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U.S. Air Force Special Operations Command Remotely Piloted Aircraft Operator Fatigue Levels and Compensatory Strategies

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for October 2016 to November 2017

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14. ABSTRACT
U.S. Air Force Special Operations Command (AFSOC) MQ-9 Reaper remotely piloted aircraft have emerged as critical assets in intelligence, surveillance, reconnaissance, and close air support operations. The increased requirement for their engagement in combat missions has created the constant expanding need for MQ-9 Reaper operators to keep pace with surges in operations. Continual expansion and surges often result in crewmembers within AFSOC carrying a workload that exceeds available manpower. Line leadership must put crew rest waivers in place to support extended 24/7 shifts to accomplish assigned missions. At the request of AFSOC line and medical leadership, the U.S. Air Force School of Aerospace Medicine conducted psychological assessments of remotely piloted aircraft operators at their operational units to assess the implications of working around-the-clock and to gain a better understanding of the prevalence of fatigue among this unique group of modern warfighters. A total of 72 MQ-9 Reaper crewmembers (pilots and sensor operators) from an AFSOC unit stationed within the continental United States participated in a series of pre-, during, and post-mission fatigue assessments. Results led to the development of recommendations for line and medical leadership to help optimize health and mitigate fatigue.

15. SUBJECT TERMS
Remotely piloted aircraft, RPA operators, health-related behaviors, occupational health, stress, healthcare utilization

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1.0 EXECUTIVE SUMMARY

U.S. Air Force MQ-9 Reaper remotely piloted aircraft (RPA) remain critical assets in intelligence, surveillance, reconnaissance, strike missions, and close air support operations. Although advancements in aviation, satellite, and computer-based technology have contributed greatly to RPA platforms and systems, maintaining the health and wellness of airmen operating such aircraft is critical to sustaining operational performance and readiness. As a result, medical and line leadership of MQ-9 Reaper units are vigilant to operational issues that may affect the well-being of operators and seek recommendations for correcting and mitigating problems. An area of concern, especially among operational units, is the prevalence of fatigue. In particular, the surge in the number of MQ-9 missions has placed some operators in the Air Force Special Operations Command (AFSOC) in a position of having to continuously sustain a workload that exceeds available manpower. To enable mission accomplishment when mission requirements exceed qualified personnel available, AFSOC line and medical leadership often overrule recommendations with regard to restrictions on the number of consecutive flying hours worked within a specific period (i.e., “crew rest”) to sustain around-the-clock operations and meet commander requests for MQ-9 Reaper missions.

The U.S. Air Force School of Aerospace Medicine conducted comprehensive psychological assessments to evaluate the physical and psychological implications of working around-the-clock warfighter roles within an active duty AFSOC MQ-9 Reaper squadron. The AFSOC unit that was targeted reported lacking the necessary number of personnel to carry out mission requirements. The purpose of this mixed-method study was to gain a better understanding of the prevalence and impact of fatigue on the warfighter as well as identify common compensatory strategies utilized by AFSOC personnel experiencing fatigue. The study utilized standardized assessment forms completed by the individual warfighter and semi-structured interviews conducted at the operational unit in-person by U.S. Air Force School of Aerospace Medicine researchers. A total of 72 MQ-9 Reaper crewmembers (pilots and sensor operators) from an AFSOC MQ-9 squadron located within the continental United States participated in this voluntary and anonymous study.

Pre- and post-mission outcomes were obtained via standardized and non-standardized fatigue survey items, as well as responses to mid-mission interview questions. In some instances, quantitative analyses (i.e., descriptive statistics) utilized overall data rather than group-specific (i.e., pilot vs. sensor operator) breakdowns due to small sample size. Fatigue topics evaluated included (a) pre-mission attention control levels; (b) self-reported levels of alertness, stress, and anxiety; (c) self-reported levels of fatigue; (d) physical, cognitive, and emotional-behavioral manifestations of fatigue; and (e) fatigue mitigation strategies (e.g., quantity and quality of sleep; frequency of exercise obtained before work; alcohol, caffeine, and nicotine use; and use of blue lighting within the ground control stations during missions).

Results led to recommendations for line and medical leadership for mitigating fatigue and improving lifestyle sustainment as well as work performance. Primary recommendations included, but were not limited to, moving from 12-hour to 8-hour shifts, reducing number of hours worked per week to minimize requirements for crew rest waivers, increasing available manpower to more evenly distribute workload, as well as improving behavioral health habits and workspace ergonomics.

2.0 INTRODUCTION

Advances in aerial, satellite, and computer-based technology have thrust remotely piloted aircraft (RPA) such as the MQ-9 Reaper into the center of U.S. military operations on the battlefield. These aircraft perform a variety of combat-related functions, ranging from intelligence, surveillance, and reconnaissance (ISR) missions to delivering weapons on targets for close air support (CAS) precision strike operations [1]. MQ-9 Reaper missions provide real-time information to commanders critical for battlefield operational and tactical decision making. This includes, but is not limited to, identification of fixed and moving targets, tracking enemy movements and assets, catching insurgents planting roadside bombs, locating and destroying weapons caches, safeguarding convoys, identifying and/or eliminating enemy combatants, augmenting manned strike missions, and surveying post-strike battle damage. These are just a few examples of their battlefield-essential capabilities. A growing appreciation for the strategic and tactical advantages such aircraft afford has led to a rapidly increasing demand for their use in regions of conflict across the globe [2,3].

Although MQ-9 Reaper operators engage the battlefield remotely (i.e., from the relative safety of the continental United States), their high operations tempo and "around-the-clock" operational environment represent unique threats to operators' health and well-being. Long work hours, rotating shift work schedules, ergonomically taxing workstations, geographically remote assignment locations, and exposure to real-time, graphic images of destruction and death characterize the MQ-9 Reaper work environment. Researchers have recently begun to investigate and elucidate the impact these factors have on MQ-9 Reaper operators. Studies have revealed high levels of self-reported symptoms of emotional exhaustion (26% among active duty personnel and 14% among those in the Air National Guard (ANG)/Reserves [4]), cynicism (17% among active duty personnel and 7% among those in the ANG/Reserves [4]), and psychological distress (20% of RPA operators [5]) among U.S. Air Force (USAF) RPA military personnel stemming from occupational stressors [4]. Long work hours, rotating shift work, and insufficient numbers of available, qualified crewmembers to carry out assigned missions stood out as primary contributing factors [4,5]. When compared to the psychological (i.e., affective) states of personnel in other major commands (MAJCOMs), Air Force Special Operations Command (AFSOC) operators' self-reported levels of exhaustion and cynicism are significantly higher, with shift work, duty position, and amount of time in current duty position all serving as predictors of exhaustion [6]. Comparisons of results from an occupational health study of RPA operators with a subsequent reassessment of the same community provide further evidence of the occupational stressors to which these individuals are exposed [7,8]. Outcomes once again identified that a high workload coupled with long shifts and irregular hours led to increased reports of stress and physical exhaustion among AFSOC RPA operators [7,8].

The impact of high workload combined with sustaining around-the-clock combat operations is clearly associated with elevated rates of exhaustion. Further, chronic exhaustion and cynicism appear to lead to elevated rates of psychological distress. This particular state of distress is characterized by a cluster of emotional (e.g., irritability, sadness, frustration), physical (e.g., difficulty sleeping, headache, elevated heart rate, diffuse muscle tension), cognitive (e.g., difficulty concentrating and sustaining attention), and social (e.g., difficulty interacting with others, increased relational conflict) symptoms that negatively affect daily functioning. Although prior research has begun to reveal elevated stress levels among MQ-9 Reaper operators and operational sources for their stress, less is known about how this occupational environment might affect their health habits. Evidence from both military and civilian populations shows that some of the unique factors that characterize the RPA work environment can detrimentally affect workers' health and health behaviors. For example, chronic job stress correlates strongly with high-risk health behaviors (e.g., increased alcohol and drug use [9,10]) and illness (e.g., back pain, eye strain, gastrointestinal problems, and headaches [11]). In addition, high demand work schedules that disrupt sleep patterns (e.g., frequently rotating shift work) can put workers at risk for poor health outcomes such as increased incidents of coronary artery disease [12]. Psychological assessments of USAF RPA operators across all MAJCOMs show emergent patterns regarding the impact of occupational stressors on the behaviors and health of this population, with AFSOC RPA operators showing a tendency to engage in potentially harmful compensatory strategies [7,8]. Initial and follow-up studies of RPA operators reveal 61.97% of AFSOC personnel reported sleeping 6 hours or less per night [7], with sleep disruptions leading some to use prescription medication [8]. Above normal alcohol consumption was also noted in these studies. In the initial assessment, 21.13% of AFSOC operators reported increases in alcohol use since assuming their RPA operator duty position [7]. In the follow-up study, among those 26 years or older, 13.25% shared the tendency to binge drink at least once a month [8], citing occupational and personal stress and shift work as contributors to this behavior. Results of both studies also showed increased somatic indicators of stress and fatigue resulting from their occupational duties, such as headache, eye strain, and musculoskeletal pain (e.g., neck, back, and joint pain) [7,8].

Operational leadership and flight medicine physicians are aware that operational sources of stress (e.g., shift work, high workload, long shifts, etc.) are nearly universal across all USAF MQ-9 Reaper platforms. However, an accurate understanding of all of the stresses and strains inherent to the duties of MQ-9 Reaper operations also requires consideration of the unique cultural contexts in which they occur. RPA operations are spread across three separate USAF MAJCOMs (i.e., Air Combat Command (ACC), AFSOC, and ANG), and each of these communities has distinct cultural, geographical, and organizational factors (e.g., mission personnel allocations and mission assignment durations) that directly shape the work environment. Previous studies comparing USAF ACC and ANG RPA operators have found differences in levels of exhaustion and cynicism [5]. These affective distinctions between operators in these different MAJCOMS suggest that, when investigating the work environment, it is important to consider not just the demands inherent in their specific RPA platform but also the broader context (i.e., MAJCOM) in which these operations are being conducted.

Taken together, the discoveries reported above regarding high levels of occupational stress and the prevalence of problematic behavioral health habits (i.e., inadequate sleep and exercise, elevated alcohol and caffeine use, etc.) suggest that line and medical leadership should monitor the health and well-being of this unique group of warfighters to better ensure both their personal health and mission readiness. Medical and line leadership of MQ-9 Reaper units should remain vigilant to operational issues that affect the well-being of operators and seek recommendations for correcting and mitigating these problem areas.

An area of specific concern, especially among operational units, is the prevalence of fatigue. The continuously increasing demand for MQ-9 Reaper ISR, precision strike, and CAS missions across a range of global Department of Defense operations has resulted in critical shortages in the number of available, qualified RPA aircrew. In particular, an operational surge for AFSOC crewmembers in a particular unit has resulted in such individuals facing chronically high workloads. Problems that result from overtaxing available human resources are particularly evident among units that sustain an "around-the-clock" operational tempo that exceeds the available number of qualified operators.

In November 2016, the USAF School of Aerospace Medicine was contacted by AFSOC line leadership to conduct a fatigue study of crewmembers within one of AFSOC's MQ-9 Reaper units. The targeted unit includes personnel who were considered to be at risk due to chronically high operational tempo and associated stressors. Line and medical leadership concerns initially stemmed from the requirement of increasing daily shift work from 8 hours to 12 hours. Additionally, crews were required to work 5 consecutive 12-hour days with only 2 days off (5-on-2-off), with rapid switches between shifts, amounting to working 60 or more hours a week to meet mission requirements. This high-tempo schedule raised concerns with regard to self-report levels of fatigue and related issues (i.e., anxiety, stress, and attention and concentration deficiencies). Additional concerns surrounded operator compensatory strategies employed both during and following shifts (e.g., sleep, exercise, alcohol, and caffeine use). Beyond these concerns, this study also looked at the utilization of blue lighting in the work area for mitigating fatigue during missions. Information emerging from these data includes:

- Amount of sleep and sleep quality of RPA crewmembers
- Contributors to mission fatigue
- Physical, cognitive, and behavioral manifestations of fatigue
- Performance implications of fatigue
- Compensatory strategies for managing fatigue, including utilization of blue light

Investigating and exploring the reported levels of fatigue and its impact on the lives of the members of this unique population will provide USAF line and medical leadership with an additional source of information and situational awareness. It will enable leadership to have a better understanding of the health-related consequences associated with sustaining around-the-clock MQ-9 Reaper operations with "less than adequate" manning. This information will aid in the development of strategies for optimizing health and performance as well as assist in the creation of policies that will maximize the capabilities of RPA operators across and within USAF MAJCOMs.

3.0 METHODS

3.1 Participants

In total, 72 RPA operators (pilots and sensor operators [SOs]) participated in the study from a large AFSOC squadron located in the continental United States, representing 49.66% of total operators on station at that unit (total unit aircrew = 145). Individuals were working 12-hour shifts in an active operational environment.

3.2 Measures

3.2.1 Pre- and Post-Mission Written Surveys. Data were collected using pre- and post-mission assessments coupled with a semi-structured one-on-one mid-mission interview. The standardized Attention/Mental Control [13] and State Anxiety [14] assessment measures, as well as a customized survey designed to capture self-report levels of alertness, stress, and fatigue, and behavioral health habits (e.g., sleep and exercise habits, caffeine and nicotine use), were administered pre-mission. The post-mission data collection consisted of re-administration of only the standardized State Anxiety assessment [14] and a customized assessment capturing (1) blue light usage during the mission, (2) post-mission alertness, stress, and fatigue, and (3) behavioral health habits for mitigating fatigue during the mission, such as caffeine and nicotine use.

3.2.2 Mid-Mission Interviews. Researchers conducted semi-structured one-on-one interviews with participants during scheduled mid-mission breaks. The intent of the interviews was to elicit self-disclosure of opinions and concerns about operational shifts and their impacts while each crewmember was experiencing operational stress. Semi-structured interviews were conducted in a conversational fashion that allowed the crewmember to respond to specific, open-ended questions (e.g., usage of blue lights and other compensatory strategies for managing fatigue) and supported going "off script" so participants could share additional information if they chose to do so. To further support discussion, there was no time limit on how long participants could spend sharing their perspective. Researchers hoped that the provision of a one-on-one setting would encourage genuine self-disclosure in a community where there may be strong cultural stigmas and concerns for negative career implications regarding mental health or other problems.

3.3 Procedure

Over 3 consecutive days, AFSOC RPA operators were solicited for participation in the study during their pre-mission brief. At that time, the on-site embedded operational psychologist (assigned to provide integrated operational mental healthcare to RPA operators) gave details of the intent and purpose of the study. RPA operators were informed that unit leadership was interested in assessing fatigue levels and related issues (i.e., symptoms of fatigue, compensatory strategies for managing fatigue) resulting from the requirement of moving from 8-hour to 12-hour shifts to accommodate and sustain increases in workload. During this introduction, RPA operators were provided with a consent document and given time to ask questions. The consent document also provided contact information for those who had questions. Operators were instructed that participation was voluntary and anonymous. To support anonymity and preserve confidentiality, all participants were provided a randomly assigned research identification number through a card attached to each assessment packet. They were asked to retain the card and use the associated research identification number throughout their participation in the study. Line leadership advocated participation during pre-mission briefs by also offering a description of the research and utilization of results to gain a better understanding of fatigue and related issues that could potentially affect readiness and performance. Those crewmembers who signed the document after being fully informed on their rights, possible study outcomes, and anonymity protections were at that point considered to have provided their informed consent and proceeded with participation. It is unknown how many operators declined participation after being briefed and reading the consent document. The study design and methodology were reviewed and approved by the Air Force Research Laboratory Institutional Review Board and assigned protocol number FWR20140085N.

To minimize intrusion/interference on operations, pre-mission surveys were completed during mission in-briefs. Mid-mission fatigue interviews were conducted at a point in the mission that was of greatest convenience to operators. Researchers were continuously available throughout both shifts to maximize participation.

On their first day of participation, individuals completed the demographics questionnaire, as well as pre- and post-mission fatigue surveys. On subsequent days, participants completed all surveys with the exception of the one-time demographic questionnaire. Typical completion time for pre- and post-mission surveys was 10-20 minutes. Researchers conducted mid-mission interviews throughout each 12-hour shift at the convenience of the participants, with no time limit on participation.

3.4 Data Analysis

3.4.1 Quantitative Analyses. To assess elements such as anxiety, stress, and fatigue, the percentage of participants who fell within a given numerical range was calculated by position (i.e., RPA pilot and SO) as well as pre- and post-mission comparisons of results. Group frequencies and proportions were calculated for items assessing the following:

1. Demographics (e.g., gender, age range, marital status, and children/dependents at home)
2. Occupational variables (e.g., rank range, time on station)
3. Health behaviors (e.g., average number of hours of sleep before work and average amount of time engaged in moderate physical exercise between shifts)
4. Health habits for managing stress (e.g., caffeine and tobacco use)

3.4.2 Qualitative Analyses. A team of behavioral science researchers performed qualitative analyses on textual responses to the open-ended, write-in responses to items on the pre- and post-mission surveys, as well as verbal responses to the mid-mission interview questions. The researcher coded information into a list of categories. Categories for fatigue included *Physical Symptoms, Cognitive Symptoms,* and *Mixed Emotional/Behavioral Symptoms*. For example, symptoms such as *headaches, eye strain,* and *changes in appetite* were grouped together in the category *Physical Symptoms* of fatigue. Similar qualitative analyses were performed for each item where respondents provided expanded commentary. The frequency of coded responses for each semantic category was computed and the most frequently endorsed responses were reported.

4.0 RESULTS

4.1 Demographics

In total, there were 72 AFSOC RPA Reaper respondents. The majority of participants were males (94.44%), with almost equal numbers of RPA pilots (47.22%) and SOs (52.78%). Table 1 provides details of study population demographics.

Table 1. Participant Demographics

Demographic	n	%
Number of Participants	72	
Position		
RPA Pilots	34	47.22
SOs	38	52.78
Gender		
Male	68	94.44
Female	4	5.56
Age Range (yr)		
18-25	36	50.00
26-35	32	44.44
36+	4	5.56
Rank		
Officer (pilots)	34	47.22
O1-O2	24	33.33
O3	10	13.89
Enlisted (SOs)	38	52.78
E3-E5	33	45.83
E6-E7	5	6.94
Time in Service (yr)		
1-5	47	65.28
6-10	14	19.44
11-15	7	9.72
16-20	4	5.56
Time on Station (yr)		
0-1	37	51.39
2-3	25	37.72
4-5	10	13.89
Marital Status		
Married	38	52.78
Single	33	45.83
No response	1	1.39
Children at Home		
Yes	21	29.17
No	51	70.83

4.2 Attention Control

AFSOC MQ-9 Reaper RPA Reaper operators work in cognitively demanding environments where they are inundated continuously with a significant amount of visual and auditory data that must be prioritized and effectively processed. The tasks they perform require a high level of focus combined with the ability to shift attention as needed. This particular aspect of cognitive functioning may be negatively impacted by chronic fatigue and/or inadequate recovery between missions. In an effort to assess attention abilities, as part of the pre-mission evaluation, RPA operators were asked to complete a standardized Attention Control survey [13]. This self-report, 20-item survey quantifies an individual's generalized attention control, their level of attentional focus, and their ability to shift focus [13]. Using a 4-point scale (i.e., almost never, sometimes, often, always), operators provided a self-assessment of their ability to focus in a given situation [13]. Generalized attentional control was assessed using all 20 statements, while attentional focus and shifting each consisted of a subset of the 20 statements, designed to hone in on a specific element of attention [13]. Examples of statements in the survey included items such as *I can quickly switch from one task to another* and a*fter being interrupted or distracted, I can easily shift my attention back to what I was doing before* [13]. Figure 1 provides a breakdown of results by attention and position type.

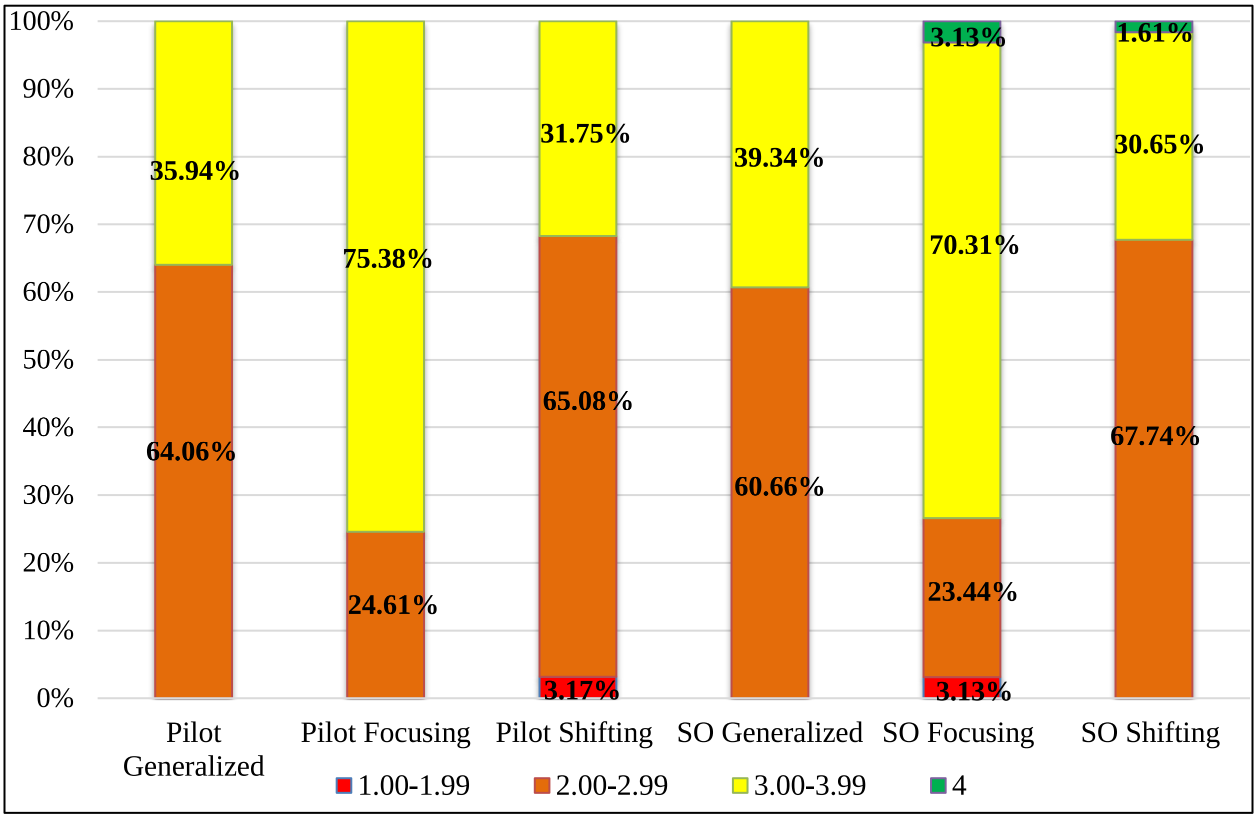

Figure 1. Self-reported attention control levels.

4.3 Alertness

Alertness was defined in this study as a general, global measure of sleepiness. This aspect of functioning is logically perceived as critical to effectively performing operator duties across all types of missions. Additionally, alertness may be degraded by fatigue and/or inadequate rest and recovery between missions. Those operators who are more rested are considered to be more alert and thereby better able to perform assigned tasks; those less alert are likely more fatigued and less able to perform at optimal levels. To explore pre- and post-mission levels of alertness among RPA operators, participants were asked to rate their level of alertness using a 9-point scale ranging from *extremely alert* to *very sleepy, great effort to keep awake,* and *fighting sleep*. Figure 2 provides responses by position and time.

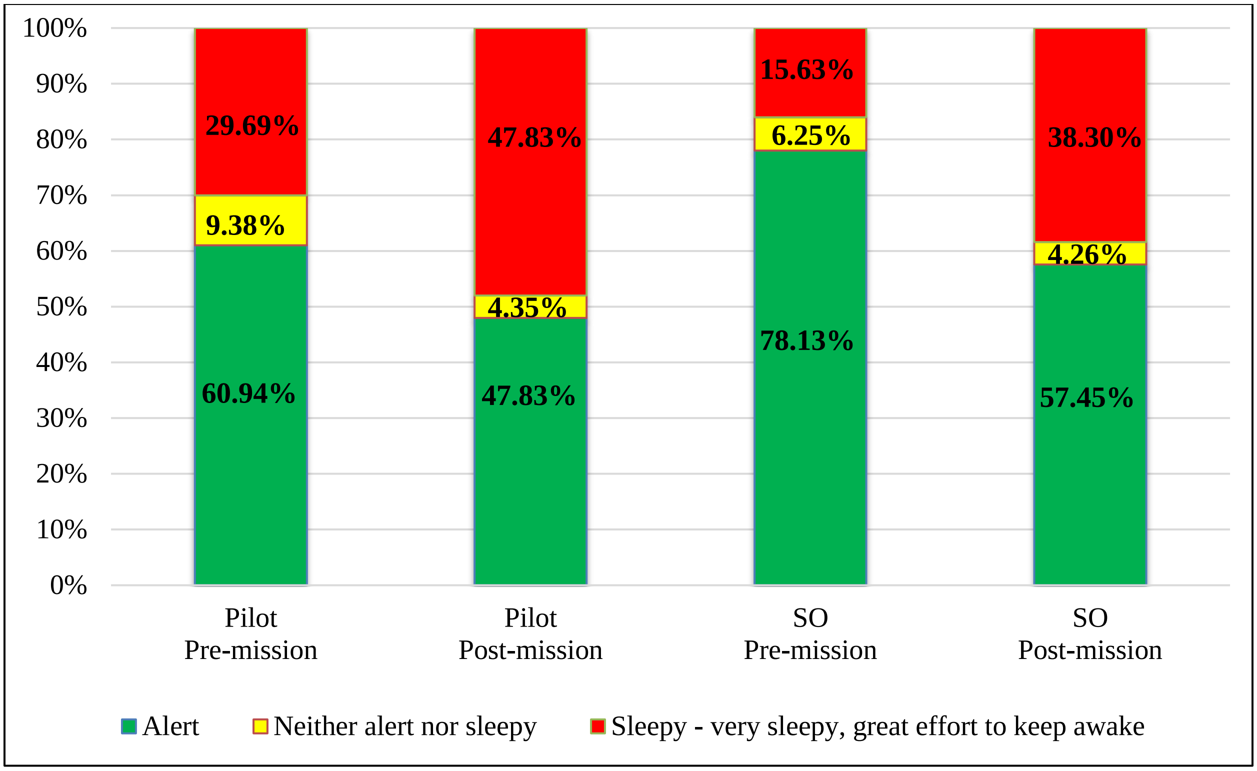

Figure 2. Self-reported levels of alertness.

4.4 Anxiety

Anxiety is a complex phenomenon, consisting of a cluster of physical, cognitive, and emotional symptoms that indicate a feeling of worry, nervousness, or unease about an imminent event with an uncertain outcome. As manifestations of anxiety vary, so, too, do individual abilities to cope with situations that lead to anxious feelings. Some people are generally prone to anxiety (an anxiety trait), while others become anxious as a reaction to events in their surroundings (a state of anxiety) [14]. These reactions to anxiety can be momentary or enduring [14]. Chronic anxiety can exacerbate existing health conditions or cause new issues, including a host of physical ailments [15]. Further, anxiety can affect behavioral health habits, leading to disruptions in sleep, changes in diet, and use of nicotine as a coping mechanism [15]. Regardless, modest to moderate levels of anxiety may be associated with enhanced performance. However, high levels of anxiety are often associated with impaired performance as well as chronic fatigue.

To investigate levels of state anxiety, participants were asked to complete a standardized, self-report State Anxiety inventory [14] both pre- and post-mission. Using a scale of 1 (not at all) to 4 (very much so), respondents were asked to endorse the response that most closely describes their current feelings [14]. Examples of statements in the inventory included items such as *I feel nervous*, *I feel calm*, and *I feel strained* [14]. Figure 3 provides results of the State Anxiety inventory. The following categories delineate low (20-39), moderate (40-59), and high (60-80) scores.

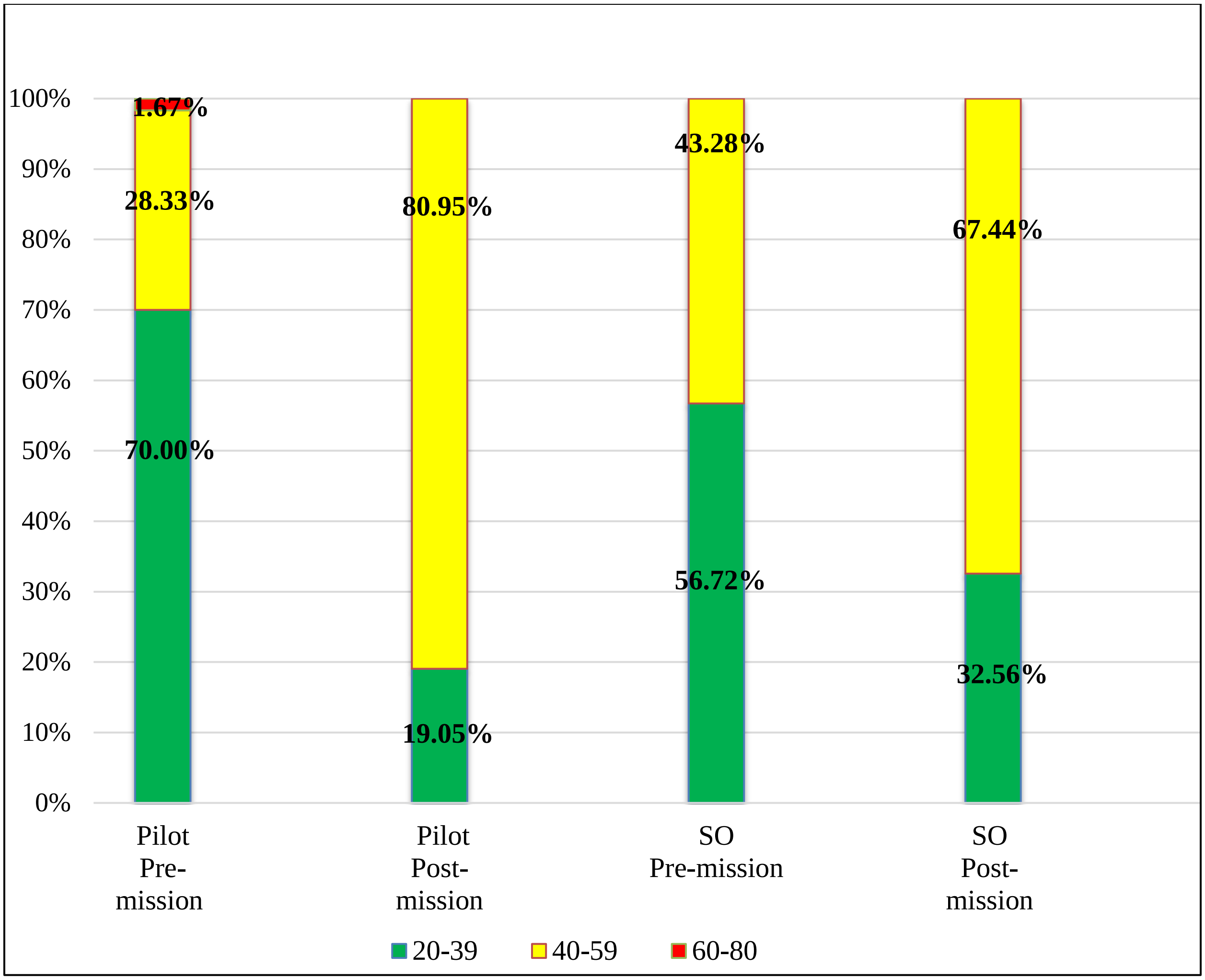

Figure 3. Self-reported levels of state anxiety.

4.5 Stress

Although there are diverse definitions for the concept of stress, in this study stress is defined as a state characterized by the clustering of emotional, cognitive, behavioral, social, and physical symptoms, creating an unpleasant state of psychological functioning that negatively impacts well-being. Previous research has noted the existence of high levels of occupational stress among USAF RPA operators, with 27.32% of operators reporting being "stressed" while 15.34% report stress levels ranging from "very stressed" to "extremely stressed [16]." Previous research identified sources of this stress as operational in nature; elements such as long hours and shift work were identified as primary contributors [16]. Associated symptoms were found to include cynicism and emotional exhaustion, with results indicating 13.67% of USAF RPA operators had a "high level of negative work attitude" [16, p. 19-6] and 19.5% suffered from emotional exhaustion [16]. To assess stress among RPA operators, participants were asked to rate their pre- and post-mission stress using a 5-point scale ranging from *not at all stressed* to *extremely stressed*. Figure 4 provides a graph of pre-/post-mission self-reported levels of stress.

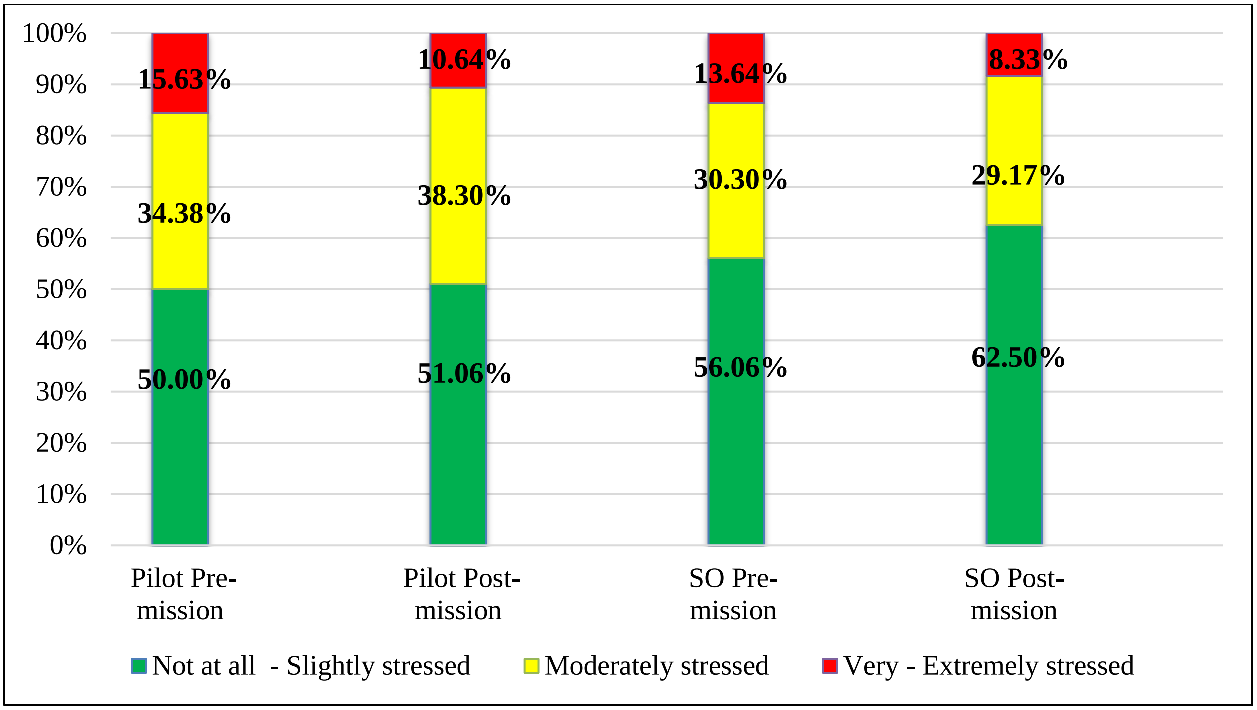

Figure 4. Self-reported stress levels.

4.6 Fatigue

Previous research has documented the demanding work environment of the USAF RPA Reaper operations, with operators reporting higher levels of emotional exhaustion when compared with non-RPA military personnel at the same locations [5]. Much like anxiety, the effects of fatigue are multi-faceted, with participants self-reporting slower information processing speed and reflexes, as well as a general feeling of sluggish and increased irritability. It is logical to assume that these effects extend beyond daily life to other areas, potentially decreasing the warfighters' ability to perform the mission safely and effectively. Thus, increased knowledge of RPA operator fatigue is critical to the success of the mission from both personal health and professional performance perspectives. To explore fatigue within this community of RPA operators, several questions were included in pre- and post-mission surveys as well as mid-mission interviews to assess fatigue and its implications to the individual warfighter.

4.6.1 Self-Reported Fatigue Levels. To assess operator pre- and post-mission fatigue, participants were asked to rate their current level of fatigue using an 11-point scale ranging from 0 (not fatigued) to 10 (extremely fatigued). Figure 5 provides results of self-reported fatigue levels.

4.6.2 Persistence of Fatigue. During mid-mission interviews, participants were given the opportunity to discuss the persistence of their fatigue by being asked, if they felt fatigue, was it intermittent or constant. Figure 6 provides a graph of results.

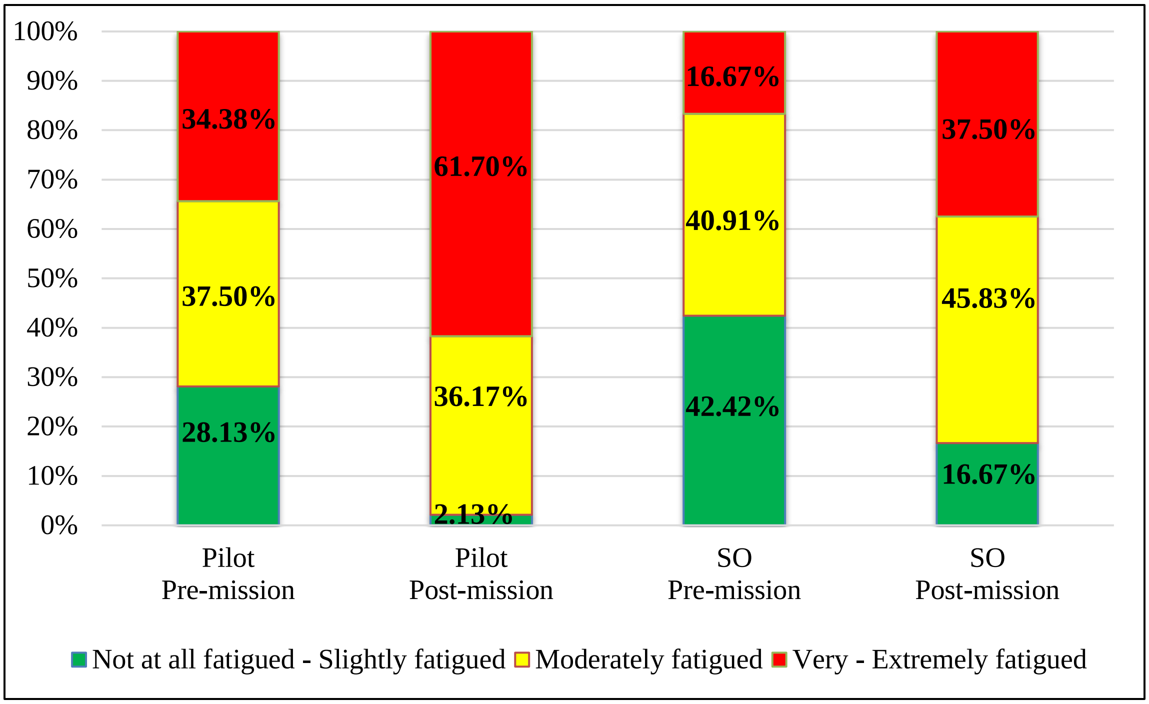

Figure 5. Self-reported fatigue levels.

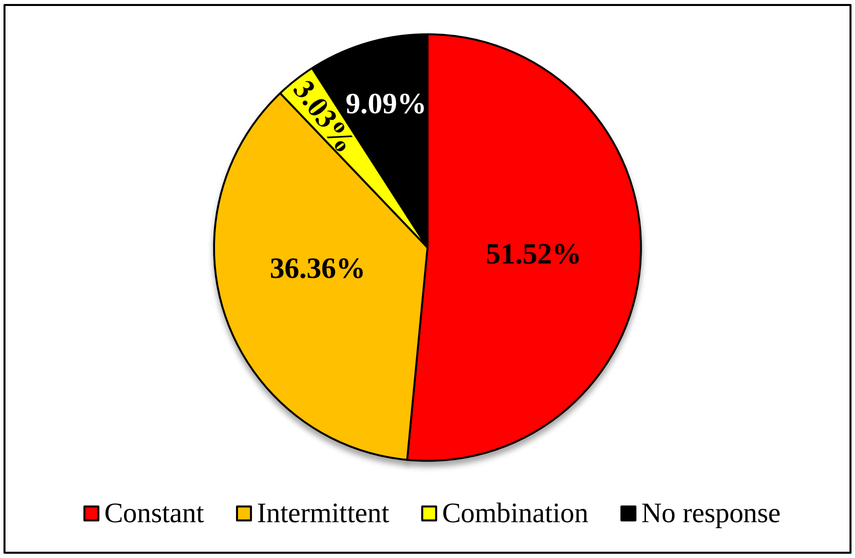

Figure 6. Self-reported persistence of fatigue.

4.6.3 Work Elements that Affect Fatigue. Beyond persistence of fatigue, operators were asked to describe elements of their work that contributed to their perceived state of fatigue. Figure 7 provides a breakdown of results based on how responses were coded into time-dependent (i.e., time of day/clock time during shift), workload-dependent (i.e., heavy versus light workload), and changing shift (e.g., moving from night to day shifts and vice versa) categories.

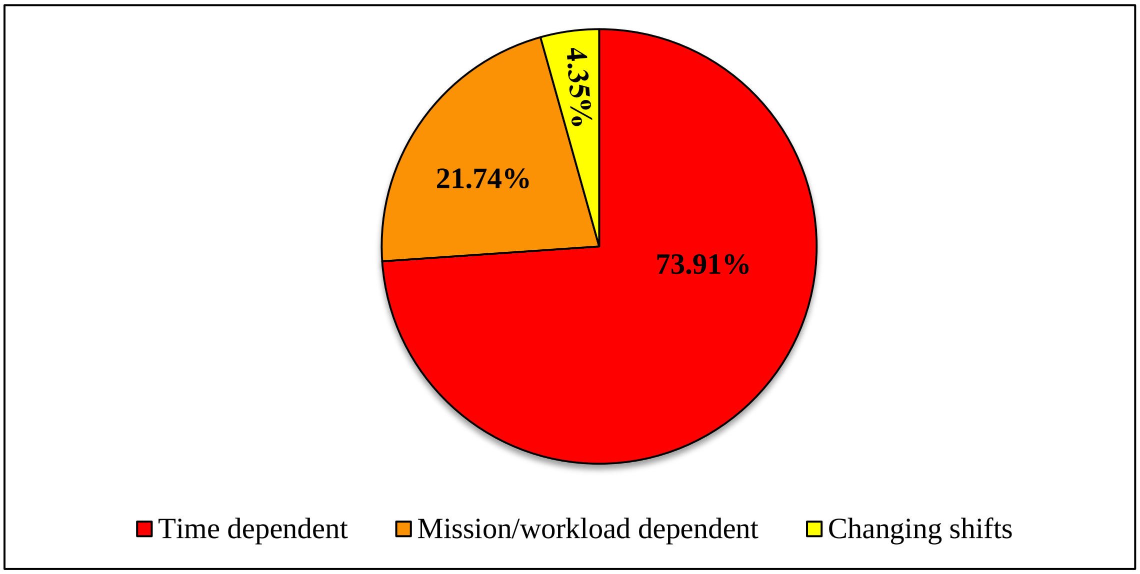

Figure 7. Work elements that affect fatigue.

4.6.4 Self-Reported Symptoms of Fatigue

4.6.4.1 Physical Symptoms. During mid-mission interviews, RPA operators were asked to describe any physical symptoms that accompanied their fatigue. While a few individuals said they could not recall such symptoms, most shared a variety of symptoms including headaches, eye strain/tired eyes, stomach discomfort (such as nausea, tense stomach, and stomach aches), diffuse body aches/muscle tension, and changes in appetite (such as loss of/decreased appetite and binge eating). The category titled "*Miscellaneous*" captured comments made by participants that did not fit in the more broadly defined symptom categories of fatigue. Examples of miscellaneous comments included (among others) feeling lightheaded, being more prone to sickness, taking longer to recover from illness, and feeling cold when tired. Figure 8 provides a breakdown of feedback.

4.6.4.2 Cognitive Symptoms of Fatigue. Research has demonstrated fatigue can negatively impact cognitive functioning (i.e., speed and accuracy of information processing, memory, reaction time, and other areas related to decision making). Maintaining a high level of cognitive functioning is critical to carrying out operator duties during missions [15]. While not specifically solicited, during open discussion of issues, RPA operators often referenced fatigue impacts that were categorized as cognitive in nature. Figure 9 shows the prevalence rate of operators endorsing specific cognitive symptoms of fatigue.

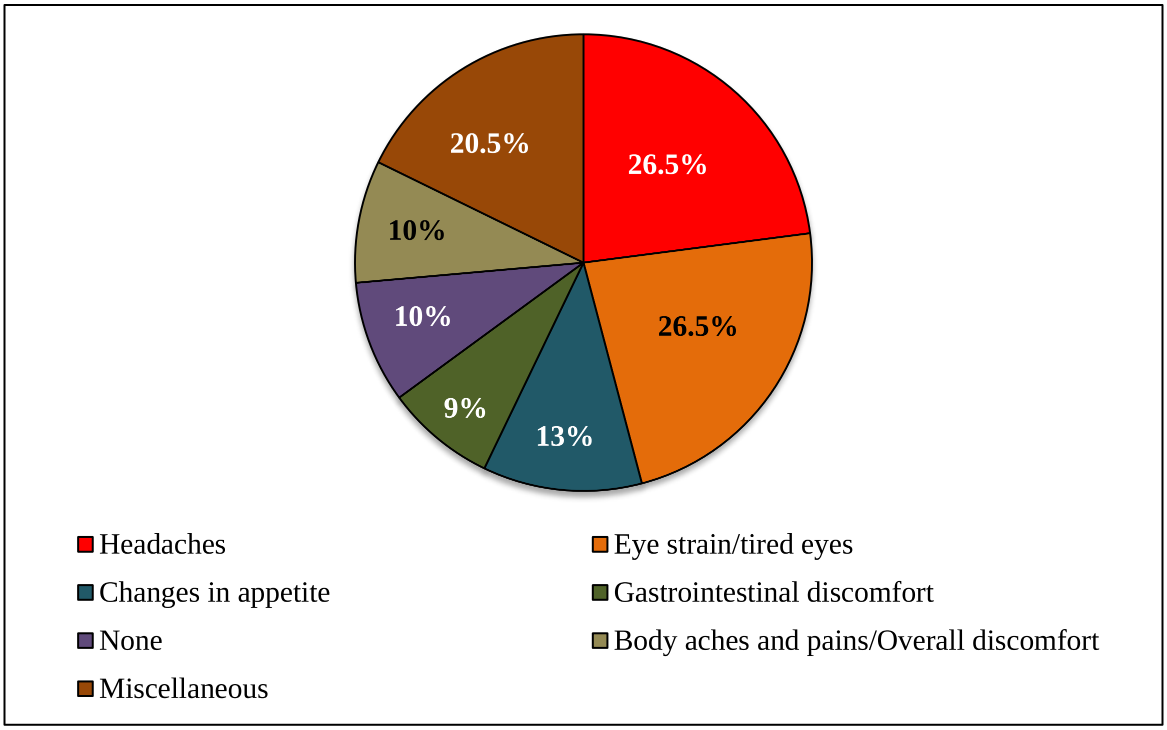

Figure 8. Chronic physical symptoms associated with fatigue.

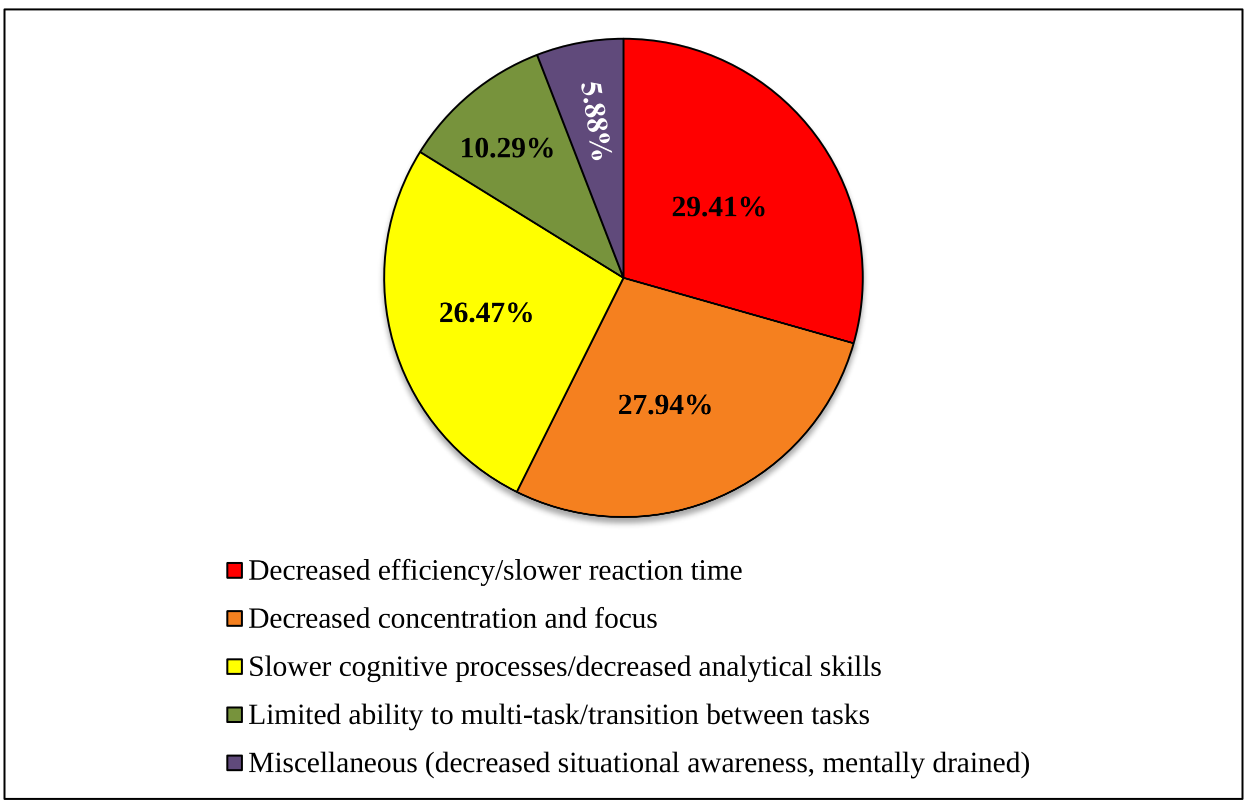

Figure 9. Cognitive symptoms of fatigue.

4.6.4.3 Emotional/Behavioral Symptoms of Fatigue. Beyond physical and cognitive symptoms, during interviews, participants reported and discussed emotional and behavioral symptoms of fatigue such as increased frustration and irritability as well as increased stress and relational tension. Figure 10 details categorization of these responses.

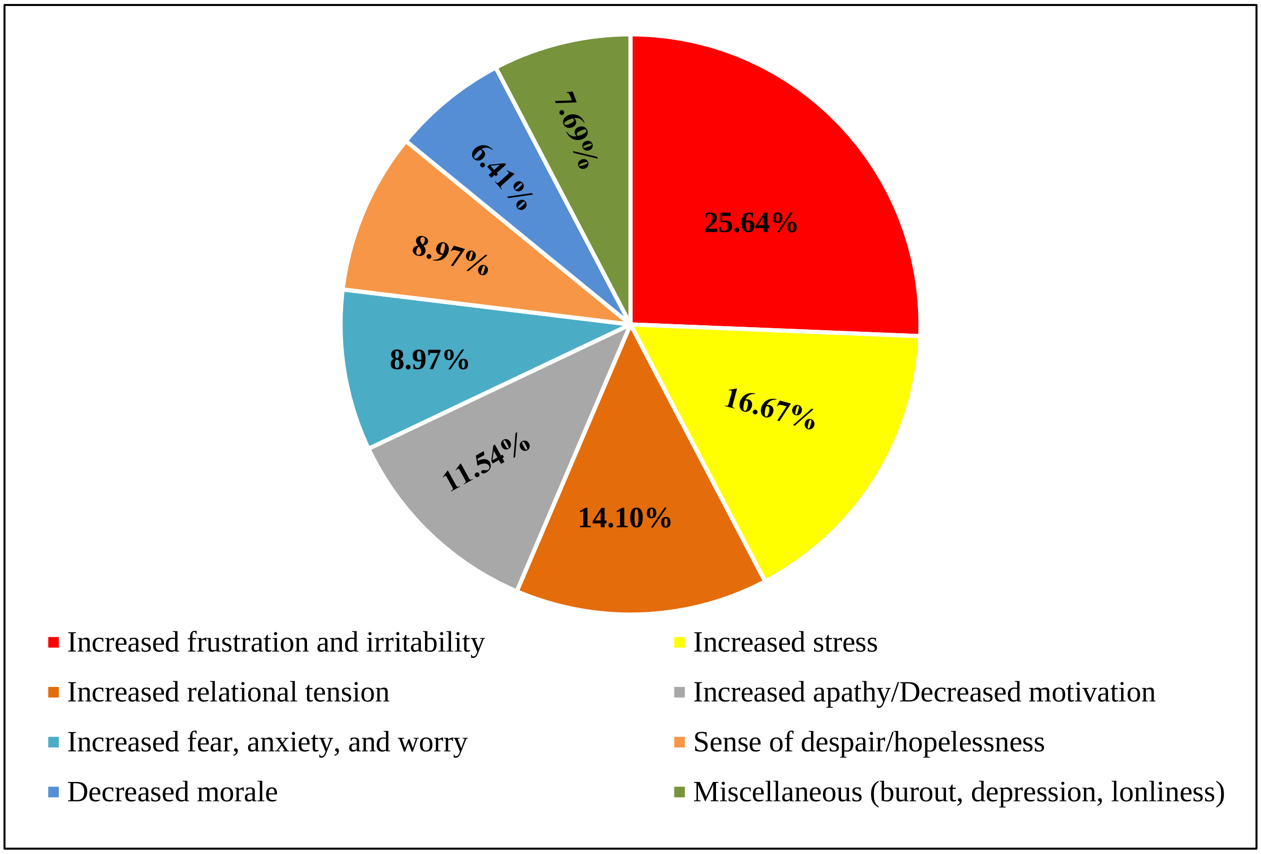

Figure 10. Emotional/behavioral symptoms of fatigue.

4.6.5 Performance Implications of Fatigue. During interviews, RPA operators were asked if their current level of fatigue affected their ability to perform their jobs as well as they would like. Of those who responded, approximately 62% said their performance was impacted by fatigue, while 36% said their performance had not been negatively impacted by fatigue-related issues; a small number (2%) could not recall if fatigue did or did not affect their performance. Those individuals who reported no impacts shared that they felt fatigued but had developed effective compensatory strategies for managing fatigue. In other words, either the participant had adjusted to the schedule (e.g., “After a while, you feel like your body copes with the strain”), figured out ways to cope (such as walking around, using “a lot of caffeine”), or relied on elements of the job (e.g., becoming very focused on tasking) to ensure they performed well. These admissions support the contention that even those who did not report performance degradation were nevertheless forced to adapt to sleep-compromised conditions.

In addition to the interviews, the customized survey items attempted to capture the perceived relationship between fatigue, performance, and hours flying by asking participants to identify how they viewed their ability to perform tasks at certain times throughout their shift during a flying mission. For this exercise, -3 represented an individual's self-perceived low period of performance, 0 represented baseline-average level of performance, and 3 represented their self-perceived highest state of performance. Tables 2 and 3 provide details of results.

Table 2. Mean Performance Rating Based on Shift Time

Hours into Shift	Mean Performance Rating	
	AM Shift[a]	PM Shift[b]
0	0.66	1.29
3	1.86	1.63
6	0.97	0.20
9	0.00	-0.66
12	-1.06	-1.49

[a]n = 35.
[b]n = 35.

Table 3. Mode Performance Rating Based on Shift Time

Hours into Shift	Mode Performance Rating	
	AM Shift[a]	PM Shift[b]
0	0	3
3	3	3
6	2	1
9	0	2
12	-2	3

[a]n = 35.
[b]n = 35.

4.6.6 Compensatory Strategies for Managing Fatigue

4.6.6.1 Sleep Quantity and Quality. Quantity and quality of sleep are important components of both physical and mental health. Adequate sleep is critical to effectively recovering from fatigue between missions. Previous research has shown that inadequate or insufficient sleep among military members has negative physical and psychological ramifications [17]. To explore the sleep habits of RPA operators, respondents were asked pre-mission to indicate the amount of sleep they had before coming to work, how long it took them to fall asleep, and the quality of their sleep. Figures 11 through 13 provide results.

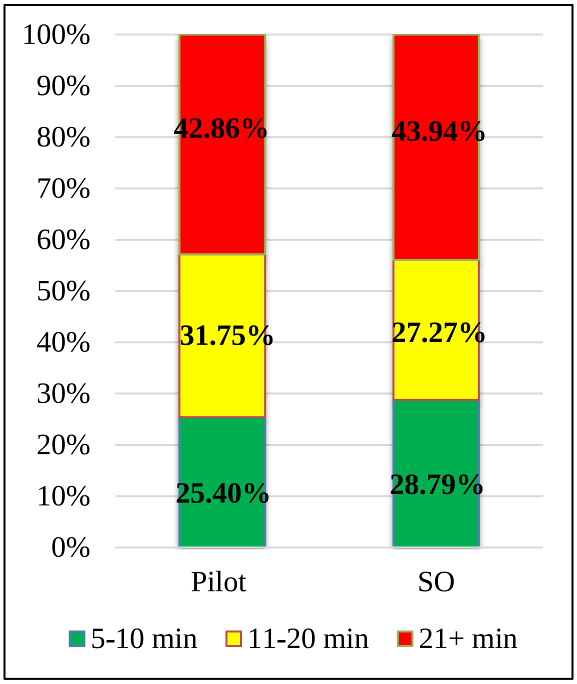

Figure 11. Time to fall asleep.

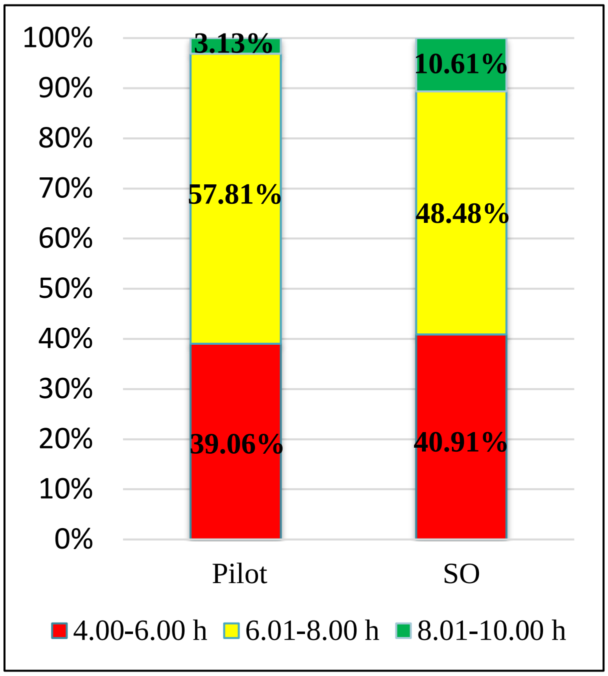

Figure 12. Hours spent sleeping before work.

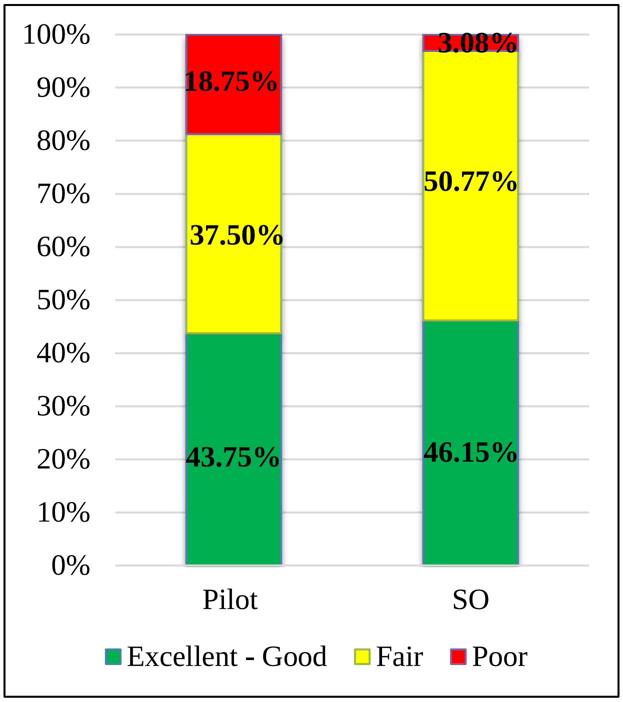

Figure 13. Self-reported sleep quality.

4.6.6.2 Blue Lighting. In an effort to help alleviate self-perceived fatigue among RPA operators, devices were installed on the ceiling of workspaces to provide blue lighting. This ergonomic feature was added as an option for use in workstation areas with an on-off switch and a slider to adjust the intensity of the lighting. To solicit operator feedback on the use and perceived value of blue lighting in their work environment, respondents were asked about their experiences with using blue lights. They were also asked post-mission whether or not they used the blue light and the intensity at which it was set.

Lighting Preference. As part of their pre-mission demographic questionnaire, RPA operators were asked to report their work area lighting preferences. They were provided a list of choices and asked to describe their typical use of lighting in the ground control station (GCS) (i.e., *all blue lights*, *all white lights*, *a mix of blue/white lights*, or *no lights*); the most common response was *all blue light*. Figure 14 provides details of crewmember responses.

Blue Light Use and Intensity during Mission. Post-mission surveys asked RPA operators to indicate whether or not they utilized blue light during their mission and, if so, the intensity setting of the light, using a scale of 0 (blue light off) to 4 (blue light at maximum setting); surveys included a depiction of a sliding scale for participant reference. Figure 15 provides details of results as well as the graphic of the associated rating scale.

Blue Lighting Effects. When using blue light, individuals may or may not experience different effects such as increased/decreased eye strain, increased/decreased fatigue, or increased/decreased occurrence of headaches. Using a scale of 0 (N/A – never an issue) to 5 (major impact), RPA operators were asked to rate the impact of blue lighting on specific physical and workspace elements, such as eye strain and glare. Table 4 provides results of this exploration.

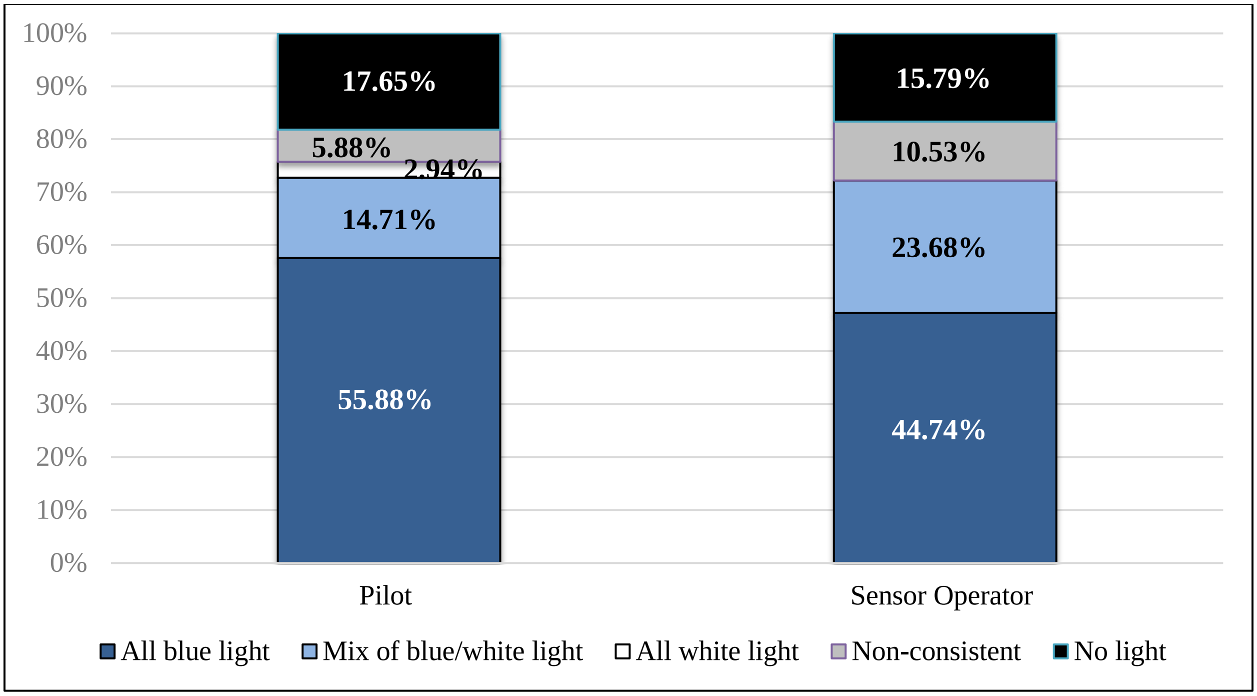

Figure 14. Self-reported GCS lighting preferences.

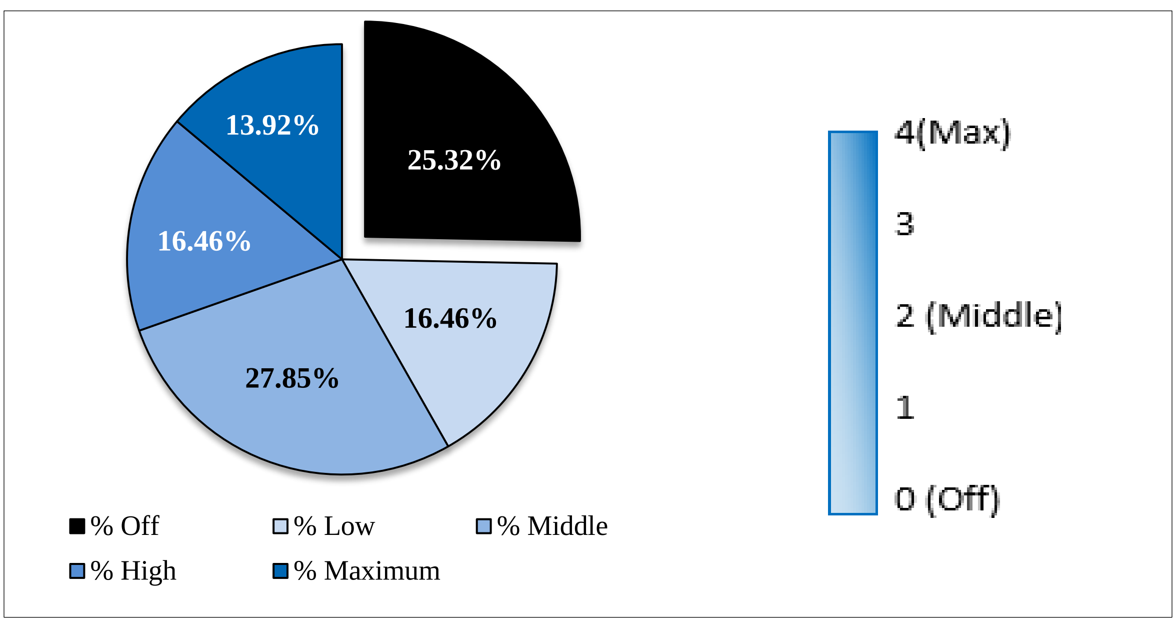

Figure 15. Blue light usage and intensity during missions.

Table 4. RPA Self-Reports of Blue Light Effects

Effect	Mean Rating of Effect	No or Neutral Impact (%)	Minor to Moderate Impact (%)	Major Impact (%)
Increase in eye strain	2.39	57.74	42.25	0.00
Decrease in eye strain	2.29	71.44	25.71	2.86
Increase in fatigue	2.31	84.50	14.08	1.41
Decrease in fatigue	2.00	87.32	12.68	0.00
Increase in headaches	1.48	74.65	22.54	2.82
Decrease in headaches	2.17	95.78	4.23	0.00
Increase in glare	2.23	69.01	26.76	4.23
Decrease in glare	1.35	63.33	36.61	0.00

4.6.6.3 Caffeine, Energy Beverage, and Nicotine Use. Caffeine and nicotine are often utilized to mitigate fatigue; unfortunately, as with any other substance, misuse can lead to detrimental effects. Previous research exploring AFSOC operators and their use of these substances has shown that, while this community does not show an increased tendency for nicotine usage, there is evidence to support increased use of caffeine [8]. General caffeine consumption levels of AFSOC operators echoed those of other support/logistics personnel in terms of frequency and amount; however, individuals reported consuming more caffeinated beverages since assuming their AFSOC RPA duties [8]. The most frequently cited reasons for caffeine use included shift work, high workload, and a desire to be alert for personal commitments [8]. To explore the use of caffeine, nicotine, and other energy-related substance use among this study's RPA operators, pre- and post-mission surveys asked participants to share the frequency of their caffeine and nicotine use, as well as the type of each product. Participants were provided a list of beverages and nicotine products (e.g., coffee, soda, energy drinks, cigarette, smokeless tobacco, etc.) and asked to indicate whether they used the product as well as frequency. Unfortunately, responses to frequency of utilization were not interpretable due to the structure of survey questions; however, researchers were still able to determine the percentage of operators who endorsed usage of caffeine or nicotine as well as their preferred type. Regarding caffeine, 68.89% of pilots and 65.96% of sensor operators self-reported its use during their mission, with the most common choice being coffee. For nicotine, 17.78% of pilots and 8.51% of sensor operators endorsed its use during missions, with most choosing smokeless tobacco/dip. It should be noted that the sample size of respondents for nicotine use was quite small (i.e., 10 pilots and 2 sensor operators). In addition to survey results, during interviews many respondents shared details of their (often detrimental) daily use of caffeine. Some reported headaches associated with caffeine consumption, while others commented about having such high reliance on it that they felt there was "*too much blood in my caffeine system*." Anecdotally reported caffeine usage was associated with a need to sustain alertness during long shifts or compensate for fatigue resulting from frequently changing shifts.

4.7 Alcohol

As discussed earlier, previous research among AFSOC RPA operators has revealed their tendency for an increase and/or above normal use of alcohol as a compensatory strategy for managing the effects of chronic occupational stress [7,8]. Study results have shown these operators have a tendency to increase alcohol consumption following assumption of their RPA mission roles [7], with some (as many as 13.25%) binge drinking on a monthly basis [8]. As was the case with caffeine and nicotine, the current study sought to assess alcohol use via survey questions focusing on frequency and amount of consumption. Most operators (92.31%) self-reported they do not drink between missions. For those who did self-report alcohol use (7.67%), the results were wide ranging, with number of drinks consumed varying from 1 to 12. Of note, the individual who reported consuming 12 alcoholic beverages indicated such use was during non-duty days. Much like reports of caffeine and nicotine, the more personalized interview setting did lead to some disclosure, with those who revealed alcohol use referencing drinking for relaxation, to get numb from work stress, or out of boredom due to the lack of recreational opportunities at their remote geographical location.

4.8 Exercise

Regular, routine forms of physical exercise can mitigate the effects of fatigue by promoting rest and recovery and improving both physical and psychological health. Routine physical exercise is a critical behavioral health habit for managing fatigue and ensuring adequate recovery between missions. Pre-mission surveys asked respondents to share how much time they spend doing moderate aerobic (e.g., running, biking, etc.) and/or moderate anaerobic exercise (e.g., weightlifting, CrossFit, etc.) between flying shift missions. Figures 16 and 17 provide graphs of results.

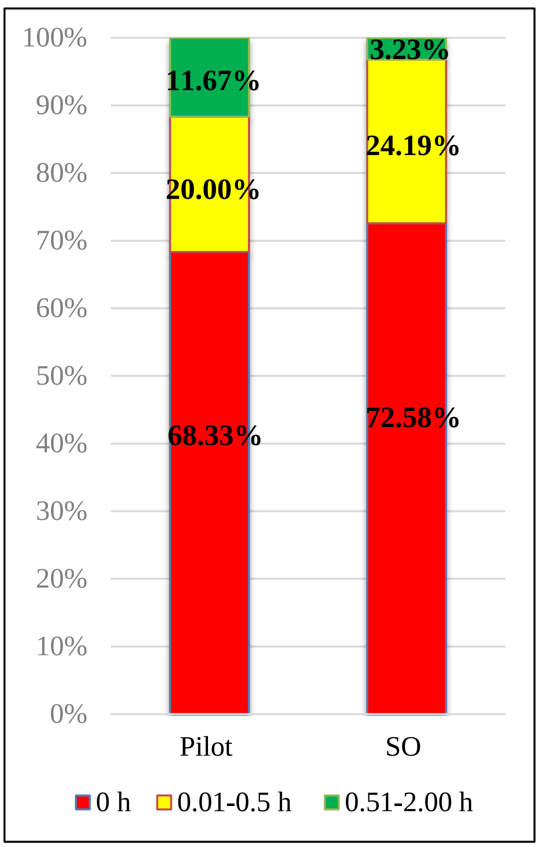

Figure 16. Aerobic exercise between shifts.

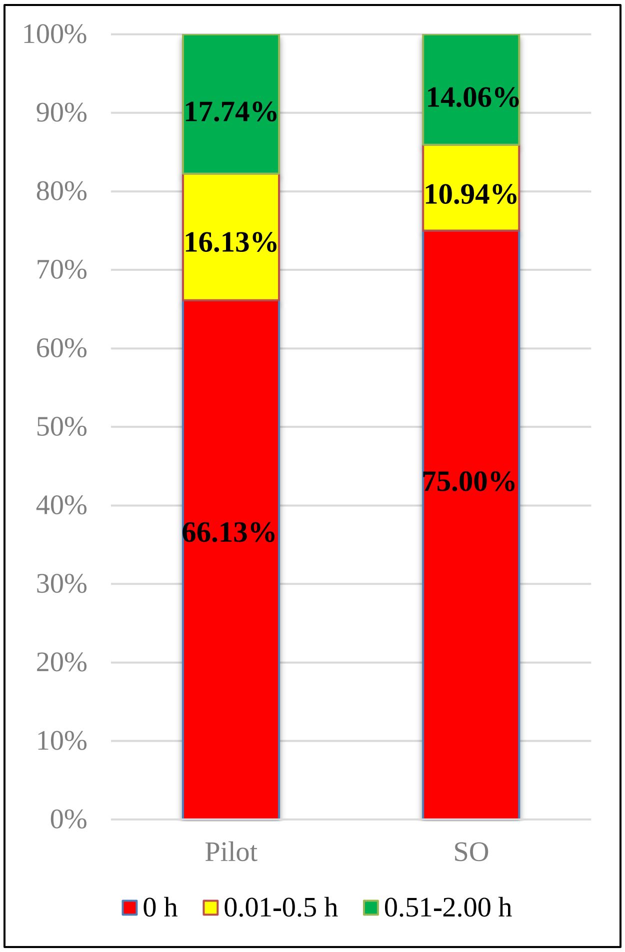

Figure 17. Anaerobic exercise between shifts.

5.0 DISCUSSION

The current study utilized anonymous and voluntary survey self-assessments of fatigue among a sample of AFSOC MQ-9 Reaper operators from an active duty squadron sustaining around-the-clock operations. Separate self-assessments were obtained from crewmembers pre-mission, during execution of the mission, and post-mission. As mentioned previously, this study was conducted at the request of operational and medical leadership concerned about the health of personnel in an undermanned AFSOC RPA unit, where increased mission requirements necessitated a shift increase from 8 hours to 12 hours to sustain additional workload resulting from operational surge. Previous research has documented the relatively high-demand, high-risk nature of the RPA career field, reporting higher than expected levels of emotional exhaustion and clinically relevant psychological distress within this unique group of operators [5]. Self-reported operator attributions have identified less than optimal manning, long hours, frequent rotations in shift work, and problematic work-rest cycles (all of which are driven by the need to sustain around-the-clock battlefield operations) as causes of their distress. This exploratory descriptive study attempted to assess the effects of sustaining around-the-clock operations through pre-/post-mission comparisons of self-report levels of alertness, anxiety, stress, and fatigue, as well as common compensatory strategies for managing fatigue (e.g., sleep, exercise, caffeine, alcohol use, workspace ergonomics, etc.) among operators. Among this study's meaningful results was identification of the implications of operator fatigue within this community, including its physical, cognitive, emotional/behavior, and mission-readiness impacts.

5.1 Attention Control

Results indicate that this sample of AFSOC MQ-9 Reaper pilots and SOs possess similar pre-mission levels of attention control in all categories. As previously discussed, attention control refers to one's ability to focus and shift focus when required by events [13]. In the dynamic, demanding environment in which RPA operators function, it seems logical to assume that possessing a high level of ability in the functional areas of attention is essential to effectively carrying out their duties. At the same time, maintaining such high levels of attention (i.e., vigilance) could be taxing, potentially contributing to operator fatigue. Both pilots and SOs reported an average level of attention control and ability to shift focus. However, both groups self-selected statements indicating a perceived strength in the ability to concentrate on a singular task. While single-task focus may be interpreted as a positive trait among RPA operators, task-oriented attentional focus appeared to come at the cost of their self-reported ability to shift focus (i.e., multi-task with divided attention). Results indicate this group of operators felt they were better equipped to focus on specific tasks during missions rather than constantly shifting and dividing their attention between different types of tasks. Based on operator feedback, this tendency to "hyper-focus" (i.e., sustained vigilance) on the task at hand may be necessary for ensuring performance, but perhaps also leads to fatigue. Both pilots and SOs reported that this aspect of their job (e.g., staring at the screen for long periods) often contributed to fatigue and eye strain during missions.

5.2 Alertness and Stress

While most pilots and SOs reported feeling alert prior to their mission, there appeared to be a marked increase in the number of operators reporting fatigue following completion of a mission. When compared to pre-mission levels, there was an 18.14% increase in pilot post-mission reports of degraded alertness and a 22.67% increase among SOs. This finding suggests that post-mission recovery and fatigue mitigation strategies are important to sustainment of health. During interviews, it was not uncommon for operators to report that driving home was a "challenge" due to "exhaustion from flying" and that, while driving home, they were (at times) concerned with "falling asleep at the wheel."

Also of note was the percentage of individuals who arrived for their shift in an already degraded state of alertness; 29.69% of pilots and 15.63% of SOs endorsed feeling sleepy to very sleepy prior to their missions. The tendency to arrive in a less than optimal state of recovery suggests that a significant portion of these operators live in a state of persistent fatigue and are engaged in inadequate recovery strategies or simply lack sufficient time to rest between shifts. Mid-mission interviews revealed the primary cause of this fatigue centered on moving from 8- to 12-hour daily shifts. Also, fatigue increased throughout the workweek, and by the fourth 12-hour shift in a row, operators reported being "spent" and "exhausted" upon arrival at their work station. While both pilots and SOs endorsed reporting for duty and ending their shifts with decreases in alertness, pilots appeared to suffer from a greater overall deficit when comparing pre- and post-mission results. Possible causes for this difference could include, but are not limited to, a greater shortfall of pilots to carry out assigned tasks, the complex nature of flying and mission duties, time in position, as well as various other professional and personal responsibilities associated with being a pilot in this unit. However, at the time of this study, there was a reportedly greater deficit in the number of pilots versus SOs available for carrying out missions. As a result, pilots reported that they had a significantly higher number of squadron-related administrative and non-flying duties, which they needed to manage along with flying missions. Research has demonstrated that subjective reports of decreased alertness coincide with decreases in performance; this effect is magnified when individuals work a schedule outside of their typical routine [18]. Given the additional duties, as well as frequency of shift changes that is disruptive to their domestic lives, it is reasonable to assume that this shift effect is a contributor to operator reports of decreased alertness.

Regarding stress, the majority of pilots and SOs reported slight to moderate levels of stress prior to and following flying missions. However, 13-15% of operators reported high levels of stress. This percentage decreased to 8-10% following mission completion. Nonetheless, the finding that 1 in 10 operators are experiencing high levels of stress pre- and post-mission is an unfavorable finding and likely a strong contributor to fatigue. Mid-mission interviews suggest those who reported high levels of stress were juggling with workloads (and/or domestic responsibilities) that exceeded their current strategies for managing stress; such operators would likely benefit from outreach efforts from operational medicine and psychology providers. It is possible that those with the highest levels of pre-mission stress struggle with finding adequate time and implementing effective physical and psychological recovery. It is also reasonable to perceive that such operators were carrying out specific missions of unusually high intensity, impact, and visibility among combatant commanders. Regardless, the findings of this study suggest that outreach efforts to improve and mitigate fatigue may also have direct effects on the mitigation of stress.

5.3 Anxiety

Both pilots and SOs reported low to moderate levels of pre-mission anxiety. However, post-mission, both groups showed an elevation in moderate levels of anxiety, with 80.95% of pilots and 67.44% of SOs reporting moderate levels of anxiety. In the short term, moderate levels of anxiety may improve cognitive functioning and performance during flying missions; however, being able to quickly recover and mitigate lingering anxiety following missions is critical to both physical and psychological post-mission recovery. While not reported as high, the reported persistence of moderate anxiety may be a contributor to operators' reported fatigue. Responses to semi-structured interviews revealed perceptions of mission demands (including an implied desire for perfectionism in mission execution), sustaining vigilance during long shifts, fear of making a mistake during ISR and CAS missions, concerns about excessive workload (juggling administrative duties with professional military education with flying duties), as well as juggling work life with daily responsibilities can be problematic and limit operator ability to decompress following missions. Such information suggests the need for both line and medical operational support interventions aimed at helping operators achieve balance between the demands of their personal and domestic lives.

5.4 Fatigue

As referenced earlier, previous research has documented that RPA Reaper operators have reported higher than expected levels of emotional exhaustion when compared with non-RPA personnel at the same installations [5]. To better explore fatigue among the MQ-9 Reaper operators participating in this study, a multi-faceted approach involving pre- and post-mission assessment questions as well as mid-mission interviews was used to assess fatigue and its potential implications.

5.4.1 Self-Reported Fatigue Levels. Figure 5 provides a visual of the fatigue levels of MQ-9 Reaper operators, especially when comparing pre- and post-mission states. A significant portion of pilots and SOs reported arriving for duty in an already fatigued state, with greater than 50% of respondents in both groups reporting fatigue levels ranging from moderate to extreme. Post-mission, self-reported fatigue levels increased markedly in both groups, with 61.70% of pilots and 37.5% of SOs reporting very high to extreme levels of fatigue. The data suggest that individuals arriving for work fatigued and leaving with extreme fatigue are in a chronic condition that could lead to long-term physiological effects such as chronic headaches [19], difficulty concentrating [19], physical pain [19], and other health-related disorders (many of which were self-reported by operators during interviews). As mentioned previously, it is likely that insufficient and inadequate recovery between shifts is a primary contributor. Additional self-reported contributing factors include the number of consecutive shifts worked during the workweek, number of hours worked in a week, domestic responsibilities and obligations between shifts, amount of administrative work requirements between shifts, how recently the crewmember has changed shifts (i.e., from day shift to night shift and vice versa), and use of healthy compensatory strategies for managing fatigue and promoting recovery.

5.4.2 Persistence of Fatigue. Of respondents who admitted to feeling fatigue, 51.52% rated their fatigue as constant, 36.36% as intermittent (e.g., increasing at various times during the flying mission based on operational demands), and 3.03% said their fatigue was both constant and intermittent. When elaborating on their endorsement, those reporting intermittent fatigue displayed a tendency to relate their fatigue experience to workload and amount of time they were on shift. Critical moments in real-time ISR and CAS operations during flying were reported to be accompanied by an “adrenaline rush” and “excitement,” which helped reduce fatigue. Despite this reported energy surge, operators nevertheless often indicated experiencing fatigue increases approximately 6-8 hours into a shift, with feelings of fatigue becoming more pronounced as the shift neared its end (see Tables 2 and 3). For those operators reporting constant fatigue, respondents described exhaustion as “something from which there was no escape”; essentially, they described fatigue as an all-day experience that led to a debilitating level of post-mission exhaustion that interfered with their ability to accomplish remaining work and domestic tasks. Much like those who reported intermittent fatigue, respondents with constant fatigue reported experiencing the most fatigue near the end of their shift. Responses to semi-structured interviews revealed this fatigue increased as the number of consecutive 12-hour shifts in a row were worked, with the operators self-reporting the highest levels of fatigue during the fourth consecutive 12-hour shift.

5.4.3 Symptoms of Fatigue. In addition to providing contextual contributors to operators' fatigue, interview responses yielded details regarding physical, cognitive, and emotional/ behavioral symptoms of fatigue. The most common physical symptom reported was headache. Many operators described headaches with eye strain (the second most common symptom). Eye strain/tired eyes were often said to be associated with long periods of "staring" and continuously being required to visually "dart back and forth" between different various monitors to sustain vigilance to the various sources of information. Another commonly reported symptom was weight loss. This condition was often accompanied by reports of decreased appetite exacerbated by inadequate time to eat during work hours. Due to increased hunger from not eating during the workday, it was not unusual for operators to report binging after work instead of eating during their shift. Other commonly reported physical symptoms of fatigue included somatic sensations of being cold, degraded immune system functioning with increased susceptibility to illness and longer recovery times, diffuse body aches/muscle tension, and stomach discomfort.

The most common cognitive symptoms of fatigue were decreased information processing speed and reaction time, as well as decreased concentration. In general, individuals expressed a tendency to lose focus because of their fatigue (especially 6 hours or more into their flying mission). Individuals shared that they do not feel as "sharp" as when rested, commenting that fatigue impacts their ability to think clearly and process information efficiently (e.g., "I get behind the airplane as opposed to looking ahead"). As focus and vigilance declined, operators reported a similar decline in motivation to accomplish work or interact with their families upon mission completion. For example, one operator reported, "There are days when I don't want to do anything because I'm so tired." Another troubling comment came from another operator who self-reported "reaching a point of continual despair."

The most commonly reported emotional/behavioral symptoms of fatigue were increased frustration and irritability leading to impatience with both co-workers and family; 30% of respondents endorsed such symptoms. Operators reported an increased tendency to socially isolate themselves and withdraw from relationships/friendships, as well as increased anger during elevated levels of fatigue. RPA operators often reported that such emotions led to increased post-mission relational conflict with others at home and work. Additionally, RPA operators reported elevated fatigue leading to lethargy accompanied by a decline in ability and motivation to accomplish non-flying, administrative tasks, as well as domestic tasks; lethargy was reported to last until adequate rest or recovery was obtained.

5.4.4 Work Elements that Impact/Contribute to Fatigue. When asked to elaborate on contributors to their fatigue, the most common response from operators was that fatigue is time-dependent, becoming more pronounced toward the end of the shift and workweek. Participant commentary indicated that fatigue is intermittent at first, increasing and becoming more persistent further into the workweek. For example, those on their fourth 12-hour shift in a row reported during interviews higher levels of intermittent and persistent fatigue than those who were on their first or second 12-hour shift that week. Additionally, operators reported they began to "fall off a cliff" after approximately 6 hours on shift. During interviews, operators reported that missions requiring longer than 6 hours resulted in higher levels of fatigue during and after the mission.

Operators reported that specific types of missions (i.e., high-visibility strike missions in urban settings with high-value targets) and workload (i.e., high level of administrative duties in addition to 12-hour flying missions) were also significant contributors to fatigue. Participants also reported that fatigue was noticeable when there were lulls in activity. For example, when missions were primarily ISR (in which the most prominent duty was typically watching people or places on screens), crewmembers indicated that fatigue could creep in and make it hard to attend to tasking. Crew also considered shift work problematic due to inadequate adjustment time between shift changes and long shifts in which actual hours worked often exceeded hours planned.

Beyond insufficient sleep, AFSOC MQ-9 Reaper operators reported other factors that contributed to their fatigue, such as stress, administrative duties, and extended hours. Operators commented on the stress associated with having to live a “deployed position” (i.e., in-garrison lifestyle). Because RPA operators essentially “deploy” from home, they are still expected to interact with their families and accomplish household tasks when they return home. For those with spouses and/or children, domestic duties were said to interfere with sleep and recovery time. RPA operators self-reported that there was often “no buffer” between job stress and stresses of life at home. Further feedback from operators included comments that difficulty adjusting to family life in an already stressful job is one of the hardest aspects of being an RPA operator, with attempts to balance home and work priorities as a significant contributor to fatigue.

RPA operators also cited administrative duties as an issue that interfered with recovery time because extra-mission duties extended the already long workday. Respondents indicated that long duty hours on a constantly rotating shift leads to a lack of recovery time and prevents adequate sleep between shifts, as do demanding shift workloads and sometimes monotonous, repeated taskings leading to a “ground hog day” effect.

In addition to the psychological stressors of the job, physical contributors to mission fatigue were also offered. One such element was nutrition. RPA operators reported that irregular hours limited their time and access to quality nutritional foods. RPA operators additionally cited ergonomic issues with their workstations as contributors to mission fatigue. Monitor position and visual displays were noted as problematic. Approximately 32% of operators reported being less than moderately satisfied with their obligatory workspace. The overall arrangement of controls and general workspace configuration were viewed as suboptimal, with 43% of operators less than moderately satisfied. Key issues included the position of monitors relative to neck position and monitor crosscheck efficiency. Of final note, headset quality was of most concern to those surveyed, with 71% of operators reporting less than moderate satisfaction with them, reporting physical discomfort.

During interviews, RPA operators often cited the remote, geographical location of the duty location as a source of stress and fatigue. Operators referenced the difficulty of working a 24/7 shift in a small town that does not operate on a similar schedule (e.g., business and food establishments close early) or have the necessary resources to support areas of interest (i.e., recreation, leisure) for mitigating fatigue. Respondents frequently reported a sense of geographical isolation that affects both their personal and professional lives, creating negative perspectives on career prospects for operators and quality of life concerns for their families due to the base’s distance from the nearest large city. Operators commented on a perceived negative impact to quality of life for their families due to limited employment opportunities, fewer choices for quality education for their children, and social isolation (particularly for single crewmembers and warfighter spouses) resulting from the base’s somewhat geographically isolated location.

5.4.5 Fatigue and Exercise. A significant proportion of respondents fall below the exercise frequency and intensity recommended by the Centers for Disease Control and Prevention and the U.S. Department of Health and Human Services [20]. For maximum health benefits, the current Physical Activity Guidelines for Americans recommends at least 150 minutes a week of moderate-intensity exercise, or 75 minutes a week of vigorous-intensity aerobic physical activity [20]. Although questionnaires in this study did not explore weekly levels of exercise, reported daily exercise clearly indicated that members of the sampled RPA operators fall below the Centers for Disease Control and Prevention's recommendations for exercise. Approximately 68% of pilots and 73% of SOs reported they do not participate in moderate aerobic exercise. Similarly, when asked about anaerobic exercise (e.g., weightlifting, CrossFit, etc.), 66% of pilots and 75% of SOs reported zero hours of participation. During interviews, many operators reported that they either have no time to exercise or are simply too exhausted following extended shifts. The exercise deficits among RPA operators in this study are contrasted with previous studies wherein 86.11% [8] to 95.34% [7] of USAF RPA operators reported participating in some form of exercise at least one or more times a week. Regular physical activity has benefits for long-term health; it decreases the risk of developing conditions such as cardiovascular diseases, diabetes, and obesity [21]. In addition, research has shown that physical exercise reduces stress [22]. Overall, the respondents to this survey were not getting enough exercise to achieve optimal health benefits and were potentially putting themselves at risk for long-term health deficiencies. The lack of exercise reported by operators in this study may have a circular effect on their reported fatigue. It is well known that regular exercise can improve energy and mitigate fatigue. However, the increased operational tempo and 12-hour shifts likely interfered with at least some of the operators having enough time to exercise; in time-limited circumstances, choosing to exercise often comes at the expense of accomplishing other work or domestic-related tasks. A reduction in operational tempo or shift length (i.e., cutting back to 8-hour shifts) may naturally lead to increased opportunity for operators to engage in a more healthy level of exercise.

5.4.6 Performance Implications of Fatigue. Research has demonstrated the detrimental effects of working with sustained fatigue, providing evidence of fatigue-associated deficits in cognitive and physical functioning [23]. During interviews, the majority of RPA operators (62%) did not hesitate to share their belief that fatigue affects their ability to perform their job at optimal levels. Although some operators reported no fatigue-related performance degradation (36%), it is reasonable to assume that some did experience a decline in performance and attempted to work through it via compensatory strategies prior to, during, and following flying missions. Operator comments during interviews with regard to reliance on caffeine and other energy-related substances are indicators that operators were struggling with fatigue and were, perhaps, not always successful at mitigating its impact on performance.

Exploration of perceived performance levels over the course of a 12-hour shift showed a pattern of self-reported deteriorating performance, with operators reporting a downward trend in self-perceptions of ability to maintain peak performance over an extended shift, regardless of time of day. RPA operators working both morning and evening shifts reported a decline in performance 6 hours into their shifts, a trend that continued at 9 and 12 hours (see Tables 2 and 3). These reports support the contention that, in addition to creating fatigue, extended shifts also negatively impact performance, an effect that begins approximately 6 hours into the mission. Operator comments shared in interviews coupled with self-reports of an inability to maintain peak performance over the course of a 12-hour shift related the potential implications of operating while fatigued.

5.4.7 Sleep and Sleep Quality as Compensatory Strategies for Managing Fatigue. Both pilots and SOs reported less than optimal amounts of sleep prior to their missions, with 39.06% of pilots and 40.91% of SOs reporting sleeping 6 hours or less the night before their shift. Difficulty falling asleep and poor sleep quality compound the problem of insufficient sleep. Both pilots and SOs reported approximately equal difficulty falling asleep, with 42.86% of pilots and 43.94% of SOs taking 21 minutes or more to fall asleep. Similarly, sleep quality was comparable in both groups, with 56.25% of pilots and 53.85% of SOs reporting fair to poor sleep quality. It is worth noting that a higher percentage of pilots rated their sleep quality as poor, with 18.75% of pilots versus 3.08% of SOs sharing that they felt they slept poorly. Both internal and external factors could have led to differences in sleep quality. Where and when an individual sleeps; amount of time for recovery between shifts; nutritional intake; caffeine, alcohol, and nicotine use; and stress management strategies all potentially affect sleep quantity and quality. Since more pilots appear to struggle with obtaining adequate quantity and quality of sleep, this finding coincided with pre-mission fatigue levels. As mentioned previously, both pilots and SOs had significant roles during missions; at the time of this study, pilots were significantly undermanned when compared with SOs. Elements of workload and job strain may have been contributing factors to pilots' fatigue, leading to higher levels of stress that subsequently affected sleep quality.

When examining health-promoting behaviors such as obtaining adequate sleep, the sampled group of MQ-9 Reaper operators falls below national averages and recommendations for adults. According to the National Sleep Foundation, while the amount of sleep needed varies from individual to individual, it is recommended that the average adult (ranging in age from 18-64 years) obtain 7 to 9 hours of sleep per night to function at his/her peak [24]. While 52.31% of respondents indicated they are getting the recommended 7 to 9 hours of sleep before a typical shift, an almost equal number (46.92%) indicated they are not. Even though these sleep patterns are not optimal, based on previous studies of AFSOC operators, this group of MQ-9 Reaper operators slept slightly longer than RPA operators in other locations (i.e., ACC and ANG units), where only 38.03% [7] to 31.49% [8] of operators reported getting 7 or more hours a night. The reason for this difference is unclear; possibilities include cultural differences (both regional and within the unit), work schedules, and assigned tasks. Additionally, leadership may have been more vigilant in enforcing crew rest for their RPA operators at AFSOC than at the other MAJCOMs.

Beyond time spent sleeping, there is also the question of sleep quality. Research has shown that sleep quality is as important as sleep quantity for adequate recovery [25,26]. When questioned about aspects of sleep such as time needed to fall asleep, sleep quality, and sense of recovery upon awakening, many respondents reported less than optimal sleep quality, regardless of reporting sufficient time to sleep. This trend is suggestive of a problem with overall sleep efficiency that takes into account both time spent sleeping and total time in bed. For example, results show that 72.87% of respondents reported taking 11 minutes or longer to fall asleep, 37.21% reported feeling fatigued upon awakening, and 55.04% reported their sleep quality as being fair to poor. Taken together, the trend of insufficient time asleep coupled with suboptimal sleep quality indicates problems with multiple aspects of sleep. These problems may be mitigated by educating operators about sleep hygiene (e.g., caffeine and energy beverage usage, alcohol usage, and other behavioral habits that affect sleep quality and quantity). However, mitigation of sleep problems will likely require additional collaborative line-medical leadership strategies.

Additionally, pre-mission self-reports indicated that greater than 50% of respondents arrived to work in an already fatigued state. It is likely that insufficient sleep and recovery were primary contributors to pre-mission fatigue. Other contributors may have included consecutive shifts in a row (i.e., greater pre-mission fatigue during the last shift of the workweek when compared with earlier shifts and/or starting a change in which one is in the beginning of switching from night shift to day shift and vice versa). Temporary and chronic fatigue at the beginning of the workday, especially after sufficient time to rest, often resulted in negative physiological and psychological consequences. Unless corrected, insufficient sleep (in terms of inadequate quantity and/or quality) has the potential to lead to several chronic disease outcomes such as hypertension [27], cardiovascular disease [28], and obesity [29,30] affecting operator readiness and sustainment levels. Overall, the findings of this study revealed that a large portion of RPA operators surveyed are routinely struggling to fall asleep, obtaining inadequate amounts of sleep prior to work, and feel fatigued even after sleeping; all of these factors could increase risks to general health, performance, and safety.

5.4.8 Caffeine and Alcohol as Compensatory Strategies for Managing Fatigue. When tired or stressed, many operators engage coping strategies to improve their energy and reduce stress. When looking at health habits, such as caffeine, nicotine, and alcohol use, respondents' self-reports clearly demonstrate this community's reliance on caffeine as a mitigation strategy. In addition, anecdotal evidence obtained from interviews revealed RPA operators reported high levels of caffeine consumption (e.g., three or more caffeinated and/or designer energy beverages) during shifts, as well as elevated levels of alcohol use between shifts. Participants often referenced dependence on caffeine use, sometimes indicating sustained use at levels that may have impacted their health (e.g., drinking so much caffeine that they felt bad). Some operators shared that they consumed beverages such as coffee and designer energy drinks (e.g., Monster) on a daily basis, citing fatigue, shifting work hours, and mission alertness as the most common reasons. While no one discussed nicotine use, a small number of operators talked about alcohol use, saying they would drink to relax, to get numb from work, or simply out of boredom. While the frequency and level of caffeine and alcohol use were not documented in this study, interviews suggested that those who did choose to use these substances did so, in large part, in response to the rigors of their jobs. This finding has similarities to previous research wherein results suggested there is a strong correlation between occupational stress and increased alcohol use [31].

5.4.9 Blue Lighting as a Method of Mitigating Fatigue. GCS workstations are equipped with blue lighting devices for operators to utilize at their discretion as a possible fatigue management option. Research has shown that blue light has significant positive impacts on individual reports of alertness, job performance, and mood [32]. Looking beyond subjective measures, further research provides physiological evidence of blue light's impact on alertness, demonstrating positive electrocardiogram and electroencephalogram effects [33]. In the current study, operator feedback on blue lighting provided interesting information not only on frequency of use but also on its intended effects. When asked to indicate a lighting preference, both pilots and SOs indicated a preference for working with some sort of blue light. Approximately 70.59% of pilots and 68.42% of SOs reported that their choice would be to use all blue light or a mixture of blue and white light rather than all white light or no light at all. Reported use during missions reflected desired levels, with 74.68% of RPA operators reporting use of some level of blue light in the GCS; however, it is unknown whether they operated with all white light or no white light at all.

Despite reported ability of blue light usage to mitigate fatigue and positively affect job performance [32], surveyed operators provided mixed perspectives on the value of blue lighting, with more than 50% rating it as having little to no impact on elements such as fatigue, eye strain, headaches, and glare. Interestingly, the average blue light rating indicated that it contributed to, rather than mitigated, fatigue (mean = 2.31 vs. mean = 2.00); only a small number of operators noted this effect (15.49% and 12.68%, respectively). Better educating operators on blue lighting through provision of a standardized approach for its utilization coupled with more information on its potential benefits may position operators to more effectively benefit from blue lighting in the GCS. A more accurate determination of the impact and value of blue light utilization may become available through such an approach, or if it is studied in conjunction with reports of individual performance.

6.0 STUDY OUTCOME RECOMMENDATIONS

6.1 First Tier – MAJCOM, Group, Wing, and Squadron

6.1.1 Crew Rest. We offer several recommendations to improve the health and sleep quality of pilots and SOs. However, we do not believe any of them will have long-term or meaningful effects unless crew rest is observed for AFSOC RPA operators in accordance with Air Force Instruction 11-202 volume 3, General Flight Rules [34]. Before RPA operators can begin obtaining sufficient sleep, leadership must ensure and enforce crew rest. When conducting surge operations, we recommend that implementation of such activities include consideration of length of surge and potential impacts on AFSOC RPA weapon strike operators, particularly when crew rest waivers are in place. Furthermore, crew rest waivers should be issued on a case-by-case basis and only in response to critical real-time developing needs. AFSOC operators cannot maintain optimal performance levels without getting adequate sleep. The surge under which study respondents operated appears to be the result of low manning issues rather than battlefield activities, leading to a continually high workload tempo that has become "normal" operations. It is imperative for leadership to manage personnel from the "top down" by fostering a command climate that does not allow for continual crew rest violations. Crew rest should be observed by the operator and directly enforced by the commander.

Data collected in this study demonstrate that current garrison-based operations do not support crew rest among sampled operators; as a possible solution, "deployment" conditions may enable leadership to better control rest conditions/environment of operators and enforce crew rest. Thus, detachment-based operations are recommended for implementation: specifically, operators engaged in their multi-day operational cycles may be considered on temporary duty (TDY) (mini-deployments). If implemented, the following are recommended:

1. Operators should expect to sleep on base for the duration of their operational cycle. Leadership should ensure that rooms at the base transient housing facilities are available for crewmembers' exclusive use while on TDY (they may consider indefinitely reserving

the necessary number of rooms). All operators (including those who live off base and in the barracks) should expect to occupy the reserved deployment quarters. This recommendation directly addresses reports that some crew who share living space with spouses, children, or roommates do not get adequate quality rest or rest of sufficient duration to sustain a high ops tempo schedule.

2. Leadership should consider the merits of geographically restricting in-cycle operators to base to reduce the pressure on crewmembers with dependents to return home after their shifts (while understanding that such geographical restrictions could be perceived as punitive). Many deployed crewmembers may feel obligated to return to their homes regardless of availability of deployment housing. This measure may also have the effect of reducing distractions to operators while in crew rest. Leadership should also be proactive in working with families to anticipate and mitigate domestic difficulties that are likely to result from a high-frequency TDY/deployment schedule.
3. Leadership should likewise ensure that while the operator is on TDY, his or her squadron duties are temporarily reassigned; deployed operators in operational cycle should not be considered "at home" and should avoid squadron spaces and squadron duties for the duration of their deployment, by direction from leadership.

Regarding crew rest, it should be clearly defined and enforced per Air Force Instruction 11-202 [34]. Crew rest is defined doctrinally as a 12-hour period before the crew day begins in which the operational crewmember may not perform flight or job-related duties; 8 of the those 12 hours must be spent in quarters [34], ostensibly getting sleep. Additionally, a standard "crew day" could be established for ease of scheduling. (We offer 12 hours as an example.) Crew day starts for each operator when he or she walks through the RPA facility door or performs some operational or job-related task; crew day ends when the mission is complete and all post-mission reports have been filed OR when he or she reaches the crew rest 12-hour window. For example, if an operator's 8-hour shift begins at noon, and he has 2 hours preflight, briefs, and mission planning prior to his noon shift, his crew day actually begins at 1000. As a result, he would be placed on crew rest no later than 2200 the night before. If his mission the following day is scheduled for 0900 and he has 2 hours preflight and briefs, then his crew day starts at 0700 and he must be placed on crew rest no later than 1900 that evening, regardless of tasks that may arise or remain incomplete. Leadership should also consider the merits of establishing sun-synchronous schedules.

A detachment officer in charge should be selected from among senior squadron pilots whose primary job is to manage his or her deployed personnel and ensure that the flight schedule and crew day are synced for optimal operations. This individual should interface between the squadron and the deployed personnel and provide a buffer between in-cycle crewmembers and the squadron. This individual should also be considered on deployment; he or she should be tasked with tracking, monitoring, and (if necessary) enforcing operator crew rest; he or she should also be empowered to modify flight requirements as necessary to facilitate crew rest.

Finally, in addition to the currently prescribed Ambien, leadership may wish to consider the merits of empowering flight medicine to pharmaceutically regulate the sleep-wake cycles of deployed operators in the use of "go/no go" prescriptions or supplements [35,36]. Operators currently report using caffeine to chemically compensate for inadequate sleep. Caffeine is a powerful and effective tool when utilized judiciously, and it is not the object of this report to eradicate caffeine use among RPA operators. However, the unregulated use of caffeine coupled with the excessive stress and the insufficient sleep that were observed by researchers may have negative long-term consequences for operators. Flight medicine may be required to get involved in hands-on management of the short-term sleeping and waking physiology of operators while in the deployment cycle, similar to the proactive relationship between flight medicine personnel and U-2 pilots or astronauts. Go/no go meds should only be used once crew rest periods are actively observed; leadership should not regard go/no go meds as chemical substitutes for sleep. Rather, leadership should view these pharmaceutical options as tools to help ensure optimal quality and adequate duration of sleep once crew rest commences and, subsequently, alertness and productivity throughout the crew day.

6.1.2 Proactive Health Behaviors. Aircrew in this study reported that shift work limits their access to healthy nutrition and impedes their ability to get adequate exercise. Duties that constrict a service member's ability to maintain combat readiness are directly in opposition to the warrior ethos embraced by AFSOC; corrective measures should be implemented from the top down. We recommend that leadership consider implementing the following.

6.1.2.1 Exercise. Leadership should consider proactively finding ways to facilitate opportunities for deployed crew to obtain at least the minimum weekly recommendation of physical exercise. Often, the crewmember simply does not have time to go to the fitness center (a highly common complaint in this report). Leadership may reach out to local fitness trainers to develop alternate exercise options for time-limited or space-limited workouts. Lifting free weights is not adequate by itself to maintain fitness. Cardiovascular training and core strength training must be included in these alternative options (Physical Activity Guidelines [20]). Trainers should be directed to design both beginner and advanced training routines that can be implemented on mission breaks and with minimal equipment (for example, P90X or similar programs); leadership should ensure that any simple equipment identified as necessary to these routines is available on site (such as free weights, a bench, medicine balls, and mats). Leadership may wish to consider the merits of requiring each crewmember to individually meet with a trainer to design a tailored deployment training plan versus simply making fitness trainers available to personnel as a resource.

6.1.2.2 Nutrition. Receiving adequate nutrition has both short-term energy and cognitive benefits and long-term total health benefits. Respondents frequently reported inadequate access to healthy food and not enough time to consume it. This practice has led to metabolic stresses as aircrew personnel reported starving while on duty and then binging on junk food at end of shift. Leaders should be proactive in ensuring deployed operators have access to the right kinds of food and snacks on site in the facility.

What are the right kinds of food? In high stress environments, it is imperative to the short- and long-term health of the individual that he or she consumes foods and supplements that provide energy, aid cognition, and promote calmness and mental clarity. Among AFSOC RPA aircrew (i.e., individuals who are routinely exposed to extreme stress and images of violence and death), it is critical to the operators' health maintenance that all neuroprotective measures available be taken. Foods and supplements containing antioxidants reduce stress-related cell oxidation and thus reduce the effects of stress-induced accelerated aging on the central nervous system [37-43]. In addition, foods and supplements that provide the ideal combination of omega-3 and omega-6 long-chain fatty acids have been demonstrated to reduce mental health pathologies like depression, anxiety, stress-related autonomic dysregulation, and even cardiovascular distress [44-50]; Omega-3 and omega-6 even reduce incidence of suicide and anger [51]. Leadership should consider the merits of engaging professional nutritionists to work with each crew operator to devise a tailored on-cycle meal and nutrition plan that implements omega-3, omega-6, and antioxidants, taking into consideration the limited access to preparation facilities.

6.1.2.3 Ergonomics. Survey results were not significant with regard to the positive effects of blue lighting. We recommend that blue lighting be standardized among all aircrew across all missions after which time a follow-up study be conducted to evaluate benefits.

6.2 Second Tier – Embedded Psychological Care Provider

We suggest that embedding psychological care can drastically improve the overall mind-body health maintenance within the unit. The on-site psychologist should be empowered to work directly with flight medicine in a collaborative relationship. We do not propose that the psychologist be given authority to ground operators who appear to be in distress. However, an on-site psychologist should have the most comprehensive situational awareness of both the mind-body effects of stress and the functioning state of the operators under his or her care. Dialogue between the on-site psychologist and the flight surgeon regarding the mind-body health of operators will empower flight medicine to make fitness for duty medical calls with more precision and confidence; communication between professionals can help flight medicine determine if emotional or physiological distress events are the result of “state” versus “trait” mental characteristics.

Toward the goal of monitoring and providing precision mind-body medicine for stressed operators, we recommend that leadership ensure the on-site psychologist conduct proactive post-mission debriefs with aircrew who conduct or witness unexpected traumatic violence against U.S., allied force, or enemy combatants or civilians. This measure should be implemented any time pilots and SOs conduct strikes against targets in which they see or know there were casualties or surveil events in which they observe traumatic unexpected violence. We recommend follow-up with an embedded provider within 24 to 48 hours [52]. We further recommend a 2-week and a 2-month follow-up with the embedded on-site psychologist.

Current survey results suggest that operators were highly reluctant to reach out to mental health at base medical or civilian mental health providers, with some operators fearing negative career ramifications. When a psychologist is embedded within the unit, operators may receive guidance and counseling from a professional who interacts daily with the squadron and has functional knowledge of operational conditions affecting operator health. The on-site psychologist can tailor outreach strategies addressing identified issues. An embedded provider with the appropriate security clearance may also act as a trusted confidant who is readily accessible in times of need. An embedded mental healthcare professional could build a rapport with individuals and provide council on issues before they become more substantial or require significant intervention, creating a safe haven for sharing and providing group and individual outreach. Other contributions from embedded mental healthcare professionals could include outreach to operator families as well as group and squadron commanders. Such outreach would include providing families with a better perspective on the effects of operational demands and effective ways to respond and adapt to such demands. Consultation with operational decision makers may help the command with improving its situational awareness of operator needs, as well as advising line leadership on the organizational, physical, and social climate factors unique to the unit and affecting operator readiness and performance.

It is highly recommended that the embedded psychological provider be a dedicated licensed mental health provider with appropriate security clearance (i.e., Top Secret/Sensitive Compartmented Information). Being located with the unit would improve operator access to health services and potentially decrease stigmas associated with seeking help, acting as a liaison between operators and the command with regard to identifying and resolving issues affecting readiness and personal well-being. To help optimize the success of this recommendation, mental health providers embedded within line units should be selected based upon their consultation capabilities. Additional considerations should include (1) leadership qualifications and experience as mental health providers, (2) clinical diagnoses and treatment acumen, (3) intrinsic interest in learning and being a part of RPA operations, and (4) ability to effectively bridge the gap and remove stigmas to mental healthcare.

6.3 Third Tier – Outreach Beyond Line Leadership

A final recommendation involves outreach beyond line leadership to improve engagement with operators and support development of unit cohesion and morale. An incidental, but meaningful, finding from responses to interviews revealed many operators were quick to point out that they perceive a lack of leadership support outside of their own units, with some operators offering negative commentary during interviews about their view of MAJCOM and USAF Headquarters leadership "as detached, uninvolved, and unsympathetic." Through better engagement with operators (i.e., improved communication, meaningful demonstrations of behavior to improve work-related conditions), leaders could alleviate some of this angst. A suggested approach to support improved relationships and build morale would be to focus less on flight-centric operations and more on squadron-centric operations, allowing individuals to get to know more people in the squadron as a whole, spending time together and building comradery. Suggestions to support such changes include the provision of a dedicated Heritage room for social gatherings and, on schedules less than 12 hours, reinstating "dragon debriefs" wherein crewmembers not only review events of the day, but also have the opportunity for socializing and decompressing with individuals who share their experiences.

6.4 Areas of Future Study

Future researchers into the sleep and health behaviors of MQ-9 Reaper operators should seek to understand and model the exposure-response relationship among the various individual, organizational, and mission-related factors involved in RPA operations. The potential factors to be considered in this relationship are the age of the operator, time spent in RPA duties, hours worked per week, length of shifts, frequency of shift work rotation, and the protective benefit of factors such as physical fitness, sleep hygiene, and resiliency training. Developing models based on these recommendations may begin to elucidate questions, including the following:

- Is there a limit to how long someone should be an RPA operator?
- Is there an age at which someone is too young to be an RPA operator due to a lack of emotional/physical maturity that impacts his or her ability to cope with the rigors of the job?
- Is there an age at which someone is too old to be an RPA operator without sustaining significant negative health consequences?

- What is the work schedule that will minimize negative health consequences for operators while minimizing manning and maximizing performance?

7.0 STRENGTHS AND LIMITATIONS OF THE STUDY

The primary strength of this study was its unique pre-/post-mission approach to assessing operator states. In addition to providing opportunity to assess MQ-9 Reaper operator conditions upon arrival for a mission, this model also allowed for study of potential changes in specifically explored elements (such as anxiety and fatigue) following completion of a shift. A limitation, however, resulted from the problematic structure of caffeine/stimulant use questions, resulting in responses that were difficult to interpret. With regard to future studies, the format and wording of survey questions assessing caffeine and stimulant use may be altered to minimize the likelihood that this will happen in future research. Limitations on researchers' ability to access classified work areas led to less-than-optimal post-mission response rates. In addition to these content and administration issues, the study will be difficult to replicate or generalize using another population; there are no comparable Air Force groups assigned to the same location, with the same job, or under the same surge conditions as the MQ-9 Reaper operators. This limits our ability to make definitive statements about changes and challenges that are unique to this RPA community versus unique to its geographic location. Additional studies are required to draw definitive conclusions regarding caffeine and alcohol use among high-fatigue groups. It is important to note that participants reporting high incidences of sleep issues, increased caffeine use, and questionable alcohol consumption do not necessarily require treatment. The study could be improved through functional assessments of other associated fatigue-related impairments to support the validity of assumptions made about performance implications. Finally, self-report surveys are prone to response bias from a self-selected sample, which might affect generalization of results. Simply put, whenever assessing for the impact within an organization, it is always a possibility there will be sampling bias. In the case of this sample, self-reported concerns about fear of retribution resulting from disclosure may limit individual reports of behaviors commonly deemed risky. Conversely, those same individuals may use this as a platform to report their particular circumstance. Sampling bias, however, is not necessarily a negative issue if it helps highlight troubling behaviors within a population that is potentially at risk. Despite these limitations, the current findings support the previous work, which indicated that working around-the-clock real-time operations may place individuals at risk for adverse health consequences. These individuals would benefit from assessment and intervention by leadership and medical personnel.

8.0 CONCLUSION

The results of this study identify the salient and complex physical and psychological reactions that MQ-9 Reaper pilots and SOs experience in response to high-stress, extended-shift operations with an unprecedented workload while living an in-garrison lifestyle. The individuals who maintain mission-essential, around-the-clock RPA operations face demands that are inherently arduous and taxing; they work under organizational and environmental factors, too-fluid work schedules, manning shortfalls, and even local climate stressors. All of these add additional pressures and demands that can negatively affect the health and well-being of these operators. The current survey results indicate that modifications to aspects of the RPA work environment, such as frequency of shift work rotations and hours worked per week, plus re-education of beneficial health behaviors may go a long way toward primary and secondary prevention of poor health behaviors and outcomes. Embedding a licensed healthcare professional is a potential solution to the problem of treating an at-risk population whose members do not typically seek treatment. Additionally, employing methods to bolster morale and unit cohesion at both the unit and command levels could not only aid in day-to-day performance, but perhaps overall retention in a demanding career field that, despite challenges, is viewed with pride by those who serve.

9.0 REFERENCES

1. Stulberg AN. Managing the unmanned revolution in the U.S. Air Force. Orbis. 2007; 51(2):251-265.
2. U.S. Air Force. The U.S. Air Force remotely piloted aircraft and unmanned aerial vehicle strategic vision. Washington (DC): Department of the Air Force; 2005. Report No. 1-1-2005. [Accessed 27 Jan 2014]. Available from http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1000&context=usafresearch.
3. Department of Defense. FY 2009-2034 unmanned systems integrated roadmap. Washington (DC): Department of Defense; 2009. [Accessed 27 Jan 2014]. Available from www.dtic.mil/get-tr-doc/pdf?AD=ADA522247.
4. Ouma JA, Chappelle WL, Salinas A. Facets of occupational burnout among U.S. Air Force active duty and National Guard/Reserve MQ-1 Predator and MQ-9 Reaper operators. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2011. Technical Report No. AFRL-SA-WP-TR-2011-0003.
5. Chappelle W, McDonald K, Thompson B, Swearengen J. Prevalence of high emotional distress and symptoms of post-traumatic stress disorder in U.S. Air Force active duty remotely piloted aircraft operators (2010 USAFSAM survey results). Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2012. Technical Report No. AFRL-SA-WP-TR-2013-0002.
6. Chappelle W, McDonald K, Prince L, Goodman T, Ray-Sannerud BN, Thompson W. Assessment of occupational burnout in United States Air Force Predator/Reaper “drone” operators. Mil Psychol. 2014; 26(5-6):376-385.
7. Chappelle W, Swearingen J, Goodman T, Cowper S, Prince L, Thompson W. Occupational health screenings of U.S. Air Force remotely piloted aircraft (drone) operators. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2014. Technical Report No. AFRL-SA-WP-TR-2014-0007.
8. Chappelle W, Swearingen J, Goodman T, Prince L, Thompson W. Reassessment of occupational health among U.S. Air Force remotely piloted aircraft (drone) operators. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2017. Technical Report No. AFRL-SA-WP-TR-2017-0009.
9. Kouvonen A, Kivimäki M, Väänänen A, Heponiemi T, Elovainio M, et al. Job strain and adverse health behaviors: the Finnish Public Sector Study. J Occup Environ Med. 2007; 49(1):68-74.
10. Frone MR. Are work stressors related to employee substance use? The importance of temporal context in assessments of alcohol and illicit drug use. J Appl Psychol. 2008; 93(1):199-206.

11. Nixon AE, Mazzola JJ, Bauer J, Krueger JR, Spector PE. Can work make you sick? A meta-analysis of the relationship between job stressors and physical symptoms. Work & Stress. 2011; 25:1-22.
12. Knutsson A. Health disorders of shift workers. Occup Med (Lond). 2003; 53(2):103-108.
13. Judah MR, Grant DM, Mills AC, Lechner WV. Factor structure and validation of the Attentional Control Scale. Cogn Emot. 2014; 28(3):433-451.
14. Spielberger CD, Gorsuch RL, Lushene R, Vagg PR, Jacobs GA. State-trait anxiety inventory for adults: sampler set manual, test, scoring key. Redwood City (CA): Mind Garden; 1983.
15. American Psychological Association. How stress affects your health. 2013. [Accessed 3 Jan 2018]. Available from http://apa.org/helpcenter/stress.aspx.
16. Chappelle W, Salinas A, McDonald K. Psychological health screening of remotely piloted aircraft (RPA) operators and supporting units. Proceedings of the RTO Human Factors and Medicine Panel (HFM) Symposium on Mental Health and Well-Being across the Military Spectrum; 2011 Apr 11-13; Bergen, Norway. Neuilly-Sur-Seine (France): North Atlantic Treaty Organization, Research and Technology Organisation; 2011. Paper No. MP-HFM-205-19. [Accessed 3 Jan 2018]. Available from http://www.dtic.mil/docs/citations/ADA582856.
17. Lentino CV, Purvis DL, Murphy KJ, Deuster PA. Sleep as a component of the performance triad: the importance of sleep in a military population. US Army Med Dep J. 2013:98-108.
18. Dijk DJ, Duffy JF, Czeisler CA. Circadian and sleep/wake dependent aspects of subjective alertness and cognitive performance. J Sleep Res. 1992; 1(2):112-117.
19. Aaron LA, Burke MM, Buchwald D. Overlapping conditions among patients with chronic fatigue syndrome, fibromyalgia, and temporomandibular disorder. Arch Intern Med. 2000; 160(2):221-227.
20. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee report, 2008. Washington (DC): U.S. Department of Health and Human Services; 2008. [Accessed 27 Jan 2014]. Available from http://www.health.gov/paguidelines/Report/pdf/CommitteeReport.pdf.
21. Hoffman C, Rice D, Sung HY. Persons with chronic conditions. Their prevalence and costs. JAMA. 1996; 276(18):1473-1479.
22. Salmon P. Effects of physical exercise on anxiety, depression, and sensitivity to stress: a unifying theory. Clin Psychol Rev. 2001; 21(1):33-61.
23. Krueger GP. Sustained work, fatigue, sleep loss and performance: a review of the issues. Work & Stress. 1989; 3(2):129-141.
24. National Sleep Foundation. How much sleep do we really need? (n.d.). [Accessed 3 Jan 2018]. Available from https://sleepfoundation.org/how-sleep-works/how-much-sleep-do-we-really-need.
25. Pilcher JJ, Ginter DR, Sadowsky B. Sleep quality versus sleep quantity: relationships between sleep and measures of health, well-being and sleepiness in college students. J Psychosom Res. 1997; 42(6):583-596.
26. Knudsen HK, Ducharme LJ, Roman PM. Job stress and poor sleep quality: data from an American sample of full-time workers. Soc Sci Med. 2007; 64(10):1997-2007.
27. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. Hypertension. 2006; 47(5):833-839.

28. Ayas NT, White DP, Manson JE, Stampfer MJ, Speizer FE, et al. A prospective study of sleep duration and coronary heart disease in women. Arch Intern Med. 2003; 163(2):205-209.
29. Di Milia L, Mummery K. The association between job related factors, short sleep and obesity. Ind Health. 2009; 47(4):363-368.
30. Marshall NS, Glozier N, Grunstein RR. Is sleep duration related to obesity? A critical review of the epidemiological evidence. Sleep Med Rev. 2008; 12(4):289-298.
31. Liu S, Wang M, Zhan Y, Shi J. Daily work stress and alcohol use: testing the cross-level moderation effects of neuroticism and job involvement. Pers Psychol. 2009; 62(3):575-597.
32. Viola AU, James LM, Schlangen LJ, Dijk DJ. Blue-enriched white light in the workplace improves self-reported alertness, performance and sleep quality. Scand Work Environ Health. 2008; 34(4):297-306.
33. Figueiro MG, Bierman A, Plitnick B, Rea MS. Preliminary evidence that both blue and red light can induce alertness at night. BMC Neurosci. 2009; 10:105.
34. U.S. Air Force. General flight rules. Washington (DC): Department of the Air Force; 2016. Air Force Instruction 11-202, Volume 3.
35. Caldwell JL, Hall KK, Prazinko BF, Norman DN, Rowe T, et al. The efficacy of temazepam for improving daytime sleep and nighttime performance in Army aviators. Ft. Rucker (AL): U.S. Army Aeromedical Research Laboratory, Aircrew Health and Performance Division; 2001. USAARL Report No. 2002-05. [Accessed 3 Jan 2018]. Available from http://www.dtic.mil/docs/citations/ADA397776.
36. Storm WF. A fatigue management system for sustained military operations. Ft. Detrick (MD): U.S. Army Medical Research and Materiel Command; 2008.
37. Bhat AH, Dar KB, Anees S, Zargar MA, Masood A, et al. Oxidative stress, mitochondrial dysfunction and neurodegenerative diseases; a mechanistic insight. Biomed Pharmacother. 2015; 74:101-110.
38. Bjørklund G, Chirumbolo S. Role of oxidative stress and antioxidants in daily nutrition and human health. Nutrition. 2017; 33:311-321.
39. Croft KD. Dietary polyphenols: Antioxidants or not? Arch Biochem Biophys. 2016; 595:120-124.
40. Oroian M, Escriche I. Antioxidants: Characterization, natural sources, extraction and analysis. Food Res Int. 2015; 74:10-36.
41. Pisoschi AM, Pop A. The role of antioxidants in the chemistry of oxidative stress: A review. Eur J Med Chem. 2015; 97:55-74.
42. Zhang H, Tsao R. Dietary polyphenols, oxidative stress and antioxidant and anti-inflammatory effects. Curr Opin Food Sci.. 2016; 8:33-42.
43. Sies H. Oxidative stress: a concept in redox biology and medicine. Redox Biol. 2015; 4:180-183.
44. Carmona RH. Omega-3 fatty acids: nutritional armor for the warfighter and historical trends behind optimal warrior performance. Mil Med. 2014; 179(11 Suppl):176-180.
45. Crawford MA, Broadhurst CL, Cunnane S, Marsh DE, Schmidt WF, et al. Nutritional armor in evolution: docosahexaenoic acid as a determinant of neural, evolution and hominid brain development. Mil Med. 2014; 179(11 Suppl):61-75.
46. Kiecolt-Glaser JK, Glaser R, Christian LM. Omega-3 fatty acids and stress-induced immune dysregulation: implications for wound healing. Mil Med. 2014; 179(11 Suppl):129-133.

47. Kim HY. Neuroprotection by docosahexaenoic acid in brain injury. Mil Med. 2014; 179(11 Suppl):106-111.
48. Marriott BP, Yu K, Majchrzak-Hong S, Johnson J, Hibbeln JR. Understanding diet and modeling changes in the omega-3 and omega-6 fatty acid composition of U.S. garrison foods for active duty personnel. Mil Med. 2014; 179(11 Suppl):168-175.
49. McCarthy MS, Morgan BB, Heineman JT, Martindale RG. Nutritional armor for the injured warfighter: omega-3 fatty acids in surgery, trauma, and intensive care. Mil Med. 2014; 179(11 Suppl):88-94.
50. Montain S, Jonas WB. Nutritional armor: omega-3 for the warfighter. Mil Med. 2014; 179(11 Suppl):1.
51. Hibbeln JR, Gow RV. The potential for military diets to reduce depression, suicide, and impulsive aggression: a review of current evidence for omega-3 and omega-6 fatty acids. Mil Med. 2014; 179(11 Suppl):117-128.
52. Carmi L, Fostick L, Burshtein S, Cwikel-Hamzany S, Zohar J. PTSD treatment in light of DSM-5 and the "golden hours" concept. CNS Spectr. 2016; 21(4):279-282.

LIST OF ABBREVIATIONS AND ACRONYMS

ACC	Air Combat Command
AFSOC	Air Force Special Operations Command
ANG	Air National Guard
CAS	close air support
GCS	ground control station
ISR	intelligence, surveillance, and reconnaissance
MAJCOM	major command
RPA	remotely piloted aircraft
SO	sensor operator
TDY	temporary duty
USAF	United States Air Force