprised of three evolutions, the Fire Trainer, the Wet Trainer, and the Pool Trainer ("Pool"). The afternoon of the third day included a high-traffic shiphandling simulation exercise ("Traffic"), and the fourth day included an *extremis* extraction shiphandling simulation ("Extraction"). The study protocol is shown in Figure 3.



Notes:

- “Pre” and “Post” denote collection of saliva samples, RPE, and BWS.
- HR: Heart Rate

Figure 3. The study protocol.

E. ANALYTICAL APPROACH

1. Actigraphy Data Cleaning and Reduction Procedures

The preparation of the actigraphy data for analysis included two steps. First, we evaluated the quality of the actigraphic data (number of days of data available, missing data or gaps in the data). Based on this assessment, it was decided that actigraphic data from 28 participants would be used for further analysis. Next, an initial database of sleep intervals was developed. From the rest/in-bed intervals the time in-bed (TIB) was calculated. Within each rest interval, the actigraphically-assessed sleep was calculated.

2. Analysis Roadmap

All variables underwent descriptive statistical analysis to identify anomalous entries and to describe our population in terms of demographic characteristics, use of caffeine, nicotine, medication, and whether they had a regular exercise routine. Next, we assessed stress, mood, and sleep during the classroom portion of the study. We used two methods. First, metrics of interest were aggregated by participant. Second, we assessed differences in participant well-being between visits and groups. Actigraphy data were analyzed to determine daily sleep duration. Daily sleep duration was aggregated to get an average score for each individual. Therefore, daily sleep duration provided an overall estimate of participant sleep deprivation during the classroom portion of the study.

Next, we assessed differences in stress responses between participant groups during the Fire Trainer evolution which was the only evolution experienced by the Control group, but the first one experienced by the SIT group. Initially, we verified equivalence between the participant groups by comparing stress variables at the beginning of the Fire Trainer evolutions. Analysis of covariance (ANCOVA) was used to assess differences in post-evolutions responses/levels with participant group as the potential predictor factor and the pre-evolution level as a covariate.

The next steps in our analyses focused on the stress levels of week 10. Mixed model analysis of variance with participants as the random factor was used to assess differences in the pre-evolution levels of the variables of interest (BWS, RPE, α-amylase, cortisol, C-reaction protein). We repeated the mixed model analysis of variance to assess differences in the post-evolution levels of the variables of interest. Pre/post-evolution differences were assessed with the Wilcoxon Signed Rank test. Lastly, we compared stress metrics between participant groups. To facilitate this comparison, we aggregated stress metrics by participant. Specifically, we calculated the median of post-evolution BWS, RPE, cortisol, and C-reactive protein data during the entire week 10 for the SIT group, whereas for the Control group we used the post- Fire Trainer data. The aggregated metric of α-amylase for the SIT group was calculated as the median of all available data during week 10.

Statistical analysis was conducted with JMP statistical software (JMP Pro 15; SAS Institute; Cary, NC). The criterion for statistical significance was set at $p = 0.05$. Data are presented as mean (M) ± standard deviation (SD) or median (MD) (interquartile range – IQR) as appropriately needed. Continuous variables were assessed for normality with the Shapiro-Wilk W test. Correlation analysis between study variables was conducted using Spearman's *rho*. The exact 1-sided binomial test was used to compare POMS scores with adult norms. Box Cox Y transformation was applied to the dependent variables of the multiple regression analyses when these variables were not normally distributed (Box & Cox, 1964).

The Wilcoxon Rank Sum test was used to conduct pair-wise comparisons between independent samples, whereas the Wilcoxon Signed Rank test was used for dependent samples. Effect size r and η^2_p metrics were used.

III. RESULTS

A. DEMOGRAPHIC CHARACTERISTICS, SERVICE HISTORY, AND HEALTH-RELATED BEHAVIORS

A total of 40 SWOS students participated in this study; 21 students were in the Control group and 19 students were in the SIT group. The two groups were equivalent in demographic characteristics, service history, and health (Table 1). Both groups included experienced Naval Officers who reported a combined average of 16 years (range 10-29 years) on active duty and 5 (range 2-9) deployments. Nearly all of the participants reported regular caffeine use and having a regular exercise routine.

Table 1. Demographic characteristics, service history, and health-related behaviors.

	Entire sample (N = 40)	Control group (n = 21)	SIT group (n = 19)	p-value
Age (years), MD (range)	37.5 (31-50)	38 (31-50)	37 (32-47)	0.595 [A]
Sex (male), % (#)	75% (30)	66.7% (14)	84.2% (16)	0.281 [B]
Years on Active Duty, MD (range)	16 (10-29)	16 (10-27)	16 (10-29)	0.502 [A]
Times Deployed (#), MD (range)	5 (2-9)	5 (2-9)	4.5 (2-8)	0.344 [A]
Caffeine Use, % (#)	97.5% (39)	95.2% (20)	100% (19)	0.999 [B]
Nicotine Use, % (#)	20% (8)	28.6% (6)	10.5% (2)	0.241 [B]
Medication Use, % (#)	40% (16)	38.1% (8)	42.1% (8)	0.999 [B]
Exercising Regularly, % (#)	92.5% (37)	95.2% (20)	89.5% (17)	0.596 [B]

[A] Wilcoxon Rank Sum test

[B] Fisher's Exact test

B. STRESS, MOOD, AND SLEEP DURING THE CLASSROOM PORTION OF THE STUDY

1. Overall

This section focuses on participant well-being during the classroom portion of the study. Metrics of interest were aggregated by participant.

During the classroom portion of the study, the median PSS score reported by the participants was 9.5 (IQR = 5.6). On average, this stress score is well below the norms reported for the age groups represented in this study, which range from 12.7 to 17.5 (Cohen & Janicki-Deverts, 2012). Based on their PSS score, 30 (75.0%) participants reported low perceived stress, 9 (22.5%) reported moderate perceived stress, and one participant reported high perceived stress. The distribution of PSS scores for all participants is shown in Figure 4.

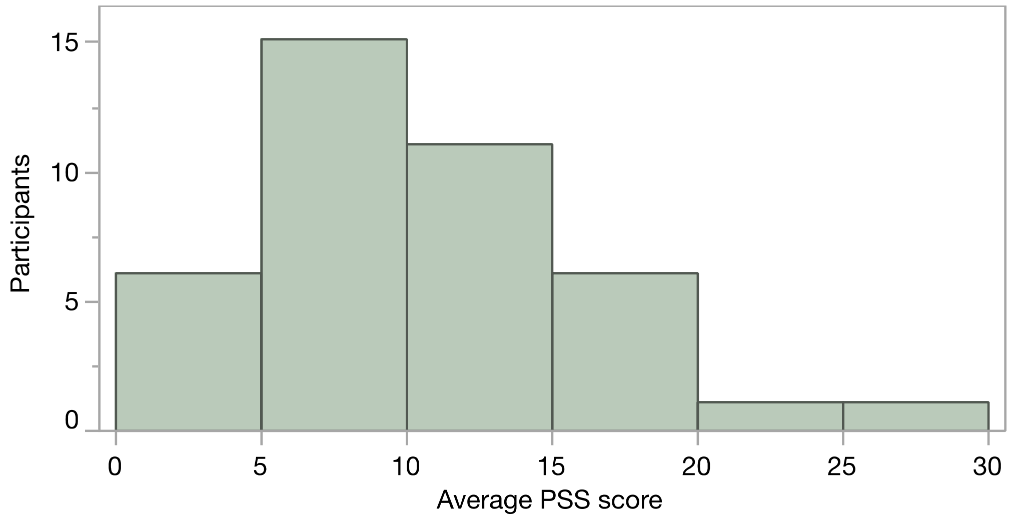


Figure 4. Distribution of Perceived Stress Scale (PSS) scores across all participants.

The following table shows the POMS scores during the classroom period.

Table 2. POMS score during the classroom period.

POMS scale	Score	Minimum score	Maximum score
Total Mood Disturbance	11.8 (28.6) [A]	-10.5	142
Tension-Anxiety	8.00 (5.50) [A]	0	31
Anger-Hostility	5.50 (3.25) [A]	0	35
Depression	3.50 (5.50) [A]	0	47
Vigor	18.3 ± 5.68 [B]	0	28
Fatigue	6.86 ± 3.60 [B]	0.5	16
Confusion-Bewilderment	5.25 (3.38) [A]	1	18

[A] Score presented as MD (IQR)

[B] Score presented as M ± SD

Next, we compared the POMS scores using the standardized adult norms. Our analysis showed that participants' mood was better than the adult population norms in terms of Depression (80.0%, exact 1-sided binomial test, $p < 0.001$) and Anger-Hostility (82.5%, exact 1-sided binomial test, $p < 0.001$). Participants' mood was equivalent to adult population norms in terms of Total Mood Disturbance ($p = 0.077$), Confusion-Bewilderment ($p = 0.077$), Tension-Anxiety ($p = 0.318$), Vigor-Activity ($p = 0.437$), and Fatigue ($p = 0.215$). These results are shown in Figure 5.

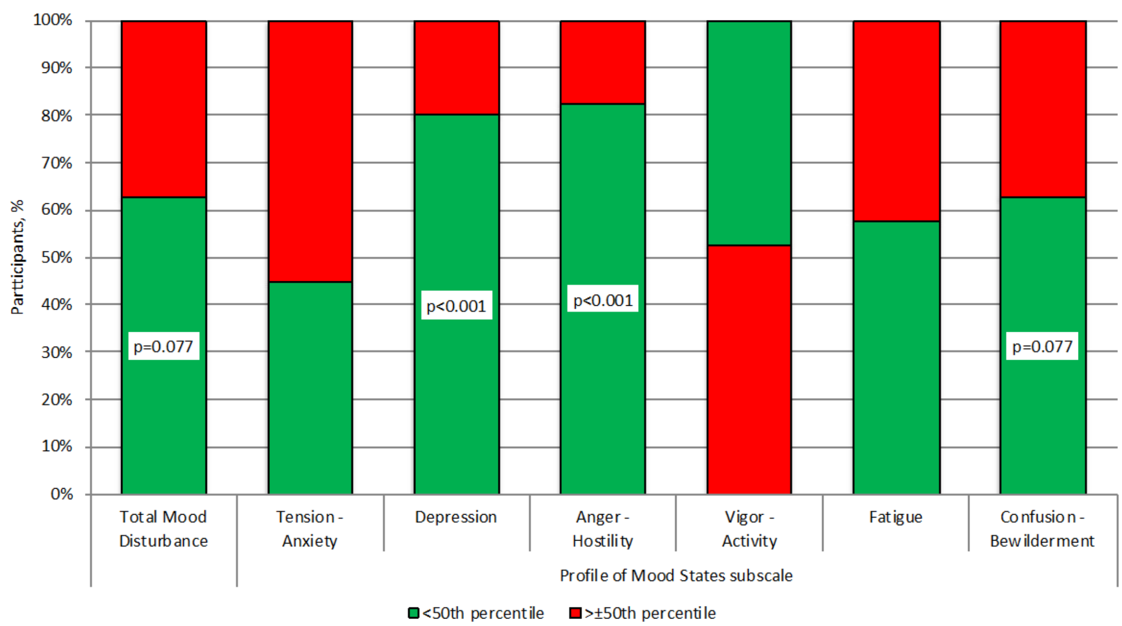


Figure 5. Percent of all participants reporting POMS scores that were better than (green) or worse than (red) the population norms.

During the classroom portion of the study, the median α-amylase activity was 143 U/mL (IQR = 94.4), the median cortisol level was 0.183 ug/dL (IQR = 0.110), and the median C-reactive protein (CRP) level was 243 pg/mL (IQR = 503). The next three diagrams show the frequency plots of the biomarkers.

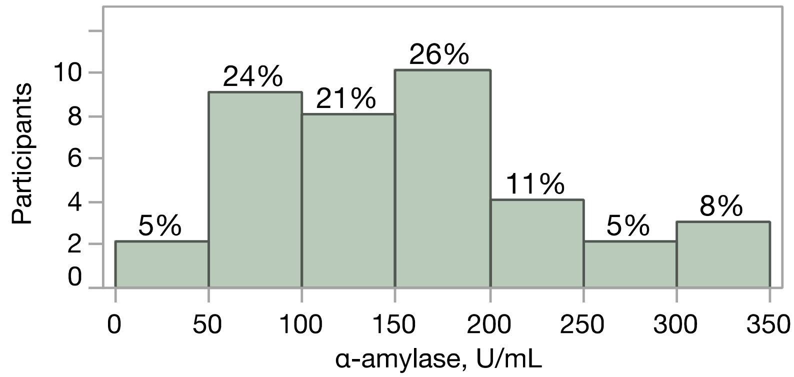


Figure 6. Frequency plot of α-amylase activity during the classroom portion of the study.

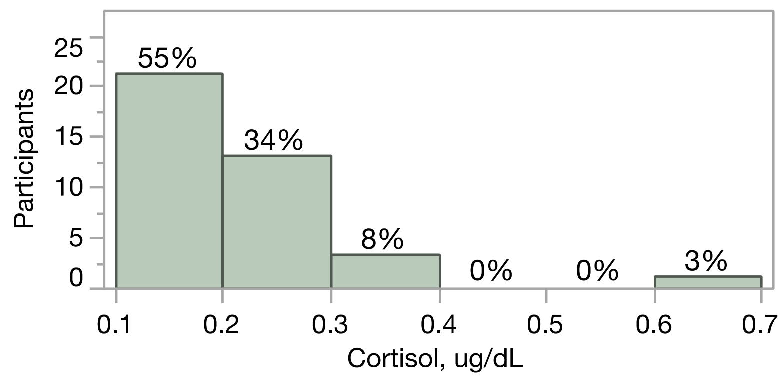


Figure 7. Frequency plot of cortisol levels during the classroom portion of the study.

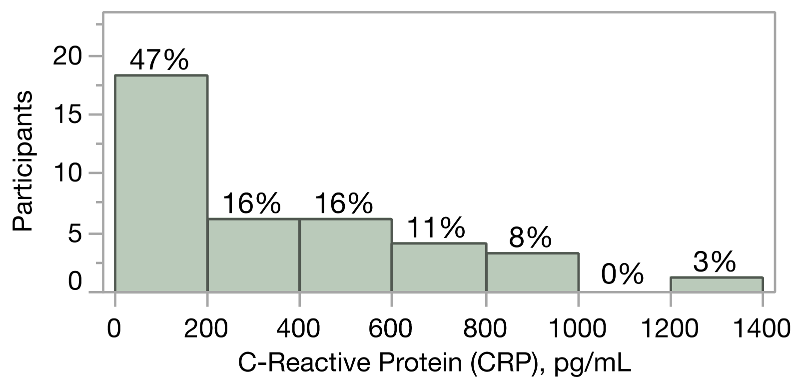


Figure 8. Frequency plot of C-reactive protein (CRP) levels during the classroom portion of the study.

During the time period preceding the week containing the training events, participants averaged 6.76 (median value with IQR = 0.77) hours of sleep per night. Also, 70% of the participants slept on average less than 7 hours per day.

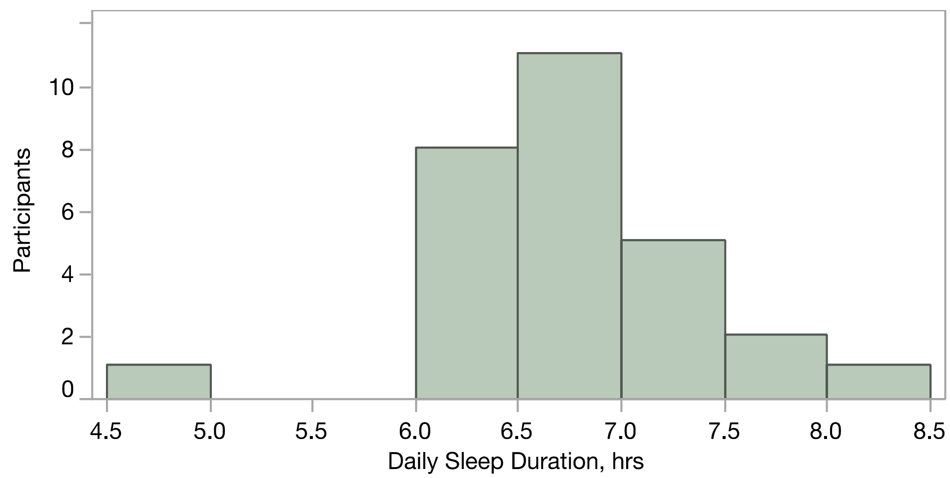


Figure 9. Daily sleep duration.

2. Associations among study variables

This section is focused on the associations among the study variables during the classroom portion of the study. Given that most variables were not normally distributed, we used the non-parametric Spearman's rho to conduct the correlation analysis. We identified two patterns of results. First, the subjective metrics were correlated with each other. Second, there was a disassociation among the objective metrics or between the subjective and the objective metrics. Results are presented in Figure 10.

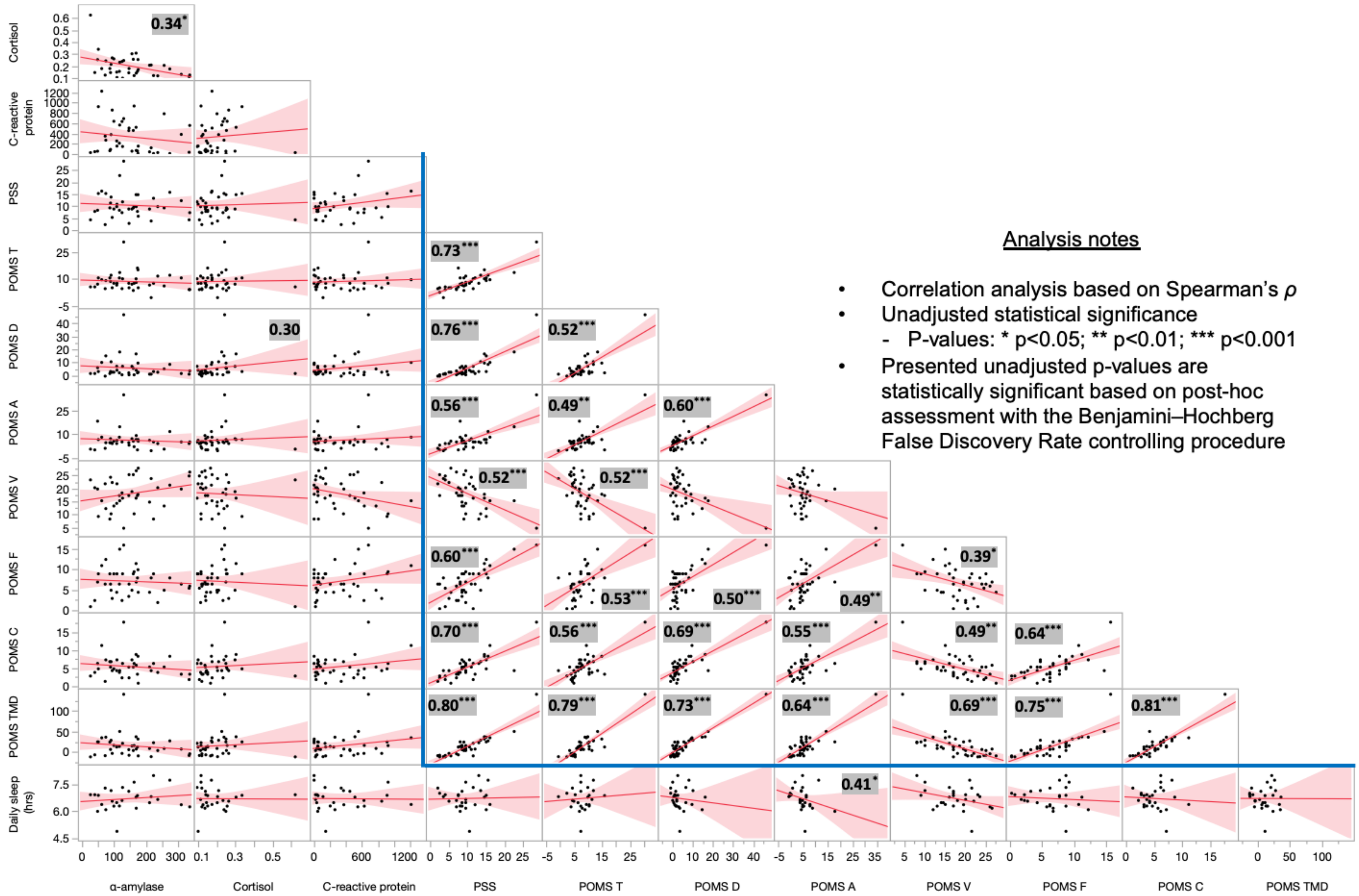


Figure 10. Correlation plots among study variables during in the classroom portion of the study.

3. Differences between visits and groups

The results we presented thus far provided an aggregated picture of the classroom portion of the study. This next section is focused on identifying differences in participant well-being between visits and between groups.

First, we assessed differences in daily sleep duration. Analysis showed that daily sleep duration did not differ between the two groups (Control: 6.96 hours/day (IQR = 0.59); SIT: 6.51 hours/day (IQR = 0.50); Wilcoxon Rank Sum test, Z = 1.80, p = 0.074).

Analysis of the rest of the variables of interest was based on multiple regression. Potential predictor factors included participant group (Control, SIT) and visit (visit 1, visit 2). Participants were nested within group. Results showed that both groups had higher Tension-Anxiety scores on visit 1 compared to visit 2. In general, however, group attributes did not differ substantively during visit 1 and visit 2 of the classroom period.

Table 3. Comparisons between participant groups and across classroom study visits.

	Model			Group	Visit
	F statistic	p-value	R^2_{adj}	p-value	p-value
PSS [A]	F(40,79) = 6.65	<0.001	0.594	0.982	0.743
Mood (POMS)					
Tension-Anxiety [A,B]	F(39,77) = 3.52	<0.001	0.561	0.894	0.038
Depression [A,B]	F(39,77) = 3.83	<0.001	0.589	0.891	0.754
Anger-Hostility [A,B]	F(39,77) = 4.90	<0.001	0.610	<0.001	0.612
Fatigue	F(40,79) = 4.23	<0.001	0.620	0.087	0.751
Vigor	F(40,79) = 6.65	<0.001	0.741	0.314	0.914
Confusion-Bewilderment [A,B]	F(39,77) = 3.88	<0.001	0.593	0.372	0.747
Total Mood Disturbance [A,B]	F(39,77) = 4.26	<0.001	0.623	0.104	0.832
Biomarkers					
α-amylase [A]	F(38,75) = 10.6	<0.001	0.830	<0.001	0.985
Cortisol [A]	F(38,75) = 1.35	0.179	0.152	-	-
C-reactive protein [A]	F(38, 75) = 4.76	<0.001	0.656	0.038	0.220

[A] Box-Cox transformation applied

[B] One outlier excluded

Also, as shown in Table 3, participant groups differed in Anger-Hostility scores, α-amylase activity, and CRP levels. Specifically, compared to the Control group, the SIT group reported worse (higher) Anger-Hostility scores, higher α-amylase activity, and lower CRP levels. Table 4 shows the biomarker levels by participant group, whereas Figure 11 shows biomarkers by site visit and participant group.

Table 4. Biomarker levels in the classroom portion of the study by participant group. Biomarker levels in MD (IQR).

	Control group	SIT group	p-value [1]
α-amylase, U/mL	132 (94.8)	168 (107)	< 0.001
Cortisol, ug/dL	0.210 (0.123)	0.175 (0.111)	NS
C-reactive protein, pg/mL	389 (579)	164 (417)	0.038

[1] Two-factor analysis of variance with results adjusted for site visit.

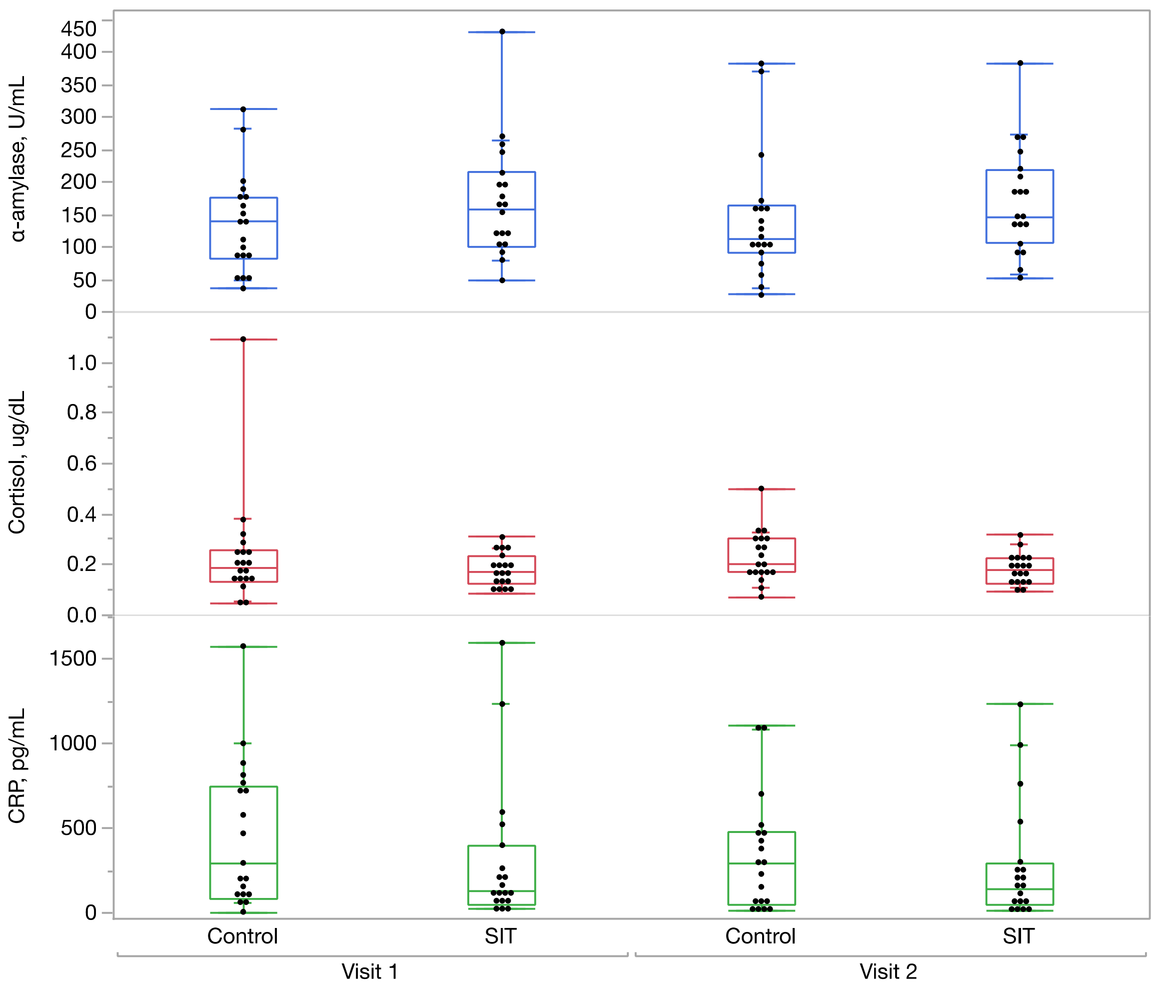


Figure 11. Biomarker levels by participant group during the classroom study visits.

C. STRESS RESPONSES IN THE FIRE TRAINER EVOLUTION

Both participant groups underwent a comparable training evolution in the Fire Trainer. In this section of the report, we assessed differences in stress responses during this evolution.

We conducted two types of comparisons. First, we compared stress variables at the beginning of the evolutions to verify equivalence between the Control and the SIT groups. On average, participant groups reported low levels of physical exertion (assessed by RPE scores) and low to moderate levels of task workload (assessed by BWS scores). Pairwise comparisons showed that reported stress levels were equivalent between groups at the beginning of the Fire Trainer evolution (Wilcoxon Rank Sum test, all $p>0.900$). In terms of the salivary biomarkers, the SIT cohort had a slightly higher α-amylase activity before the evolution (Wilcoxon Rank Sum test, $p=0.047$), but the participant groups were equivalent in cortisol ($p=0.466$) and C-reactive protein ($p=0.137$) levels.

Next, we assessed stress differences between groups at the end of the evolutions. Adjusted using the pre-evolution levels, our analysis showed that participant groups were equivalent in RPE scores, BWS scores, α-amylase, cortisol, and C-reactive protein. Detailed results are shown in Table 5.

Table 5. Stress metrics before and after the Fire Trainer evolution.

Stress Metric	Phase	Entire Study Sample MD (IQR)	Control MD (IQR)	SIT MD (IQR)	p-value
Physical exertion (RPE score)	Pre	1 (0) [C]	1 (0) [C]	1 (0)	1.0[A]
	Post	3 (1.25)	4 (2)	3 (1)	0.401[B]
Workload (BWS score)	Pre	1 (0) [C]	1 (0) [C]	1 (0)	1.0[A]
	Post	3 (1)	3 (2)	3 (1)	0.660[B]
α-amylase, U/mL	Pre	61.2 (49.6)	51.2 (39.1)	67.4 (76.3)	0.047[A]
	Post	170 (137)	165 (148)	193 (146)	0.737[B]
Cortisol, ug/dL	Pre	0.511 (0.28)	0.538 (0.45)	0.459 (0.29)	0.466[A]
	Post	0.153 (0.07)	0.160 (0.10)	0.143 (0.05)	0.604[B]
C-reactive protein (CRP), pg/mL	Pre	234 (519)	370 (609)	201 (286)	0.137[A]
	Post	512 (847)	608 (894)	325 (722)	0.596[B]

[A] Wilcoxon Rank Sums test

[B] P-value of Group as potential predictor factor of an ANCOVA model with the pre-level as a covariate; Box-Cox transformation applied; pre-level square root transformed

[C] Pre-evolution Control group data are imputed

Also, participant groups were equivalent in terms of heart rate responses. Specifically, the median value of the peak rate (HR) in the Control group was 125 (28) beats per minute (BPM) and 116.5 (20.5) BPM in the SIT group (Wilcoxon Rank Sum test, p=0.150). The same pattern of results was evident in the percent of age-predicted maximal HR (Control group: 66.8% [16.0%]; SIT group: 63.7% [13.1%]; Wilcoxon Rank Sum test, p=0.247). On average, therefore, the percent of age-predicted maximal HR for both groups was within the criterion of moderate intensity, i.e., between 50% and 70% of maximal HR.

Overall, our analyses showed a consistent pattern of results. That is, participant groups were equivalent in all subjective and objective metrics of stress in the Fire Trainer evolution. Both groups experienced a moderate level of stress.

1. Pre/post differences in stress biomarkers in the Fire Trainer evolution

We also assessed differences in stress biomarkers before and after the Fire Trainer evolution. Given that participant groups were equivalent, we combined them for this analysis.

The α-amylase activity increased from 61.2 (49.6) U/mL before the evolution to 170 (147) U/mL immediately after the evolution (Wilcoxon Signed Rank test, $p<0.001$). The same pattern was evident for C-reactive protein levels which increased from 234 (519) pg/mL before the evolution to 512 (847) pg/mL immediately afterwards (Wilcoxon Signed Rank test, $p<0.001$). The abovementioned increase indicates the activation of two stress response systems, specifically the sympathetic branch of the autonomic nervous system and the inflammatory component of the immune system, during the evolution. In contrast, cortisol levels decreased during the evolution from 0.511 (0.284) U/mL before the evolution to 0.153 (0.069) ug/dL (Wilcoxon Signed Rank test, $p<0.001$).

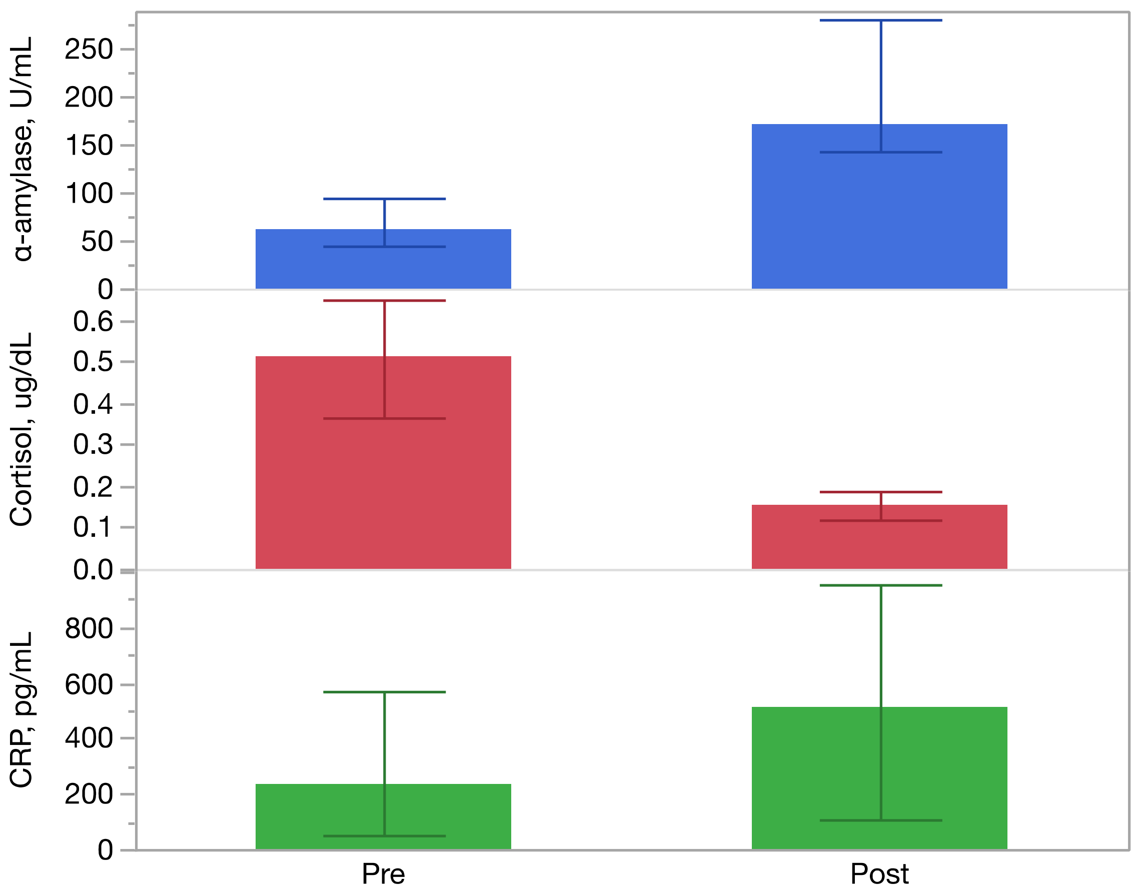


Figure 12. Changes in salivary biomarkers from pre-evolution to post-evolution in both groups undergoing the Fire Trainer.

D. STRESS LEVELS DURING THE MULTI-DAY SERIES OF TRAINING EVOLUTIONS

As noted earlier, pre- and post-measurements were collected for each of the training evolutions. The SIT group took part in a multi-day series of training evolutions, with the evolutions occurring in the following order: Fire, Buttercup, Battle, Traffic, and Extraction (detailed information in the Methods section). The same measurements were collected from the Control group in the single Fire Trainer evolution. Figure 13 shows the median values of all the subjective (BWS for cognitive workload, PRE for physical effort) and objective (α-amylase, cortisol, C-reactive protein) metrics collected pre- and post-evolution for both participant groups.

1. Patterns in pre-evolution stress levels

We conducted mixed model analysis of variance (participants were the random factor) to assess differences in the pre-evolution levels of the variables of interest (BWS, RPE, α-amylase, cortisol, C-reactive protein). Results showed that the pre-evolution values for BWS ($p<0.001$), α-amylase ($p<0.001$), and cortisol ($p<0.001$) differed over time during week 10.

Specifically, pre-evolution BWS was increased for the Traffic training evolution compared to the prior training evolutions (Tukey's HSD test, all $p<0.001$). Before the last training evolution (Extraction), however, BWS levels were equivalent to the pre-Battle Stations levels (Tukey's HSD test, all $p>0.300$).

Pre-evolution α-amylase activity was increased after the second day of week 10 compared to the first two days (Tukey's HSD test, all $p<0.002$). This incremental pattern of pre-evolution α-amylase activity, and the corresponding failure to return to baseline, suggests an accumulative effect of the training activities, and that the autonomic nervous system was remaining activated.

Also, pre-evolution levels of cortisol were lower prior to the Traffic and Extraction training evolutions compared to the preceding evolutions (Tukey's HSD test, all $p<0.001$). In contrast, RPE ($p=0.253$) and C-reactive protein ($p=0.534$) pre-evolution levels did not differ across time during week 10.

2. Patterns in post-evolution stress levels

We repeated the mixed model analysis of variance to assess differences in the post-evolution levels of the variables of interest. Results showed that the post-evolution levels of BWS ($p<0.001$), RPE ($p<0.001$), and cortisol ($p<0.001$) differed across time during week 10. Specifically, post-evolution BWS was increased after Traffic and Extraction compared to prior training evolutions (Tukey's HSD test, all $p<0.001$). Post-evolution levels of RPE decreased after Traffic and Extraction compared to earlier training evolutions (Tukey's HSD test, all $p<0.100$). Also, post-evolution levels of cortisol increased after the second day of week 10 compared to the first two days (Tukey's HSD test, all $p<0.100$). In contrast, α-amylase ($p=0.128$) and C-reactive protein ($p=0.109$) post-evolution values did not differ across time during week 10.

3. Pre/post-evolution differences in stress levels

Next, we focused on the pre/post-evolution differences in the variables of interest. BWS and RPE scores were higher post-evolution than pre-evolution for all of the training exercises, indicating that they all presented some degree of cognitive and physical demand (Wilcoxon Signed Rank test, all $p<0.002$). The α-amylase activity also tended to be higher post-evolution compared to pre-evolution, indicating activation of the autonomic nervous system (Wilcoxon Signed Rank test, all $p<0.030$). The same pattern was evident in C-reactive protein pre/post differences (Wilcoxon Signed Rank test, all $p<0.050$), but did not show any notable spikes that would point to an inflammatory response associated with injury or overload. Cortisol levels, however, showed a mixed pattern. Cortisol was lower following Fire, Buttercup, and Battle Stations compared to the pre-evolution levels.

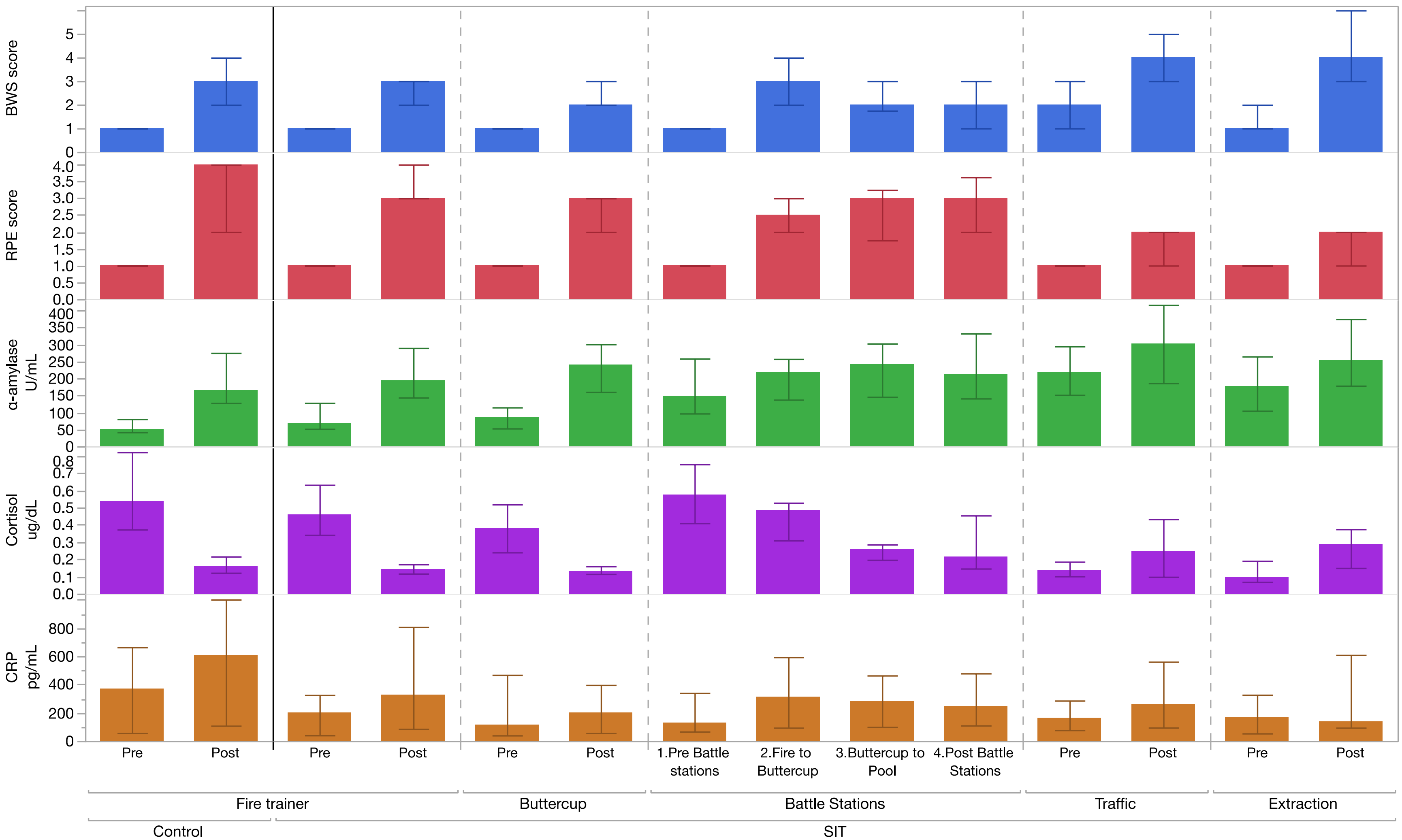


Figure 13. Stress metrics in the Fire Trainer evolution of the Control group and the multi-day training event of the SIT group. The vertical bars denote the upper and lower quartile.

4. Heart rate metrics

During the multiple training evolutions, the average peak HR for the SIT cohort was 132±19 BPM. The median peak heart rate in BPM by evolution and participant group is shown in Figure 14. Peak HR was higher during the evolutions in the Battle Stations training event.

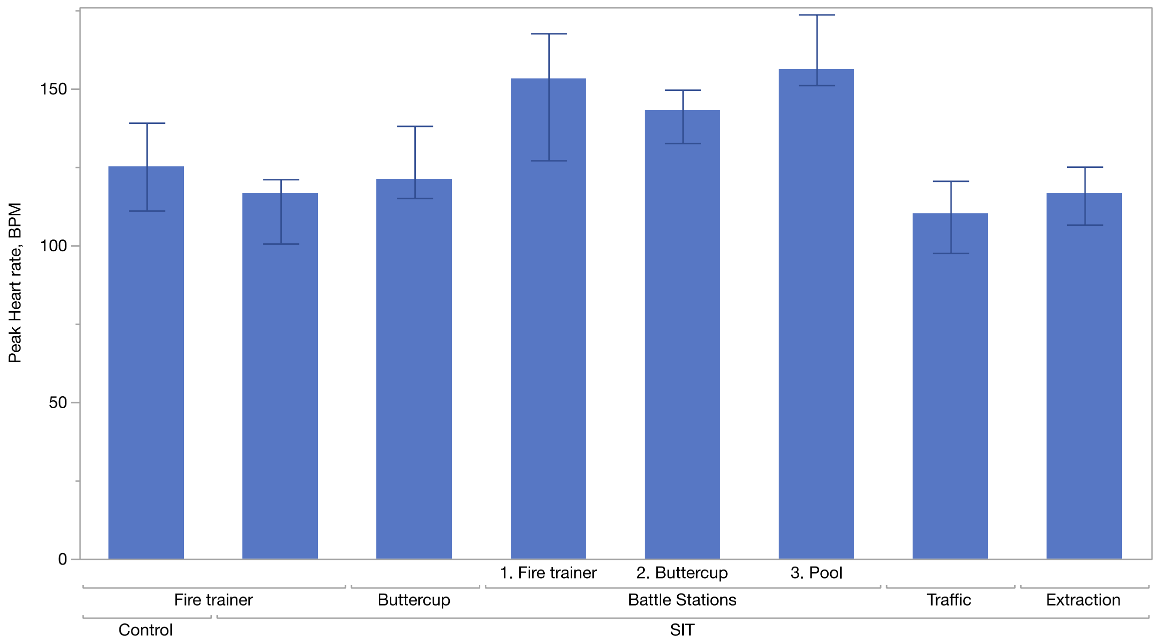


Figure 14. Median peak heart rate in BPM by evolution and participant group. The vertical bars denote the upper and lower quartile.

All SIT participants achieved a HR response of greater than 50% of their age-predicted max at some point during the training. Specifically, 44% of participants achieved an average HR response between 50% and 70% of their age-predicted max, and the other 56% of participants achieved a peak that was above 70% of their age-predicted max (the average HR per participant was calculated as the average peak HR across all evolutions). In general, more participants were in the above 70% zone during the evolutions in the Battle Stations. These results are shown in Figure 15.

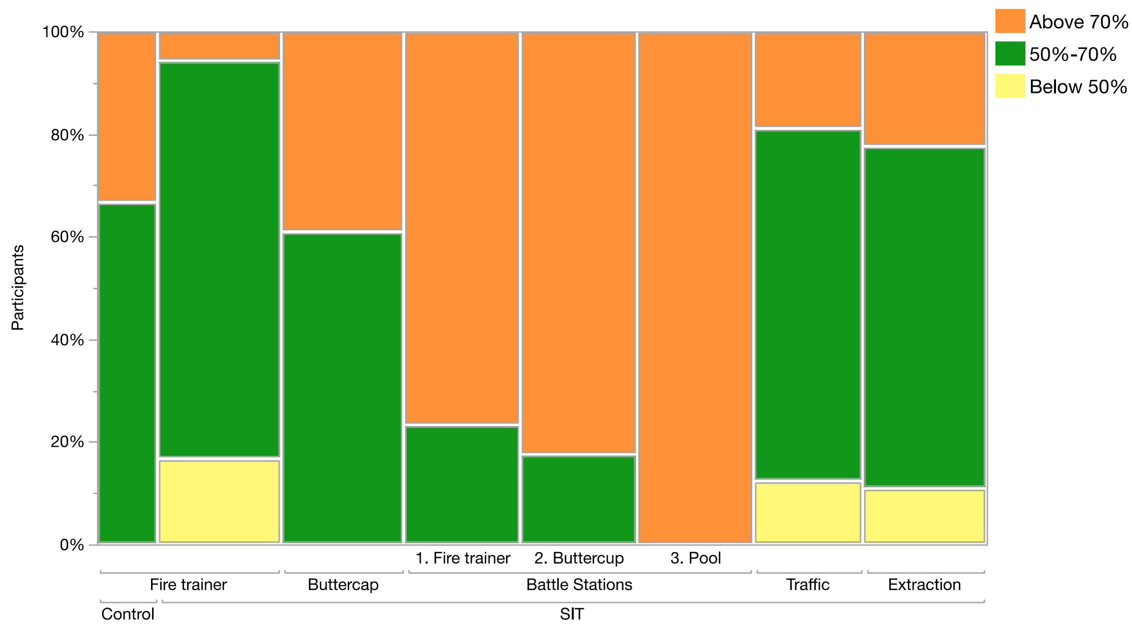


Figure 15. Percentage of participants in age-predicted max HR groups by evolution and participant group.

5. Comparison of stress levels between participant groups

Next, we compared stress metrics between participant groups. To facilitate this comparison, we aggregated stress metrics by participant. Specifically, we calculated the median of post-evolution BWS, RPE, cortisol, and C-reactive protein data during the entire week 10 for the SIT group, whereas for the Control group we used the post- Fire Trainer data. The aggregated metric of α-amylase for the SIT group was calculated as the median of all available data during week 10. Our analysis was based on general linear models in which the classroom levels of the stress metrics were used as covariates. Results showed that the SIT group had higher α-amylase activity ($p<0.001$) and reported lower perceived physical exertion (RPE scores, $p=0.013$) during week 10 compared to the Control group. These results are shown in Table 6.

Table 6. Comparison of stress metrics between SIT and Control groups.

Stress metric	Control MD (IQR)	SIT Group MD (IQR)	p-value	Effect size metric
RPE score	4 (2)	3 (1)	0.013 [A]	0.403 [C]
BWS score	3 (2)	3 (0.5)	0.325 [A]	-
α-amylase, U/mL	107 (84.2)	199 (102)	<0.001 [B]	0.30 [D]
Cortisol, ug/dL	0.160 (0.095)	0.171 (0.208)	0.426 [B]	-
C-reactive protein, pg/mL	608 (894)	241 (456)	0.285 [B]	-

[A] Wilcoxon Rank Sums test

[B] P-value of Group as potential predictor factor of a general linear model with the classroom levels as a covariate; Box-Cox transformation applied; classroom levels were square root transformed

[C] Effect size r

[D] Effect size $\eta^2{}_p$

Figure 16 shows the median levels of biomarkers in the classroom phase (visit 1 and 2) and week 10 with emphasis on the differences between participant groups. Figure 17 shows the median levels of biomarkers in the classroom phase (visit 1 and 2) and week 10 with emphasis on biomarker levels within each participant group.

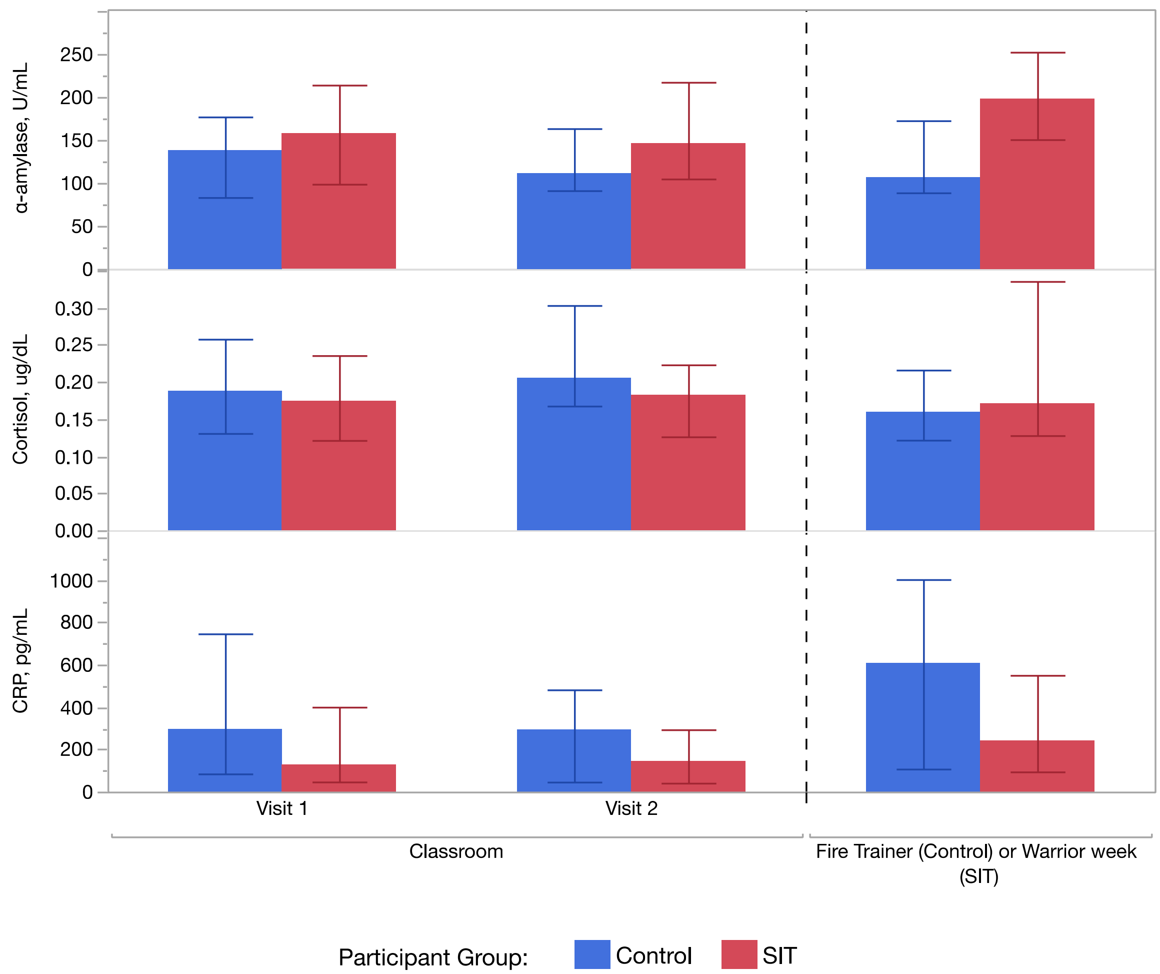


Figure 16. Median values of biomarkers in the classroom phase (visit 1 and 2) and week 10. Emphasis on the differences between participant groups. The vertical bars denote the upper and lower quartile.

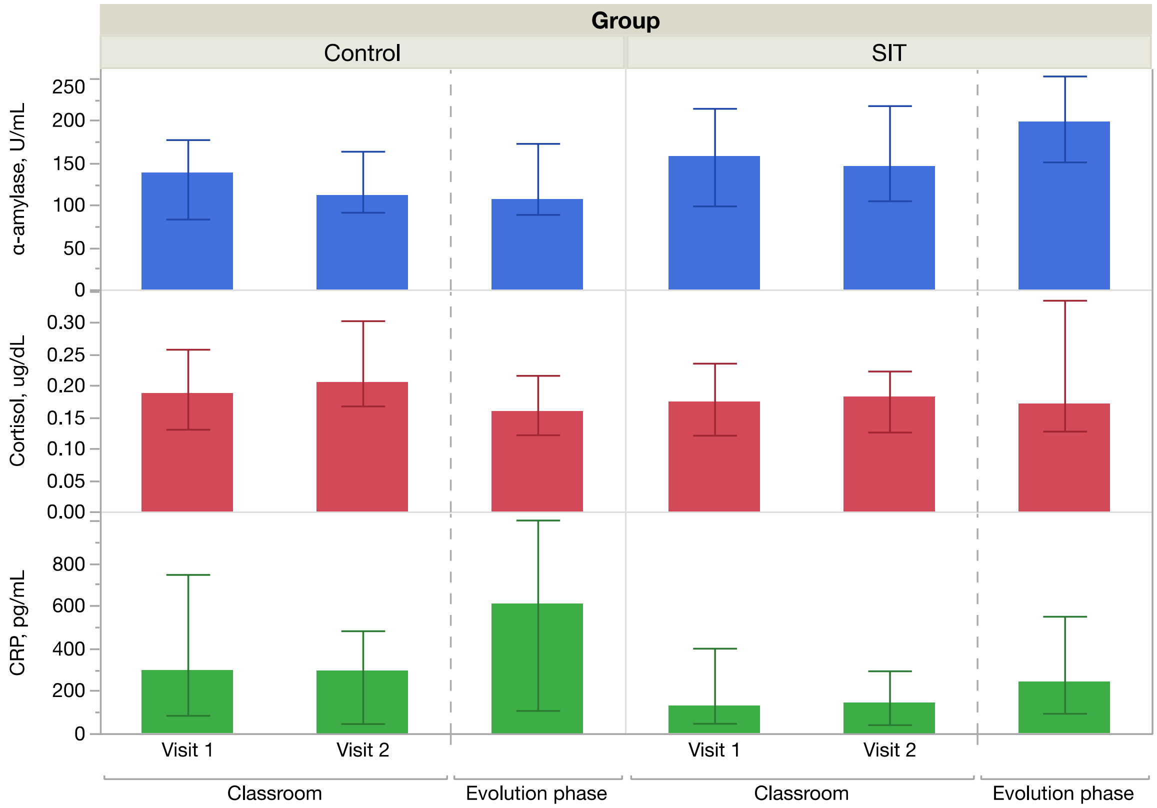


Figure 17. Median values of biomarkers in the classroom phase (Visit 1 and 2) and week 10. Emphasis on biomarker levels within each participant group. The vertical bars denote the upper and lower quartile.

Next, we focused on comparing the SIT and the Control groups in terms of the heart rate metrics of stress. Results showed that the Control and the SIT groups were equivalent in all heart rate metrics used in this study. Detailed results are shown in Table 7.

Table 7. Comparison of heart rate metrics between SIT and Control groups.

Heart rate metric	Control	SIT	p-value
Peak Heart Rate in BPM, MD (IQR)	125 (28)	132 (18.6)	0.425 [A]
% peak HR compared to age-predicted peak MD (IQR)	66.8% (16.0%)	72.3% (9.92%)	0.247 [A]
Participants with peak HR >50% age-predicted peak HR criterion, % (# participants)	100% (9)	100% (18)	>0.999 [B]
Peak HR in the 50% - 70% criterion, % (# participants)	67% (6)	44.4% (8)	0.529 [B]
Peak HR above the 70% criterion, % (# participants)	33.3% (3)	55.6% (10)	

[A] Wilcoxon Rank Sums test
[B] Fisher's Exact test

IV. DISCUSSION

Overall, our results show that stress levels during the classroom period were in general low. Even though not substantive, there were differences between groups in some of the stress-related metrics during the classroom period. We postulate that these differences may be attributed to the small number of participants in our study and emphasize the need to replicate our results in a follow-on study with a larger sample size.

In terms of the Fire Trainer evolution, the training was stressful, both in terms of the subjective assessments of stress and in terms of the psychophysiological metrics we collected. As expected, stress levels in the Fire Trainer were equivalent for the SIT and Control groups.

During week 10, pre-evolution BWS was higher for the Traffic evolution than for the other training evolutions. This training event occurred in the late afternoon on the third day, following the Battles Stations evolution in the morning and a practical exam and a "Cabin Calls" exercise in the early afternoon. Given this series of events, it is possible that the higher pre-evolution BWS score leading into the Traffic evolution is reflecting a carry-over effect.

Lastly, the inclusion of week 10 in the training regime can be considered successful from a stress perspective. Students experienced an accumulating pattern of stress during week 10. For example, the incremental pattern of pre-evolution α-amylase activity, and the corresponding failure to return to baseline, suggests an accumulative effect of the training activities, and indicates that the autonomic nervous system was remaining activated. Also, the Battle Stations event with three consecutive evolutions in the same day was stressful as evidenced by the peak heart rate metrics. Stress, however, was not extreme. Specifically, C-reactive protein did not accumulate during week 10, and the levels of the protein did not show any notable spikes that would point to an inflammatory response associated with injury or overload. Hence, the addition of these high intensity training evolutions did succeed in evoking moderate levels of stress in the SWOS students but was able to do so without causing overload or injury.

We note two interesting issues in the results from the current study. The first note refers to the use of both subjective and objective metrics to assess stress levels. Our analysis showed that the subjective metrics were correlated with each other. In contrast, there was a disassociation among the objective metrics or between the subjective and the objective metrics. These patterns of associations and disassociations emphasize the need to include both types of stress metrics in a field assessment of stress.

The second note is on the results from the salivary cortisol levels. In general, all the stress-related metrics collected in this study increased during the evolutions. Cortisol levels, however, showed a mixed pattern. We postulate that the inconsistent patterns of cortisol can be attributed to the time of day we collected the saliva samples. Specifically, for the Fire Trainer, the Wet Trainer (Buttercup), and Battle Stations, the pre-evolution samples were collected in early morning, whereas the post-evolution samples were collected shortly before noon. Therefore, any stress-evoked differences in cortisol levels may have been masked by circadian changes. Because the Traffic and Extraction events were of short duration (less than 15 minutes), cortisol levels were less likely to be impacted by circadian fluctuations in these two activities. As such, the post-evolution increase in cortisol levels after Traffic and Extraction more likely are reflective of stress effects than circadian effects.

A. LIMITATIONS

Our study has a number of limitations. First, participants were recruited from only two cohorts of students at SWOS. Therefore, the study sample was small, and week 10 was observed only once. Second, due to the schedule of the events at SWOS and the time of day that each evolution was conducted, pre- and post-evolution biomarkers were not measured at the same time of day for all training evolutions. Also, food and caffeinated beverage intake was not assessed or controlled during the study.

The last, but important, limitation of our study is the failure to record individual performance metrics. While the study was focused on stress levels, it would have been beneficial to collect objective measures of performance for the individual participants so that we could assess whether the addition of week 10 in the training regime improved student performance in the evolutions.

V. RECOMMENDATIONS

Based on the findings of this study, we recommend the following:

- Repeat the study with another SCC class to assess whether the current findings are consistent.
- Refine study design so that it is more streamlined and less intrusive.
- Provide the SIT Training lecture closer to week 10 – or provide a second SIT refresher before week 10.
- SWOS should consider assessing student performance in the training evolutions. Analysis of performance metrics will further assess the utility of the augmented training regime.

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APPENDIX A: ENROLLMENT QUESTIONNAIRE

Naval Postgraduate School

Date:_____________ Participant ID: _____________

Enrollment Questionnaire

Instructions: *Please answer ALL questions as accurately as possible. ALL information is confidential and will be used only for research purposes.*

1. What is your age: ______________years

2. Gender (Check one ☑) ☐ Male ☐ Female

3. What is your current rate: (for example, FC, HT, OS, IT, GSE) ____________________________________

4. What is your current rank: (for example, E4, O2) ____________________________________

5. Years on active duty: ____________________________________

6. How many times have you been deployed: ____________________________________

7. Total number of months deployed: ____________________________________

8. How many of the following caffeinated beverages do you drink <u>on average</u> each day?
(Check ALL that apply ☑) and indicate daily amount)

☐ Tea Servings/Cups per day:_______

☐ Coffee Servings/Cups per day:_______

☐ Soda/pop/soft drinks Servings/Cans per day:_______

☐ Energy drinks Servings/Cans per day:_______

☐ Other (specify):_________________ How often:_______ (Example: 4 times per day)

9. Do you use nicotine or tobacco products? (Check one ☑) ☐ Yes ☐ No

If yes, which of the following nicotine or tobacco products do you use?
(Check ALL that apply ☑) and indicate how often)

☐ Cigarettes (If YES, how often?______________)

☐ Chewing tobacco/snuff (If YES, how often? ______________)

☐ Nicorette gum or patches (If YES, how often?______________)

☐ Electronic smoke (If YES, how often?______________)

☐ Other (specify):________________(How often? ______________)

10. Do you take any prescribed or over-the-counter medications? (Check one ☑) ☐ Yes ☐ No

If YES, please list all medications you take ____

____

11. Do you have an exercise routine? (Check one ☑) ☐ Yes ☐ No

If YES, frequency: ____Times per week (for example, 3 times per week)
What kind of exercise routine do you do? (for example, cardio, weightlifting)

____

How long does this routine take? (for example, 45 minutes) ______________________________

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APPENDIX B: COHEN PERCEIVED STRESS SCALE

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2. In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3. In the last month, how often have you felt nervous and “stressed”?	0	1	2	3	4
4. In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
5. In the last month, how often have you felt that things were going your way?	0	1	2	3	4
6. In the last month, how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
7. In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
8. In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
9. In the last month, how often have you been angered because of things that were outside of your control?	0	1	2	3	4
10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

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APPENDIX C: PROFILE OF MOOD STATES

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

Client ID: ______________ **Age:** ______ **Gender:** Male Female (Circle one)

Birth Date: ___/___/___ (Month Day Year) **Today's Date:** ___/___/___ (Month Day Year)

To the Administrator:

Place a checkmark ✔ in one box to specify the time period of interest.

To the Respondent:

Below is a list of words that describe feelings that people have. Please read each word carefully. Then circle the number that best describes

- ☐ how you have been feeling during the PAST WEEK, INCLUDING TODAY.
- ☐ how you feel RIGHT NOW.
- ☐ other: ______________

If no box is marked, please follow the instructions for the first box.

		Not at all	A little	Moderately	Quite a bit	Extremely
1.	Friendly	0	1	2	3	4
2.	Tense	0	1	2	3	4
3.	Angry	0	1	2	3	4
4.	Worn out	0	1	2	3	4
5.	Unhappy	0	1	2	3	4
6.	Clear-headed	0	1	2	3	4
7.	Lively	0	1	2	3	4
8.	Confused	0	1	2	3	4
9.	Sorry for things done	0	1	2	3	4
10.	Shaky	0	1	2	3	4
11.	Listless	0	1	2	3	4
12.	Peeved	0	1	2	3	4
13.	Considerate	0	1	2	3	4
14.	Sad	0	1	2	3	4
15.	Active	0	1	2	3	4
16.	On edge	0	1	2	3	4
17.	Grouchy	0	1	2	3	4
18.	Blue	0	1	2	3	4
19.	Energetic	0	1	2	3	4
20.	Panicky	0	1	2	3	4
21.	Hopeless	0	1	2	3	4
22.	Relaxed	0	1	2	3	4
23.	Unworthy	0	1	2	3	4
24.	Spiteful	0	1	2	3	4
25.	Sympathetic	0	1	2	3	4
26.	Uneasy	0	1	2	3	4
27.	Restless	0	1	2	3	4
28.	Unable to concentrate	0	1	2	3	4
29.	Fatigued	0	1	2	3	4
30.	Helpful	0	1	2	3	4

POMS™

Please flip over.
Items continue on the back page...

POMS™ Standard Form

BY DOUGLAS M. McNAIR, Ph.D., MAURICE LORR, Ph.D., JW P. HEUCHERT, Ph.D., & LEO F. DROPPLEMAN, Ph.D.

POMS™

		Not at all	A little	Moderately	Quite a bit	Extremely
31.	Annoyed	0	1	2	3	4
32.	Discouraged	0	1	2	3	4
33.	Resentful	0	1	2	3	4
34.	Nervous	0	1	2	3	4
35.	Lonely	0	1	2	3	4
36.	Miserable	0	1	2	3	4
37.	Muddled	0	1	2	3	4
38.	Cheerful	0	1	2	3	4
39.	Bitter	0	1	2	3	4
40.	Exhausted	0	1	2	3	4
41.	Anxious	0	1	2	3	4
42.	Ready to fight	0	1	2	3	4
43.	Good natured	0	1	2	3	4
44.	Gloomy	0	1	2	3	4
45.	Desperate	0	1	2	3	4
46.	Sluggish	0	1	2	3	4
47.	Rebellious	0	1	2	3	4
48.	Helpless	0	1	2	3	4
49.	Weary	0	1	2	3	4
50.	Bewildered	0	1	2	3	4
51.	Alert	0	1	2	3	4
52.	Deceived	0	1	2	3	4
53.	Furious	0	1	2	3	4
54.	Efficient	0	1	2	3	4
55.	Trusting	0	1	2	3	4
56.	Full of pep	0	1	2	3	4
57.	Bad-tempered	0	1	2	3	4
58.	Worthless	0	1	2	3	4
59.	Forgetful	0	1	2	3	4
60.	Carefree	0	1	2	3	4
61.	Terrified	0	1	2	3	4
62.	Guilty	0	1	2	3	4
63.	Vigorous	0	1	2	3	4
64.	Uncertain about things	0	1	2	3	4
65.	Bushed	0	1	2	3	4

Please ensure you have answered every item.
Thank you for completing this questionnaire.

APPENDIX D: BORG RATING OF PERCEIVED EXERTION

Please rate you level of physical exertion during the previous activity.

1	Very Easy
2	Easy
3	
4	Moderate
5	
6	Hard
7	
8	Very Hard
9	Extremely Hard
10	Maximal

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APPENDIX E: BEDFORD WORKLOAD SCALE

Please rate the workload you experienced during the previous activity.

1	Workload insignificant
2	Workload low
3	Enough spare capacity for all desirable additional tasks
4	Insufficient spare capacity for easy attention to additional tasks
5	Reduced spare capacity: additional tasks cannot be given the desired amount of attention
6	Little spare capacity: level of effort allows little attention to additional tasks
7	Very little spare capacity, but maintenance of effort in the primary task not in question
8	Very high workload with almost no spare capacity. Difficulty in maintaining level of effort
9	Extremely high workload. No spare capacity. Serious doubts as to ability to maintain level of effort
10	Task abandoned. Unable to apply sufficient effort

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