Examining the Relationship Between Soldiers' **Sleep, Activity,** and **Nutrition** Behaviors and Readiness Outcomes

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Performance Triad

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Authority

Army Regulation 600-63 (14 April 2015), *Army Health Promotion* defines health promotion as "any combination of health education and related organizational, political, and economic interventions designed to facilitate behavioral and environmental changes conducive to health and well-being of the Army community." Army health promotion involves evaluating the effectiveness of the programs as defined above (Chapter 1, Section 1-6a and b. (4), pages 1-2).

Army Regulation 40-5 (12 May 2020), *Army Public Health Program* directs the U.S. Army Public Health Center (currently the DCPH-A) to perform "Army-wide scientific and technical studies, surveys, evaluations, consultative services, and assistance visits in coordination and collaboration with regional health authorities" in support of U.S. Army Medical Command oversight responsibilities (at para 2-17cc(3)(c), page 17).

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Abstract

The U.S. Army actively promotes healthy sleep, activity, and nutrition (SAN) behaviors as a means for improving Soldiers' health and readiness. The Performance Triad is the Army's initiative to enhance Soldiers' readiness by encouraging the Army Family to engage in healthy SAN behaviors and emphasizes the synergy, or interrelation, of SAN behaviors. The Defense Centers for Public Health Aberdeen (DCPH-A) assessed the relationship between Army Active Duty (AD) Soldiers' self-reported SAN behaviors and select injury and behavioral health outcomes to inform programs and policies that best support Soldier readiness. The DCPH-A analyzed self-reported data from Army AD Soldiers who completed the Global Assessment Tool or Periodic Health Assessment in calendar year 2018; analyses included frequencies, multivariable logistical regression models, and hierarchical logistic regression models. Demographic differences were observed for SAN behaviors and the prevalence of injury and behavioral health outcomes; however, healthy SAN behaviors appear to be protective factors for injury and adverse behavioral health outcomes, after controlling for demographic characteristics. Additionally, the prevalence of injury, depression, and PTSD was lower among Soldiers who met combinations of recommended SAN targets. Future studies are needed to explore the temporal association between SAN behaviors and readiness outcomes.

1 Background

1.1 Performance Triad Description

The U.S. Army actively promotes healthy sleep, activity, and nutrition (SAN) behaviors as a means for improving and maintaining Soldier health, optimizing Soldier readiness, and reducing injuries (Caravalho 2015). The Performance Triad (P3) is the Army's initiative to enhance Soldiers' readiness by encouraging the Army Family to engage in healthy SAN behaviors. The P3 emphasizes the synergy, or interrelation, of SAN behaviors because a deficit in one can lead to a deficit in the others.

U.S. Army Photo

The Army integrates the P3 into a variety of efforts, including the Armed Forces Wellness Centers (AFWC) and the Army's Holistic Health and Fitness (H2F) System. The AFWCs, for example, provide health assessments, health coaching sessions, and health education classes to help improve the Army Family's physical fitness, nutrition, and sleep (Rivera et al. 2016). The Army's H2F System, as another example, supports Soldiers' readiness through five domains: sleep, physical, nutritional, spiritual, and mental (Department of the Army 2020). This system underscores both the importance of sleep and nutrition for physical and mental performance, and the importance of physical training for Soldier readiness.

1.2 Sleep, Activity, and Nutrition Behaviors

Sufficient sleep, activity, and nutrition are associated with positive health outcomes. U.S. Army service members who were not bothered by lack of energy because of poor sleep and were positively satisfied with their sleep were more likely to report better health outcomes (e.g., healthier body mass index and higher ratings for psychosocial status and overall health), routinely engage in physical activity, and less often report being overweight or obese (Lentino et al. 2013). Research suggests that sleep wellness is also associated with greater levels of motivation, improved cognitive performance (Ritland et al. 2019), and decreased psychological distress (Hansen et al. 2018). A systematic review of the physical activity literature concluded that engaging in regular physical activity is associated with more desirable health outcomes including better general and health-related quality of life, functional capacity, and positive mood (Penedo and Dahn 2005). Optimal nutrition is also important for Soldiers' health (Purvis et al. 2013), performance, and recovery from injury (Hill et al. 2011).

Conversely, insufficient sleep, both in quality and quantity, is associated with negative health outcomes. People who do not get enough sleep are susceptible to cognitive issues such as incomplete memory formation, poor attention, and difficulty concentrating and learning (Ellenbogen 2005). Physical effects, such as obesity, and behavioral effects, such as depression, are associated with lack of sleep (Troxel et al. 2015). Furthermore, physical activity and nutritional deficits are associated with increased rates of overweight and obese Soldiers in the U.S. Army (Dall et al. 2007).

Given the independent benefits of each SAN behavior, it is important to understand the interrelation of these behaviors as well (Purvis et al. 2013). For example, one study found that sleep quality is most important for mental health and well-being, with physical activity and healthy nutrition providing secondary benefits (Wickham et al. 2020). These results suggest that individuals may prioritize good quality sleep to improve mental health and well-being and

emphasize the need for additional studies assessing whether a combination of SAN behaviors is associated with other health outcomes. Another study found that the odds of post-traumatic stress disorder (PTSD), suicide ideation, and serious psychological distress were lower for military service members who reported healthy sleep and physical activity behaviors (Perez et al. 2021). These results suggest that healthy sleep and physical activity are associated with positive behavioral health outcomes. Collectively, these studies suggest the need for additional studies assessing the combined effects of SAN behaviors.

1.3 Sleep, Activity, and Nutrition Benchmarks

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As part of its effort to promote healthy SAN behaviors, the U.S. Army has established minimum recommended thresholds for Soldiers based on official recommendations from both national organizations and the cited literature in this report. The Centers for Disease Control and Prevention (CDC) (2020a) and the National Sleep Foundation (2020) both recommend adults obtain at least 7 hours of sleep nightly. The CDC recommends two targets for physical activity: attaining adequate aerobic activity and 2 or more days per week of resistance training. Adults may attain adequate aerobic activity in one of three ways: 150 minutes a week of moderate-intensity aerobic activity, 75 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity (CDC 2020b). The U.S. Department of Agriculture (2015) recommends two or more servings of fruits and two or more servings of vegetables daily.

1.4 Sleep, Activity, and Nutrition Surveillance

The Health of the Force Report, an annual publication that provides a summary of health and readiness metrics for the U.S. Army Active Component Soldier population, summarizes the Azimuth Check (formerly the Global Assessment Tool (GAT)) data (DCPH-A 2023). The 2022 Health of the Force Report (which utilized 2021 Azimuth Check data) suggested that while most Soldiers met the thresholds for key measures of aerobic activity (88%) and resistance training (78%), fewer Soldiers met the thresholds for sleep and nutrition (DCPH-A 2023). The majority of Soldiers (68%) met the sleep threshold of at least 7 hours nightly during the weekend/non-duty nights; however, only about one-third of Soldiers (34%) reported attaining 7 or more hours of sleep on weeknights/duty nights. Additionally, less than half of Soldiers met the nutrition threshold of at least two servings of fruits (27%) and two servings of vegetables (38%) daily (DCPH-A 2023).

The Army has identified preventing musculoskeletal (MSK) injuries and select behavioral health outcomes (e.g., depression, alcohol misuse, PTSD) as priority foci for ensuring Soldier readiness (Curley et al. 2018; Curley and Warner 2017; Molloy et al. 2020). Specific SAN behaviors may be associated with these readiness-related health outcomes in a civilian setting but analyses on any empirical relationships for the Active Duty (AD) Soldier population are more limited.

1.5 Association between Sleep, Activity, and Nutrition and Musculoskeletal Injuries


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Research suggests that healthy SAN behaviors, such as resistance training and consuming recommended amounts of macro and micronutrients, can reduce the risk of MSK injury (Martin et al. 2018; Close et al. 2019). Published studies from military populations also found that both activity and sleep are associated with injury risk. For example, the literature suggests that Soldiers may modify physical training to mitigate the impact of activity on increased injury rates (Jones and Hauschild 2015). Additionally, data indicates that longer sleep duration may be associated with reduced risk of MSK injury among Soldiers (Grier et al. 2020).

1.6 Association between Sleep, Activity, and Nutrition and Behavioral Health


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Research also suggests that healthy SAN behaviors may reduce the risk of developing depression, anxiety, or PTSD (Mammen and Faulkner 2013; Radavelli-Bagatini et al. 2021; Hruby et al. 2021). A systematic review of the literature concluded that healthy physical activity and nutrition behaviors may reduce the risk of PTSD and increased physical activity might be beneficial to decrease PTSD symptoms (Hall et al. 2015; Rosenbaum et al. 2015). The relationship between SAN behaviors and alcohol use is less clear, as studies show mixed results with some finding significant associations between SAN behaviors and alcohol consumption, while others found no associations (Klingaman et al. 2018; Roehrs and Roth 2001; Brellenthin and Lee 2018; Kendzor et al. 2008). For example, some studies found a positive association between high alcohol consumption and insomnia, while others found that low doses of alcohol could improve sleep (Klingaman et al. 2018; Roehrs and Roth 2001). Additionally, while some studies found an association between reduced alcohol use and increased physical activity, there are mixed findings regarding the association between high alcohol consumption and physical activity, and one study found no association between increased physical activity and reduction of alcohol use (Brellenthin and Lee 2018; Kendzor et al. 2008).

Although the Army promotes combining improved SAN behaviors to increase Soldiers' health and readiness, no published studies have examined the synergy of AD Soldiers' SAN behaviors. Additionally, the Army has not investigated differences in, or the prevalence of, MSK injury and behavioral health outcomes between Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for SAN behaviors. This project examined the relationships between AD Soldiers' SAN behaviors and select readiness-related health outcomes.

1.7 Purpose

The purpose of this project was to assess the relationship between AD Soldiers' self-reported SAN behaviors and select injury and behavioral health outcomes. It is critical to assess the extent to which SAN behaviors interact so that the Army can design programs and policies to best support Soldiers.

The evaluation aimed to answer five questions:

1. What are the demographic and other characteristics of Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

2. What is the prevalence of select injury and behavioral health outcomes for Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

3. To what extent does the prevalence of select injury and behavioral health outcomes differ between groups of Soldiers with select demographic and other characteristics?

4. To what extent are sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes for Soldiers?

5. Is the interaction between sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes for Soldiers?

2 Methods

2.1 Overview

The project team used a cross-sectional design with secondary data from the GAT (as of October 2019, known as the Azimuth Check) and the Periodic Health Assessment (PHA) to assess the association between SAN behaviors and select injury and behavioral health outcomes among AD Soldiers. The project team linked Soldiers' demographic data from the Defense Manpower Data Center (DMDC) personnel rosters with SAN, injury, and behavioral health data from the GAT and PHA, respectively. The DCPH-A Public Health Review Board reviewed and approved this project as public health practice (Project Plan #21-964).

2.2 Population and Sample

The eligible population for this project included U.S. Army AD Soldiers who completed the GAT (*N* = 189,861) or PHA (*N* = 388,906) between 1 January and 31 December 2018 (Calendar Year 2018). The project team applied the following inclusion criteria to the GAT and PHA to focus analyses on the target population: Soldiers' consent for use of their data, selection of the Army branch, selection of AD status, and unique identifier in the DMDC that matched the unique identifier in the GAT and PHA, respectively. The final sample for this project included 174,351 Soldiers who completed the GAT and 322,491 Soldiers who completed the PHA. The flow chart below summarizes the inclusion criteria for this project (Figure 1).

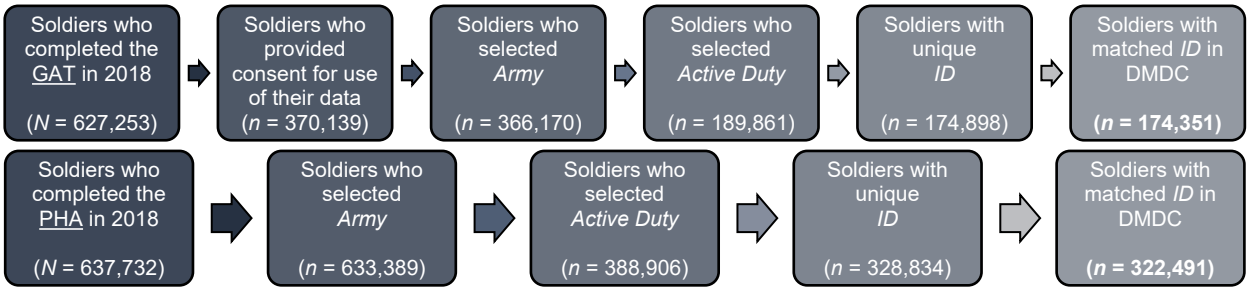

Figure 1. Summary of Inclusion Criteria

2.3 Data Sources

The project team used the self-reported data from the GAT and the PHA to examine the association between Soldiers' SAN behaviors and select injury and behavioral health outcomes, and the DMDC data to describe the sample and control for select demographic and other characteristics.

Army Regulation 350-53, *Comprehensive Soldier and Family Fitness*, requires Soldiers to complete the GAT annually (Department of the Army 2014), which is a self-reported questionnaire that assesses numerous domains, including sleep, activity, and nutrition. The questionnaire includes two sleep questions (sleep duration during the work/duty week and weekends/days off, respectively), eight activity questions (frequency and duration for vigorous activity, moderate activity, light activity, and resistance training, respectively), and two nutrition questions (amount and frequency for fruit and vegetable consumption, respectively). The GAT also includes one injury question (limited duty because of MSK injury), the Patient Health Questionnaire (PHQ-8) (Wu et al., 2019) to measure depression, and the Alcohol Use Disorders Identification Test-Concise (AUDIT-C) (Bush et al. 1998) to measure alcohol use.

The Department of Defense (DoD) Instruction 6200.06, *Periodic Health Assessment Program*, requires Soldiers to complete the PHA annually (DoD 2016), which includes a self-reported section completed by the Soldier and another section completed by a health care provider. For the purposes of this evaluation, the project team analyzed Soldiers' self-reported responses for sleep, activity, and nutrition behaviors. The questionnaire includes one sleep question (duration of sleep within the last 2 weeks), five activity questions capturing frequency and duration for vigorous and light or moderate activity, as well as number of days for muscle strengthening, and two nutrition questions (amount and frequency for fruit and vegetable consumption, respectively). The PHA also includes two muscle pain questions (whether the Soldier experienced muscle pain and whether on profile or limited duty for muscle pain), the PHQ-8 (Wu et al. 2019) to measure depression, the AUDIT-C (Bush et al. 1998) to measure alcohol use, the PTSD Checklist – Civilian version (PCL-C) (Bovin et al. 2016) to measure PTSD, and one life stressor question (whether the Soldier experienced major life stressors in the past month).

The DMDC is managed by the Office of the Secretary of Defense and is the gold standard to collect personnel, manpower, training, financial, and other data for the DoD. Neither the GAT nor the PHA contain robust demographic information, so the project team linked the DMDC demographic data with the GAT and PHA, respectively. The DMDC data included Soldiers' sex, age, rank, race, and marital status.

2.4 Data Analysis

The project team completed all analyses with Statistical Analysis Software Enterprise Guide (SAS® EG, Version 7.1) in the Person-Data Environment (PDE) housed by the U.S. Army Analytics Group (AAG). All U.S. Army AD Soldiers who participated in the GAT or PHA in CY2018 with linked DMDC demographic data were included in the analyses. Soldiers with missing data on a particular demographic characteristic, SAN domain[1], or outcome were omitted from analyses that included the demographic characteristic, domain, or outcome, but were included in other analyses, as appropriate. The list below summarizes the analyses for each guiding question (Figure 2).

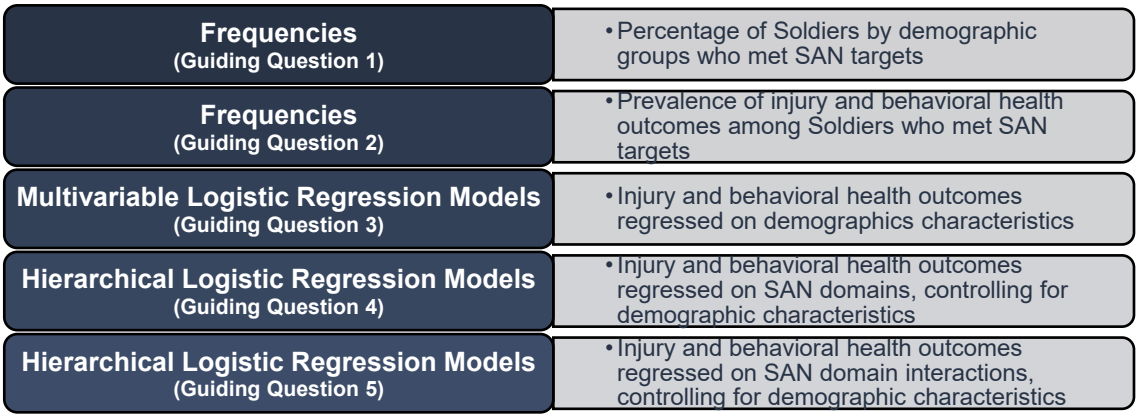

Figure 2. Summary of Analyses by Guiding Question

[1] The project team created SAN domains for Guiding Questions 4 and 5 by combining the separate SAN behaviors measured in the GAT and PHA, respectively. For example, the project team combined fruit and vegetable consumption to create the nutrition domain. These domains were created to reduce the number of regression models in the hierarchical modeling (thus simplifying the interpretation of the main effects) and to aid the interpretation of interaction effects in Guiding Question 5 by focusing on the combined effects of broader health behaviors rather than combinations of intricate related constructs that could contribute to collinearity in the models.

3 Results

3.1 Participant Characteristics

3.1.1 Demographics

A total sample of 174,351 Soldiers who completed the GAT and 322,491 Soldiers who completed the PHA were included in demographic analyses. The majority of Soldiers were male (84% (GAT), 85% (PHA)), younger than 35 years of age (76% (GAT and PHA)), Junior or Senior Enlisted (83% (GAT), 80% (PHA)), White (70% (GAT and PHA)), and married (57% (GAT and PHA)) (Figure 3).

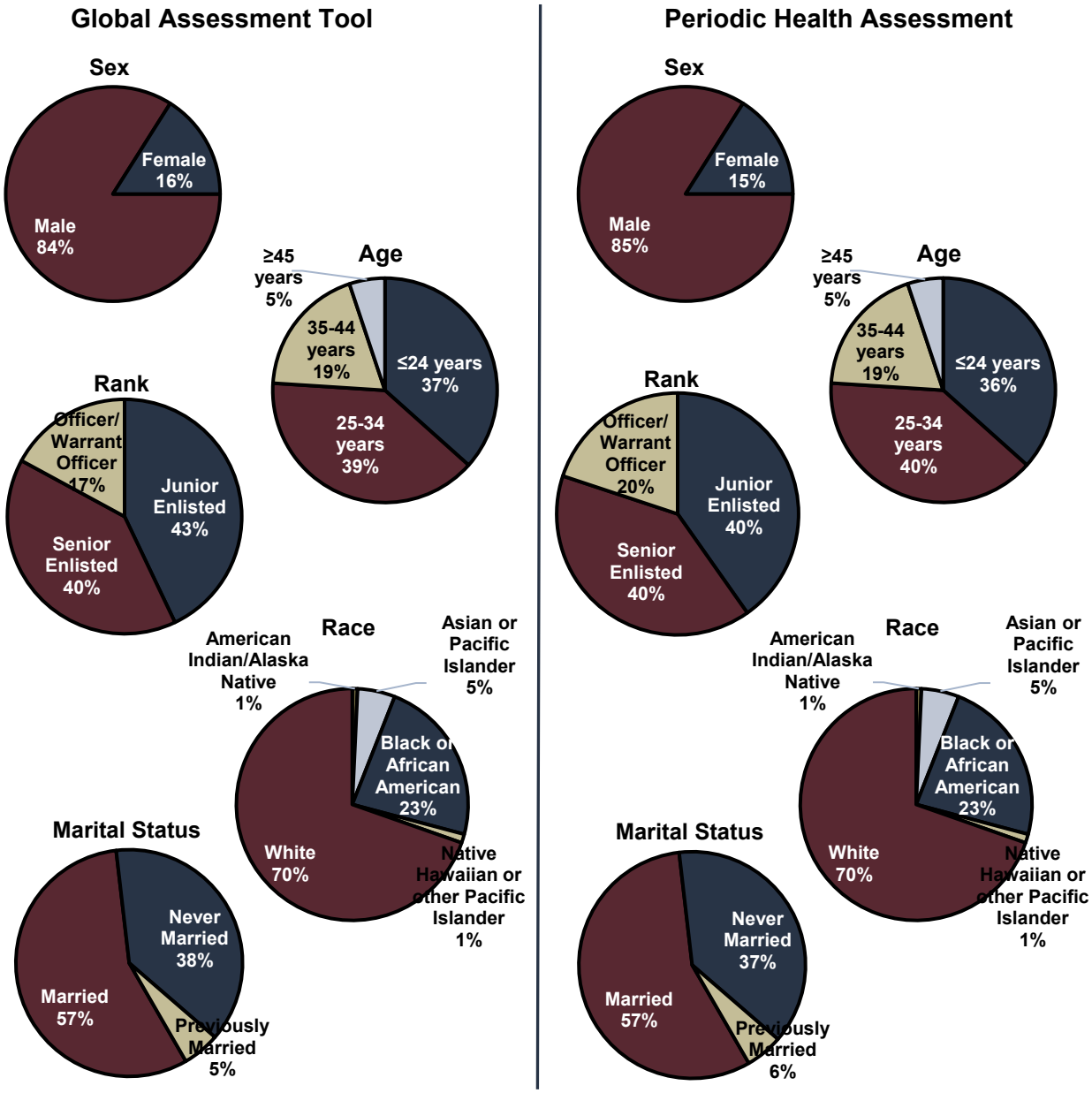

Figure 3. Soldiers' Demographic Characteristics (GAT *N* = 174,351; PHA *N* = 322,491)

3.1.2 Army Physical Fitness Test

About 25% of Soldiers (*n* = 131,216) reported that they knew their most recent Army Physical Fitness Test (APFT) score. Of the Soldiers who reportedly knew their APFT score, most Soldiers (93%) (*n* = 120,893) reported that they passed with a score ranging from 180 to 300. Given that most Soldiers reportedly passed their most recent APFT, the project team did not control for self-reported APFT scores in the hierarchical (sequential) multivariable logistic regression models because statistical comparisons with Soldiers who did not pass their most recent APFT could not be conducted.

3.1.3 Body Mass Index[2]

The project team computed Soldiers' body mass index (BMI) with Soldiers' self-reported weight (lb.) and height (in.) in the GAT (CDC 2022). Results indicated that about half of Soldiers (51%) were *overweight* (25.0–29.9), and 1 out of 3 Soldiers (35%) were *healthy weight* (18.5-24.9) (Figure 4). The project team controlled for BMI in the hierarchical (sequential) multivariable logistic regression models when injury data from the GAT was the outcome of interest because Soldiers with higher BMI may be on limited duty due to increased risk for MSK injury.[3]

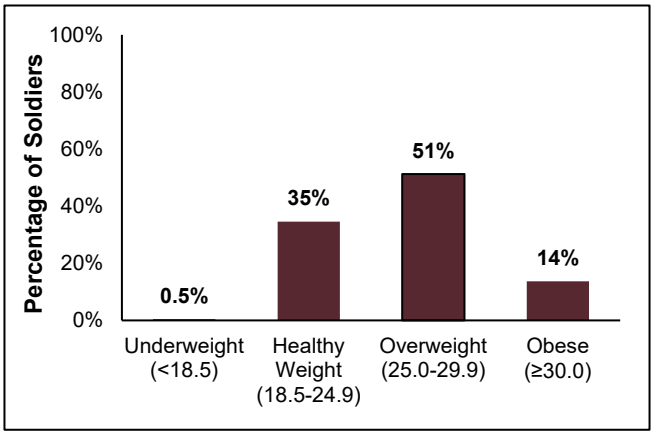

Figure 4. Percent of Soldiers by BMI Category (GAT) (*n* = 169,105)

3.2 Guiding Question 1: What are the demographic and other characteristics of Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

The project team conducted frequency distributions to report the percentage of Soldiers in each demographic group (i.e., sex, age, rank, race, and marital status) who met the minimum recommended thresholds for SAN behaviors.

3.2.1 Sleep

3.2.1.1 Global Assessment Tool

The GAT results indicated that a smaller percentage of Soldiers met the sleep target of 7 or more hours of sleep during the work/duty week than on weekends/days off. About 1 out of 3 Soldiers (39%) met the sleep target during the work/duty week, and 3 out of 4 Soldiers (75%) met the sleep target on the weekend/days off.

[2] BMI was computed by dividing weight in pounds (lb.) by height in inches (in.) squared and multiplying by a conversion factor of 703 (weight (lb.) / [height (in.)]^2 x 703).

[3] BMI may not be an accurate measurement of obesity in this population because it does not account for muscle mass. A full explanation of this limitation is included in the *Strengths and Limitations* section in the Discussion below (Page 39).

During the work/duty week, a similar percentage of male (38%) and female (40%) Soldiers met the sleep target. The percentage of Soldiers meeting the sleep target was also similar across all age (36–40%) groups. The demographic categories with the highest percentages of Soldiers who met the sleep target during work/duty weeks were Officers/Warrant Officers (49%), White (41%) or American Indian/Alaska Native (41%), married (39%) or never married (40%), and healthy weight (41%) or overweight (39%).

During weekends/days off, a similar percentage of male (75%) and female (76%) Soldiers met the sleep target. The demographic categories with the highest percentages of Soldiers who met the sleep target during weekends/days off were younger than 35 years of age (76–78%), Officers/Warrant Officers (84%), White (78%), Asian or Pacific Islander (78%), American Indian/Alaska Native (76%), never married (78%), and healthy weight (78%) or overweight (75%).

3.2.1.2 Periodic Health Assessment

The PHA results indicated that 1 out of 4 Soldiers (28%) met the sleep target of 7 or more hours of sleep. A similar percentage of male (28%) and female (27%) Soldiers met the sleep target. The demographic categories with the highest percentages of Soldiers who met the sleep target were younger than 24 years of age (32%), Junior Enlisted (31%) or Officer/Warrant Officer (32%), White (30%) or American Indian/Alaska Native (29%), and never married (32%).

3.2.2 Activity

3.2.2.1 Global Assessment Tool

The GAT results indicated that the majority of Soldiers met the activity targets of engaging in adequate aerobic activity and resistance training. Most Soldiers (95%) met the aerobic activity target because they engaged in adequate moderate/vigorous activity. The majority of Soldiers (84%) met the resistance activity target because they engaged in resistance training 2 or more days per week.

A similar percentage of male (95%) and female (93%) Soldiers met the aerobic activity target. The percentage of Soldiers meeting the aerobic activity target was also similar across all age (93–95%), rank (95%), race (93–96%), and marital status (94–95%) groups. A similar percentage of Soldiers who were healthy weight, overweight, or obese (94–95%) also met the aerobic activity target.

The demographic categories with the highest percentages of Soldiers who met the resistance activity target were male (85%), younger than 35 years of age (85–86%) and married (83%) or never married (86%). The percentage of Soldiers meeting the resistance activity target was similar across all rank (83–85%), and race (82–85%) groups. A similar percentage of Soldiers who were healthy weight, overweight, or obese (83–85%) also met the resistance activity target.

3.2.2.2 Periodic Health Assessment

The PHA results indicated that the majority of Soldiers met the activity targets of engaging in adequate aerobic activity and strength[4] training, respectively. Most Soldiers (92%) met the aerobic activity target because they achieved adequate moderate/vigorous activity. The majority of Soldiers (87%) met the resistance activity target because they engaged in strength training 2 or more days per week.

A similar percentage of male (92%) and female (90%) Soldiers met the aerobic activity target. The percentage of Soldiers meeting the aerobic activity target was also similar across all age (90-93%) and marital status (91–92%) groups. The demographic categories with the highest percentages of Soldiers who met the aerobic activity target were Senior Enlisted (92%), Officers/Warrant Officers (95%), White (93%), American Indian/Alaska Native (92%), Asian or Pacific Islander (92%), or Native Hawaiian or other Pacific Islander (90%).

The demographic categories with the highest percentages of Soldiers who met the resistance activity target were male (89%), younger than 35 years of age (87-89%), Native Hawaiian or other Pacific Islander (90%), American Indian/Alaska Native (89%), or White (88%). The percentage of Soldiers meeting the resistance activity target was similar across all rank (86-89%) and marital status (86-88%) groups.

3.2.3 Nutrition

3.2.3.1 Global Assessment Tool

The GAT results indicated that less than half of Soldiers met the nutrition targets of consuming two or more servings of fruits or vegetables, respectively, per day. About 1 out of 3 Soldiers (36%) met the fruit consumption target because they consumed two or more servings of fruits per day. Less than half of Soldiers (46%) met the vegetable consumption target because they consumed two or more servings of vegetables per day.

The demographic categories with the highest percentages of Soldiers who met the fruit consumption target were female (39%), Officers/Warrant Officers (41%) or Junior Enlisted (39%), never married (39%), healthy weight (38%) or overweight (36%). The percentage of Soldiers meeting the fruit consumption target was similar across all age (34–38%) and race (34-37%) groups.

The demographic categories with the highest percentages of Soldiers who met the vegetable consumption target were female (49%), Officers/Warrant Officers (56%), White (48%), American Indian/Alaska Native (46%), or Asian or Pacific Islander (46%). The percentage of Soldiers meeting the vegetable consumption target was similar across all age (44-47%) and marital status (44–46%) groups. A similar percentage of Soldiers who were healthy weight, overweight, or obese (43–46%) also met the resistance activity target.

[4] The GAT asks Soldiers to report the *number of days per week that* they *performed resistance training activity in the last 30 days*, and the PHA asks Soldiers to report the *number of days per week they engaged in physical activities specifically designed to their strengthen muscles*. For the purposes of this project, the strength training measured in the PHA determined if Soldiers met the resistance activity target.

3.2.3.2 Periodic Health Assessment

The PHA results indicated that less than half of Soldiers met the nutrition targets of consuming two or more servings of fruits or vegetables, respectively, per day. Nearly 1 out of 4 Soldiers (24%) met the fruit consumption target because they consumed two or more servings of fruits per day. About 1 out of 3 Soldiers (35%) met the vegetable consumption target because they consumed two or more servings of vegetables per day.

The demographic categories with the highest percentages of Soldiers who met the fruit consumption target were female (29%), Officers/Warrant Officers (31%), White (25%), Black or African American (24%), or American Indian/Alaska Native (24%). The percentage of Soldiers meeting the fruit consumption target was similar across all age (22–25%) and marital status (24%) groups.

The demographic categories with the highest percentages of Soldiers who met the vegetable consumption target were female (40%), older than 24 years of age (38–41%), Officers/Warrant Officers (48%), White (37%) or American Indian/Alaska Native (34%), and married (37%) or previously married (37%).

Summary: What are the demographic and other characteristics of Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

The demographic and other characteristics of Soldiers who met the minimum recommended thresholds for sleep, activity, and nutrition were consistent across demographic groups for many behaviors. The distribution of Soldiers meeting minimum recommended thresholds was inconsistent across demographic groups for aerobic activity and resistance training (age and rank), fruit consumption (age, race, and marital status), and vegetable consumption (marital status).

3.3 Guiding Question 2: What is the prevalence of select injury and behavioral health outcomes for Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

The project team conducted frequency distributions to report the prevalence of select injury and behavioral outcomes among Soldiers who meet and do not meet the minimum recommended thresholds for SAN behaviors. The injury outcomes of interest included limited duty because of MSK injury (GAT) and profile or limited duty for muscle pain (PHA). The behavioral health outcomes of interest included depression (GAT and PHA), hazardous alcohol consumption (GAT and PHA), PTSD (PHA), and life stressors (PHA).

3.3.1 Injury Outcomes

3.3.1.1 Limited Duty because of Musculoskeletal Injury

The GAT results indicated that 1 out of 3 Soldiers (36%) were on limited duty because of MSK injury. Among Soldiers who met SAN targets, the prevalence of being on limited duty because of MSK injury ranged from 29-35% across SAN metrics (Figure 5). The prevalence of limited duty because of MSK injury was higher among Soldiers who did not meet SAN targets.

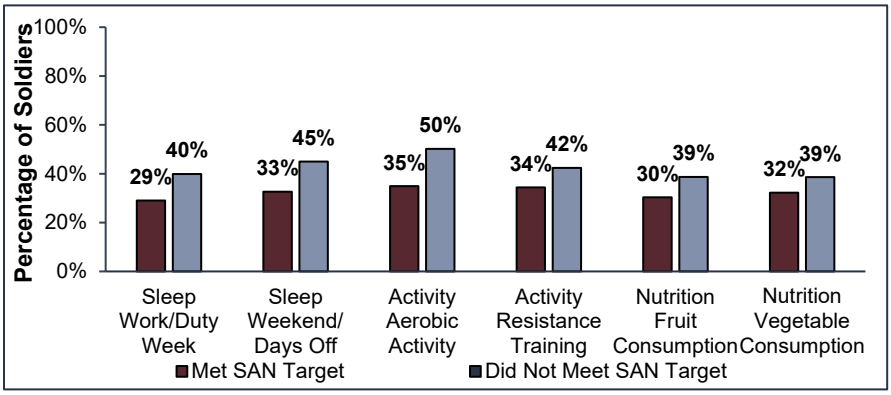

Figure 5. Prevalence of LIMDU because of MSK Injury among Soldiers who Met or Did Not Meet SAN Targets (GAT)
(*N* = 174,258)

3.3.1.2 Profile or Limited Duty for Muscle Pain

The PHA results indicated that 1 out of 3 Soldiers (34%, *n* = 109,541) experienced recurring muscle, joint, or low back pain. Of these Soldiers, 31% reported they were on profile or limited duty. Among Soldiers who met SAN targets, the prevalence of being on profile or limited duty for muscle pain ranged from 27-31% across SAN metrics (Figure 6). The prevalence of being on profile or limited duty for muscle pain was higher among Soldiers who did not meet sleep or activity targets. Nearly 1 out of 3 Soldiers were on profile or limited duty for muscle pain, irrespective of whether they met the nutrition targets (Figure 6).

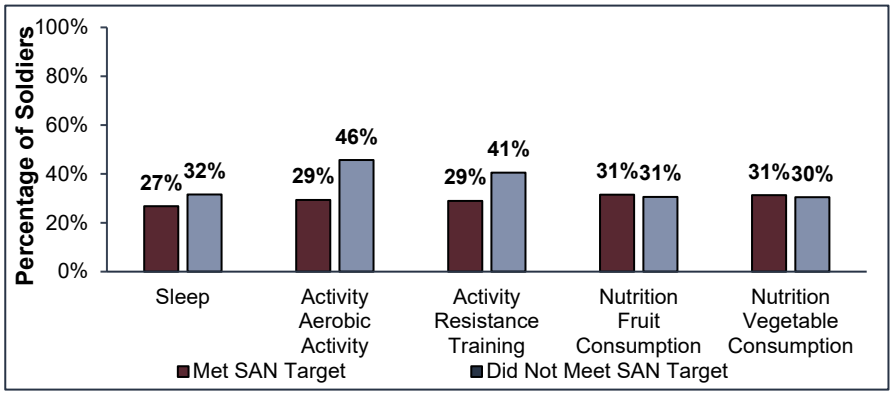

Figure 6. Prevalence of Profile or LIMDU for Muscle Pain among Soldiers who Met or Did Not Meet SAN Targets (PHA)
(*N* = 109,541)

3.3.2 Behavioral Health Outcomes

3.3.2.1 Depression[5]

The GAT results indicated that 1 out of 7 Soldiers (14%) screened positive for depression. Among Soldiers who met SAN targets, the prevalence of screening positive for depression ranged from 8-13% across SAN metrics (Figure 7). The prevalence of screening positive for depression was higher among Soldiers who did not meet SAN targets.

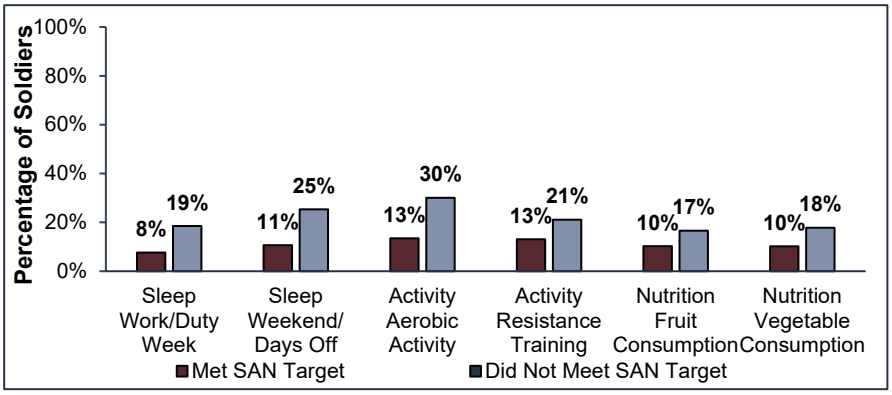

Figure 7. Prevalence of Screening Positive for Depression among Soldiers who Met or Did Not Meet SAN Targets (GAT) (*N* = 174,254)

The PHA results indicated that 5% of Soldiers screened positive for depression. Among Soldiers who met SAN targets, the prevalence of screening positive for depression ranged from 1-5% across SAN metrics (Figure 8). The prevalence of screening positive for depression was higher among Soldiers who did not meet sleep or activity targets. A similar percentage of Soldiers screened positive for depression, irrespective of whether they met nutrition targets (Figure 8).

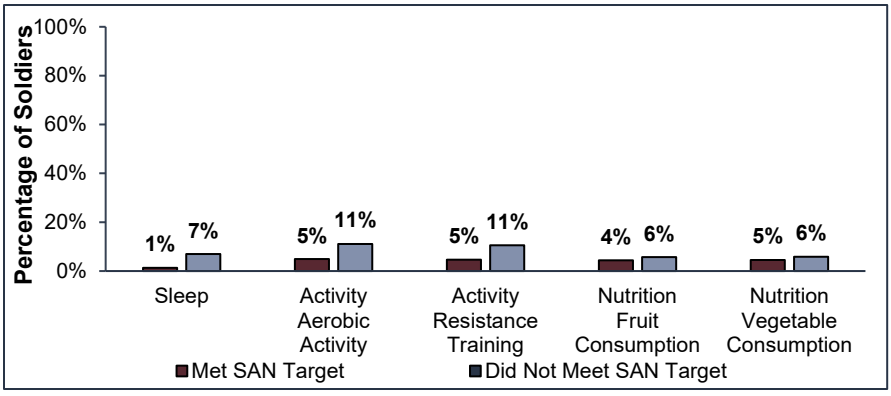

Figure 8. Prevalence of Screening Positive for Depression among Soldiers who Met or Did Not Meet SAN Targets (PHA) (*N* = 322,054)

[5] Soldiers' behavioral health symptom scores for depression were measured with the Patient Health Questionnaire (PHQ-8) (Wu et al., 2019) in the GAT and PHA.

3.3.2.2 Hazardous Alcohol Consumption[6]

The GAT results indicated that the majority of Soldiers (61%, *n* = 106,399) drink alcohol. Of these Soldiers, 33% had unhealthy alcohol use. Among Soldiers who met SAN targets, the prevalence of unhealthy alcohol use ranged from 28–32% across SAN metrics (Figure 9). The prevalence of unhealthy alcohol use was higher among Soldiers who did not meet SAN targets.

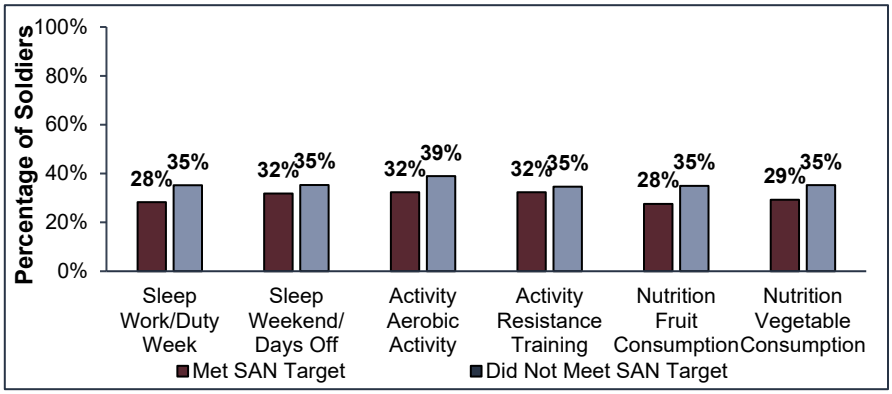

Figure 9. Prevalence of Unhealthy Alcohol Use among Soldiers who Met or Did Not Meet SAN Targets (GAT) (*N* = 106,399)

Similarly, the PHA results indicated that the majority of Soldiers (66%, *n* = 211,698) drink alcohol. Of these Soldiers, 22% had unhealthy alcohol use. Among Soldiers who met SAN targets, the prevalence of unhealthy alcohol use ranged from 17–21% across SAN metrics (Figure 10). The prevalence of unhealthy alcohol use was higher among Soldiers who did not meet sleep or nutrition targets. A similar percentage of Soldiers had unhealthy alcohol use, irrespective of whether they met activity targets (Figure 10).

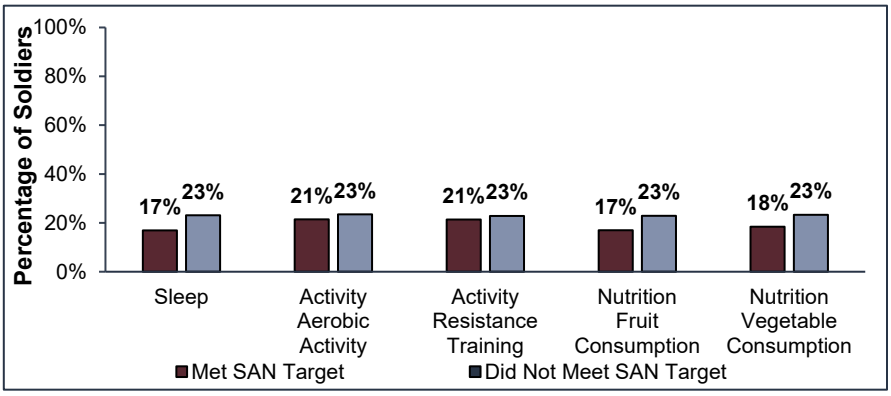

Figure 10. Prevalence of Unhealthy Alcohol Use among Soldiers who Met or Did Not Meet SAN Targets (PHA) (*N* = 211,698)

[6] Soldiers' alcohol consumption was measured with the Alcohol Use Disorders Identification Test-Concise (AUDIT-C) (Bush et al. 1998) in the GAT and PHA.

3.3.2.3 Post-traumatic Stress Disorder[7]

The PHA results indicated that 6% of Soldiers (*n* = 20,792) screened positive for PTSD. Of these Soldiers, 45% experienced mild, moderate, or severe symptoms. Among Soldiers who met SAN targets, the prevalence of experiencing PTSD symptoms ranged from 25–48% across SAN metrics (Figure 11). The prevalence of experiencing PTSD symptoms was higher among Soldiers who did not meet sleep or activity targets but met the fruit consumption target. A similar percentage of Soldiers experienced PTSD symptoms, irrespective of whether they met the vegetable consumption target (Figure 11).

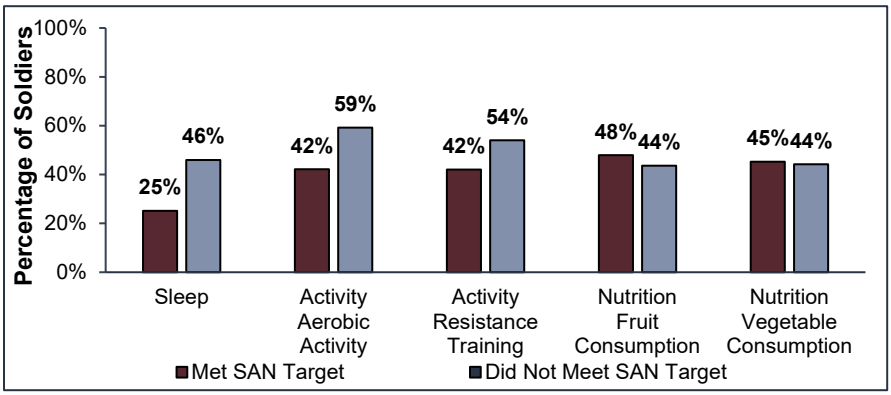

Figure 11. Prevalence of Experiencing PTSD Symptoms among Soldiers who Met or Did Not Meet SAN Targets (PHA) (*N* = 20,656)

3.3.2.4 Life Stressors

The PHA results indicated that 1 out of 10 Soldiers (10%) experienced life stressors. Among Soldiers who met SAN targets, the prevalence of experiencing life stressors ranged from 3–9% across SAN metrics (Figure 12). The prevalence of experiencing life stressors was higher among Soldiers who did not meet sleep or activity targets. A similar percentage of Soldiers experienced life stressors, irrespective of whether they met nutrition targets (Figure 12).

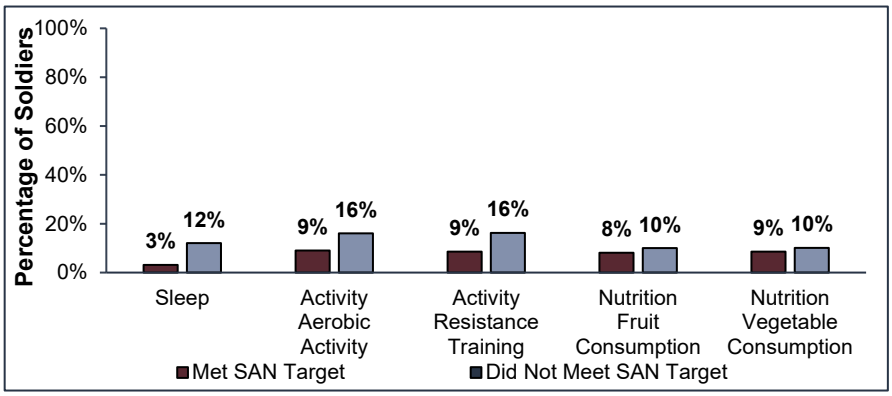

Figure 12. Prevalence of Experiencing Life Stressors among Soldiers who Met or Did Not Meet SAN Targets (PHA) (*N* = 322,031)

[7] Soldiers' behavioral health symptom scores for PTSD were measured with the PTSD Checklist – Civilian version (PCL-C) (Bovin et al., 2016) in the PHA.

Summary: What is the prevalence of select injury and behavioral health outcomes for Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

The prevalence of select injury and behavioral outcomes was lower among Soldiers who met sleep, activity, or nutrition targets in both the GAT and PHA. For injury, the prevalence of being on limited duty for MSK injury or muscle pain was lower among Soldiers who met sleep or activity targets. The GAT also indicated a lower prevalence of being on limited duty for MSK injury among Soldiers who met nutrition targets.

For behavioral health, the prevalence of depression and unhealthy alcohol use was lower among Soldiers who met sleep, activity, or nutrition targets in the GAT. The prevalence of screening positive for depression, experiencing PTSD symptoms or life stressors was lower among Soldiers who met sleep or activity targets in the PHA. The prevalence of unhealthy alcohol use was lower among Soldiers who met sleep or nutrition targets in the PHA.

3.4 Guiding Question 3: To what extent does the prevalence of select injury and behavioral health outcomes differ between groups of Soldiers with select demographic and other characteristics?

The project team conducted multivariable logistic regression analyses to assess predictors on select injury and behavioral health outcomes. The demographic predictors in each model included: sex (male or female), age (24 years or younger, 25–34 years, 35–44 years, or 45 years or older), rank group (Junior Enlisted, Senior Enlisted, or Officer/Warrant Officer), race (White, American Indian/Alaska Native, Asian or Pacific Islander, Black or African American, or Native Hawaiian or Other Pacific Islander), and marital status (never married, married, or previously married). Each category within a demographic variable was statistically compared to a reference category holding all other demographic variables constant. For the purposes of these analyses, the project team dichotomized injury and behavioral health outcomes into two categories: yes (presence of injury or behavioral health issue) or no (absence of injury or behavioral health issue). Figure 13 describes the regression analyses.

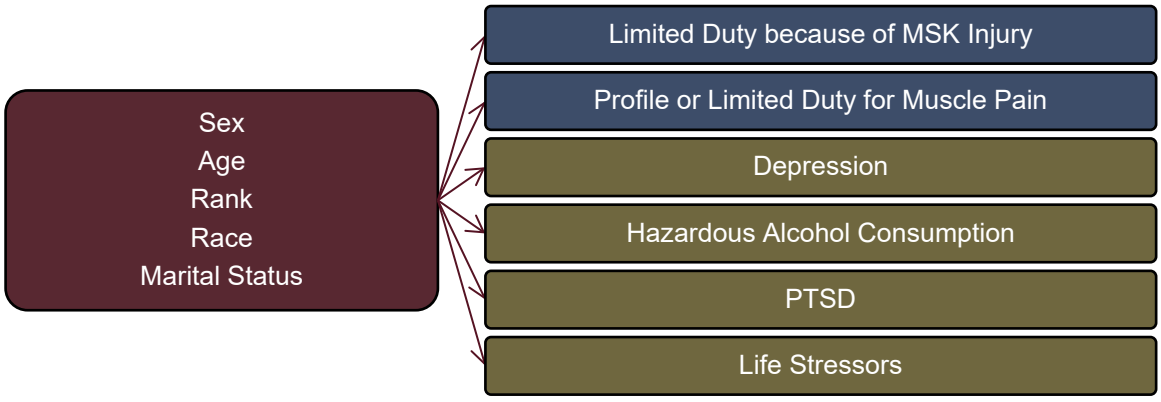

Figure 13. Demographic Predictors of Injury and Behavioral Health Outcomes

3.4.1 Injury Outcomes

3.4.1.1 Limited Duty because of Musculoskeletal Injury

The GAT results indicated that limited duty because of MSK injury statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of reporting they were on limited duty because of MSK injury if they were female, older than 24 years of age, Black or African American, and married or previously married. Senior Enlisted Soldiers and Officers/Warrant Officers were less likely to report they were on limited duty because of MSK injury. Table 1 summarizes these differences by demographic group.

Table 1. Demographic Profile for Limited Duty because of MSK Injury (GAT; *N* = 166,629)

Predictor Variable	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Sex (Ref = Male)	0.46	0.01	<.0001	1.58 [1.53, 1.62]
Age (Ref = ≤ 24 years)				
25-34 years	0.36	0.02	<.0001	1.43 [1.39, 1.48]
35-44 years	0.91	0.02	<.0001	2.47 [2.38, 2.57]
≥ 45 years	1.23	0.03	<.0001	3.42 [3.24, 3.62]
Rank Group (Ref = Junior Enlisted)				
Senior Enlisted	-0.17	0.02	<.0001	0.85 [0.82, 0.87]
Officer/Warrant Officer	-0.56	0.02	<.0001	0.57 [0.55, 0.60]
Race (Ref = White)				
American Indian/Alaska Native	0.08	0.06	0.167	1.09 [0.97, 1.23]
Asian or Pacific Islander	0.04	0.02	0.0783	1.04 [1.00, 1.09]
Black or African American	0.18	0.01	<.0001	1.20 [1.17, 1.23]
Native Hawaiian or Other Pacific Islander	-0.10	0.05	0.0457	0.91 [0.83, 1.00]
Marital Status (Ref = Never Married)				
Married	0.35	0.01	<.0001	1.42 [1.38, 1.45]
Previously Married	0.35	0.03	<.0001	1.43 [1.36, 1.50]

Legend:
MSK = musculoskeletal *B* = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval

3.4.1.2 Profile or Limited Duty for Muscle Pain

The PHA results indicated that any profile or limited duty for muscle pain statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of reporting they were on profile or limited duty for muscle pain if they were female, older than 24 years of age, Black or African American, Native Hawaiian or Other Pacific Islander, and married or previously married. Senior Enlisted Soldiers and Officers/Warrant Officers were less likely to report they were on profile or limited duty for muscle pain. Table 2 summarizes these differences by demographic group.

Table 2. Demographic Profile for Profile or Limited Duty for Muscle Pain (PHA; *N* = 102,269)

Predictor Variable	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Sex (Ref = Male)	0.40	0.02	<.0001	1.49 [1.44, 1.55]
Age (Ref = ≤ 24 years)				
25-34 years	0.41	0.02	<.0001	1.51 [1.44, 1.58]
35-44 years	0.95	0.03	<.0001	2.58 [2.44, 2.73]
≥ 45 years	1.43	0.03	<.0001	4.19 [3.92, 4.48]
Rank Group (Ref = Junior Enlisted)				
Senior Enlisted	-0.58	0.02	<.0001	0.56 [0.54, 0.59]
Officer/Warrant Officer	-1.03	0.03	<.0001	0.36 [0.34, 0.38]
Race (Ref = White)				
American Indian/Alaska Native	0.00	0.08	0.9517	1.01 [0.86, 1.17]
Asian or Pacific Islander	0.02	0.03	0.5575	1.02 [0.96, 1.08]
Black or African American	0.24	0.02	<.0001	1.27 [1.23, 1.31]
Native Hawaiian or Other Pacific Islander	0.14	0.06	0.0169	1.15 [1.03, 1.29]
Marital Status (Ref = Never Married)				
Married	0.22	0.02	<.0001	1.25 [1.20, 1.30]
Previously Married	0.24	0.03	<.0001	1.27 [1.20, 1.35]

Legend:
B = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval

3.4.2 Behavioral Health Outcomes

3.4.2.1 Depression

The GAT results indicated that depression statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of screening positive for depression if they were older than 34 years of age, Asian or Pacific Islander, Black or African American, or previously married. Females, Senior Enlisted Soldiers, Officers/Warrant Officers, and married Soldiers were less likely to screen positive for depression.

The PHA results indicated that depression statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of screening positive for depression if they were female, older than 24 years of age, Asian or Pacific Islander, Black or African American, and married or previously married. Senior Enlisted Soldiers and Officers/Warrant Officers were less likely to screen positive for depression. Table 3 summarizes these differences by demographic group for the GAT and PHA, respectively.

Table 3. Demographic Profile for Depression (GAT *N* = 166,625; PHA *N* = 307,385)

	GAT				PHA			
Predictor Variable	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**
Sex (Ref = Male)	-0.07	0.02	0.0008	0.94 [0.90, 0.97]	0.23	0.02	<.0001	1.26 [1.21, 1.31]
Age (Ref = ≤ 24 years)								
25-34 years	-0.03	0.02	0.1719	0.97 [0.94, 1.01]	0.20	0.02	<.0001	1.23 [1.17, 1.29]
35-44 years	0.16	0.03	<.0001	1.17 [1.11, 1.24]	0.81	0.03	<.0001	2.24 [2.11, 2.38]
≥ 45 years	0.12	0.04	0.0032	1.13 [1.04, 1.23]	0.95	0.04	<.0001	2.58 [2.37, 2.80]
Rank Group (Ref = Junior Enlisted)								
Senior Enlisted	-0.28	0.02	<.0001	0.75 [0.73, 0.78]	-0.49	0.02	<.0001	0.62 [0.59, 0.64]
Officer/Warrant Officer	-0.98	0.03	<.0001	0.37 [0.35, 0.40]	-1.26	0.03	<.0001	0.29 [0.27, 0.30]
Race (Ref = White)								
American Indian/Alaska Native	0.12	0.08	0.1383	1.13 [0.96, 1.32]	0.10	0.09	0.279	1.11 [0.92, 1.33]
Asian or Pacific Islander	0.29	0.03	<.0001	1.34 [1.26, 1.42]	0.24	0.04	<.0001	1.27 [1.19, 1.37]
Black or African American	0.31	0.02	<.0001	1.36 [1.32, 1.41]	0.56	0.02	<.0001	1.74 [1.68, 1.81]
Native Hawaiian or Other Pacific Islander	0.12	0.06	0.0488	1.13 [1.00, 1.28]	0.06	0.07	0.4315	1.06 [0.92, 1.23]
Marital Status (Ref = Never Married)								
Married	-0.07	0.02	<.0001	0.93 [0.90, 0.97]	0.20	0.02	<.0001	1.22 [1.17, 1.28]
Previously Married	0.14	0.03	<.0001	1.15 [1.08, 1.23]	0.53	0.04	<.0001	1.70 [1.58, 1.82]

Legend:
B = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval

3.4.2.2 Hazardous Alcohol Consumption

The GAT results indicated that hazardous alcohol consumption statistically differed by sex, age, race, and marital status. Females and Native Hawaiian or Other Pacific Islander Soldiers had greater odds of screening positive for hazardous alcohol consumption. Soldiers who were older than 24 years of age, Asian or Pacific Islander, Black or African American, married, or previously married were less likely to screen positive for hazardous alcohol consumption.

The PHA results indicated that hazardous alcohol consumption statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of screening positive for hazardous alcohol consumption if they were American Indian/Alaska Native, or Native Hawaiian or Other Pacific Islander. Soldiers were less likely to screen positive for hazardous alcohol consumption if they were female, older than 24 years of age, Senior Enlisted or Officer/Warrant Officer, Asian or Pacific Islander, Black or African American, married, or previously married. Table 4 summarizes these differences by demographic group for the GAT and PHA, respectively.

Table 4. Demographic Profile for Hazardous Alcohol Consumption (GAT *N* = 100,914; PHA *N* = 200,847)

	GAT				PHA			
Predictor Variable	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**
Sex (Ref = Male)	0.05	0.02	0.0082	1.05 [1.01, 1.09]	-0.09	0.02	<.0001	0.92 [0.89, 0.95]
Age (Ref = ≤ 24 years)								
25-34 years	-0.42	0.02	<.0001	0.65 [0.63, 0.68]	-0.49	0.01	<.0001	0.61 [0.60, 0.63]
35-44 years	-0.49	0.02	<.0001	0.61 [0.58, 0.64]	-0.47	0.02	<.0001	0.62 [0.60, 0.65]
≥ 45 years	-0.68	0.04	<.0001	0.51 [0.47, 0.55]	-0.66	0.03	<.0001	0.52 [0.49, 0.55]
Rank Group (Ref = Junior Enlisted)								
Senior Enlisted	-0.03	0.02	0.1398	0.97 [0.94, 1.01]	-0.11	0.01	<.0001	0.90 [0.87, 0.92]
Officer/Warrant Officer	0.02	0.02	0.4019	1.02 [0.98, 1.06]	-0.36	0.02	<.0001	0.70 [0.68, 0.73]
Race (Ref = White)								
American Indian/Alaska Native	-0.01	0.08	0.8593	0.99 [0.84, 1.16]	0.13	0.06	0.0402	1.13 [1.01, 1.28]
Asian or Pacific Islander	-0.35	0.03	<.0001	0.70 [0.66, 0.75]	-0.21	0.03	<.0001	0.81 [0.77, 0.85]
Black or African American	-0.28	0.02	<.0001	0.75 [0.73, 0.78]	-0.22	0.01	<.0001	0.80 [0.78, 0.82]
Native Hawaiian or Other Pacific Islander	0.13	0.06	0.036	1.14 [1.01, 1.28]	0.39	0.05	<.0001	1.48 [1.35, 1.61]
Marital Status (Ref = Never Married)								
Married	-0.31	0.02	<.0001	0.74 [0.71, 0.76]	-0.35	0.01	<.0001	0.71 [0.69, 0.73]
Previously Married	-0.16	0.03	<.0001	0.85 [0.80, 0.90]	-0.15	0.03	<.0001	0.86 [0.82, 0.91]

Legend:
B = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval

3.4.2.3 Post-traumatic Stress Disorder

The PHA results indicated that PTSD statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of screening positive for PTSD if they were female, older than 24 years of age, Asian or Pacific Islander, Black or African American, Native Hawaiian or Other Pacific Islander, married, or previously married. Senior Enlisted Soldiers and Officers/Warrant Officers were less likely to screen positive for PTSD. Table 5 summarizes these differences by demographic group.

Table 5. Demographic Profile for PTSD (PHA; *N* = 18,897)

Predictor Variable	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**
Sex (Ref = Male)	0.17	0.04	<.0001	1.18 [1.10, 1.27]
Age (Ref = ≤ 24 years)				
25-34 years	0.27	0.05	<.0001	1.31 [1.18, 1.45]
35-44 years	0.50	0.06	<.0001	1.66 [1.47, 1.87]
≥ 45 years	0.55	0.07	<.0001	1.73 [1.50, 2.00]
Rank Group (Ref = Junior Enlisted)				
Senior Enlisted	-0.36	0.05	<.0001	0.70 [0.63, 0.77]
Officer/Warrant Officer	-0.63	0.06	<.0001	0.53 [0.47, 0.60]
Race (Ref = White)				
American Indian/Alaska Native	-0.03	0.15	0.8332	0.97 [0.71, 1.31]
Asian or Pacific Islander	0.31	0.07	<.0001	1.36 [1.20, 1.55]
Black or African American	0.51	0.03	<.0001	1.67 [1.57, 1.78]
Native Hawaiian or Other Pacific Islander	0.38	0.13	0.0041	1.47 [1.13, 1.91]
Marital Status (Ref = Never Married)				
Married	0.11	0.04	0.0142	1.12 [1.02, 1.22]
Previously Married	0.26	0.06	<.0001	1.30 [1.15, 1.47]

Legend:
B = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval

3.4.2.4 Life Stressors

The PHA results indicated that experiencing a major life stressor over the past month statistically differed by sex, age, rank, race, and marital status. Soldiers had greater odds of experiencing a major life stressor if they were female, older than 24 years of age, American Indian/Alaska Native, Asian or Pacific Islander, Black or African American, married, or previously married. Senior Enlisted Soldiers and Officers/Warrant Officers were less likely to report experiencing a major life stressor. Table 6 summarizes these differences by demographic group.

Table 6. Demographic Profile for Life Stressors (PHA; *N* = 307,364)

Predictor Variable	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Sex (Ref = Male)	0.40	0.02	<.0001	1.50 [1.45, 1.54]
Age (Ref = ≤ 24 years)				
25-34 years	0.26	0.02	<.0001	1.30 [1.25, 1.35]
35-44 years	0.88	0.02	<.0001	2.42 [2.31, 2.54]
≥ 45 years	1.17	0.03	<.0001	3.22 [3.03, 3.43]
Rank Group (Ref = Junior Enlisted)				
Senior Enlisted	-0.35	0.02	<.0001	0.70 [0.68, 0.73]
Officer/Warrant Officer	-0.87	0.02	<.0001	0.42 [0.40, 0.44]
Race (Ref = White)				
American Indian/Alaska Native	0.18	0.07	0.0101	1.20 [1.04, 1.37]
Asian or Pacific Islander	0.19	0.03	<.0001	1.21 [1.15, 1.28]
Black or African American	0.43	0.01	<.0001	1.54 [1.49, 1.58]
Native Hawaiian or Other Pacific Islander	0.00	0.06	0.9318	1.01 [0.90, 1.12]
Marital Status (Ref = Never Married)				
Married	0.54	0.02	<.0001	1.71 [1.66, 1.77]
Previously Married	0.82	0.03	<.0001	2.27 [2.15, 2.40]

Legend:
B = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval

Summary: To what extent does the prevalence of select injury and behavioral health outcomes differ between groups of Soldiers with select demographic and other characteristics?

Injury and behavioral health outcomes statistically differed by sex, age, rank, race, and marital status in the GAT and PHA. Rank may be a protective factor for injury outcomes, depression, and PTSD, as Senior Enlisted Soldiers and Officers/Warrant Officers were *less* likely to report being on limited duty because of MSK injury or muscle pain, screen positive for depression, screen positive for PTSD, or report experiencing major life stressors.

3.5 Guiding Question 4: To what extent are sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes?

The project team conducted hierarchical (sequential) multivariable logistic regression analyses to assess the extent to which SAN domains were associated with injury and behavioral health outcomes, controlling for demographic characteristics (sex, age, rank, race, and marital status). Additionally, the project team controlled for BMI in the regression models where limited duty because of MSK injury, as measured in the GAT, was the outcome of interest. The first block included an injury or behavioral health outcome regressed on each SAN domain separately.

The second block included an injury or behavioral health outcome regressed on each SAN domain separately and all demographic characteristics. Figure 14 describes the regression analyses.

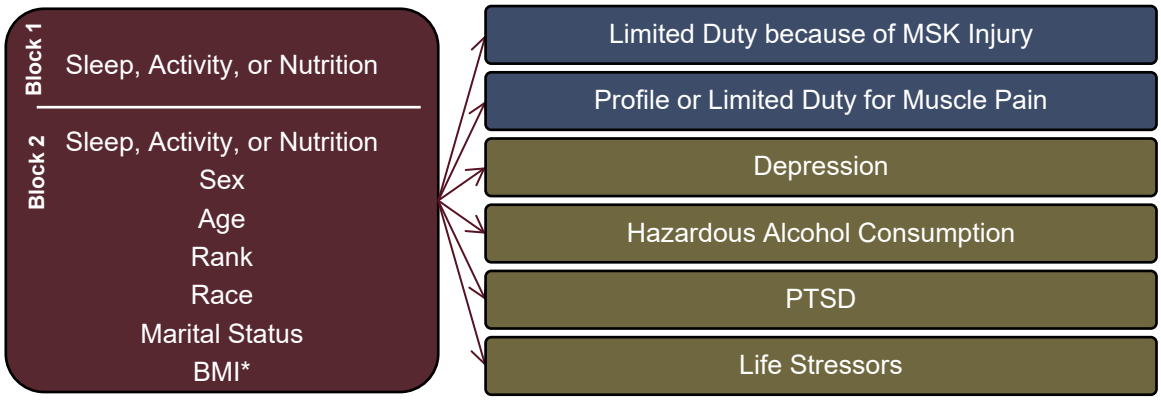

Figure 14. Hierarchical Regression Model for Injury and Behavioral Health Outcomes
**For Limited Duty because of MSK Injury in the GAT*

3.5.1 Injury Outcomes

3.5.1.1 Limited Duty because of Musculoskeletal Injury

The GAT results indicated that Soldiers who met sleep targets had 42% lower odds of reporting being on limited duty because of an MSK injury compared to those who did not meet sleep targets. After adjusting for demographic characteristics and BMI, Soldiers who met sleep targets had 34% lower odds of reporting being on limited duty because of an MSK injury compared to those who did not meet sleep targets.

Additionally, Soldiers who met activity targets had 48% lower odds of reporting being on limited duty because of an MSK injury compared to those who did not meet activity targets. After adjusting for demographic characteristics and BMI, Soldiers who met activity targets had 42% lower odds of reporting being on limited duty because of an MSK injury compared to those who did not meet activity targets.

Finally, Soldiers who met nutrition targets had 25% lower odds of reporting being on limited duty because of an MSK injury compared to those who did not meet nutrition targets. After adjusting for demographic characteristics and BMI, Soldiers who met nutrition targets had 25% lower odds of reporting being on limited duty because of an MSK injury compared to those who did not meet nutrition targets. Table 7 summarizes the hierarchical regression results for the limited duty because of MSK injury outcome.

Table 7. Hierarchical Regression for Limited Duty because of Musculoskeletal Injury

SAN Domain	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Reference Groups: Did not meet SAN Targets				
Block 1 (*N* = 174,249)				
Sleep	-0.55	0.01	<.0001	0.58 [0.57, 0.59]
Block 2* (*N* = 161,649)				
Sleep	-0.42	0.01	<.0001	0.66 [0.64, 0.68]
Block 1 (*N* = 174,251)				
Activity	-0.66	0.03	<.0001	0.52 [0.49, 0.54]
Block 2* (*N* = 161,652)				
Activity	-0.54	0.03	<.0001	0.58 [0.55, 0.62]
Block 1 (*N* = 174,251)				
Nutrition	-0.29	0.01	<.0001	0.75 [0.73, 0.76]
Block 2* (*N* = 161,653)				
Nutrition	-0.28	0.01	<.0001	0.75 [0.74, 0.77]

Legend:
B = unstandardized regression coefficient *SE* = standard error *OR* = odds ratio
p-value = probability to determine statistical significance *CI* = confidence interval
Note:
*Block 2 models were adjusted for sex, age, rank, race, marital status, and BMI

3.5.1.2 Profile or Limited Duty for Muscle Pain

The PHA results indicated that Soldiers who met the sleep target had 21% lower odds of being on profile or limited duty because of muscle pain compared to those who did not meet the sleep target. After adjusting for demographic characteristics, Soldiers who met the sleep target had 15% lower odds of being on profile or limited duty because of muscle pain compared to those who did not meet the sleep target.

Furthermore, Soldiers who met activity targets had 62% lower odds of being on profile or limited duty because of muscle pain compared to those who did not meet activity. After adjusting for demographic characteristics, Soldiers who met activity targets had 59% lower odds of being on profile or limited duty because of muscle pain compared to those who did not meet activity targets.

Lastly, Soldiers who met nutrition targets had 4% higher odds of being on profile or limited duty because of muscle pain compared to those who did not meet nutrition targets. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 4% higher odds of being on profile or limited duty because of muscle pain compared to those who did not meet nutrition targets. Table 8 summarizes the hierarchical regression results for the limited duty for muscle pain outcome.

Table 8. Hierarchical Regression for Profile or Limited Duty for Muscle Pain

SAN Domain	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Reference Groups: Did not meet SAN Targets				
Block 1 (*N* = 109,478)				
Sleep	-0.23	0.02	<.0001	0.79 [0.76, 0.82]
Block 2* (*N* = 102,211)				
Sleep	-0.17	0.02	<.0001	0.85 [0.82, 0.88]
Block 1 (*N* = 109,485)				
Activity	-0.97	0.03	<.0001	0.38 [0.36, 0.40]
Block 2* (*N* = 102,217)				
Activity	-0.88	0.03	<.0001	0.41 [0.39, 0.44]
Block 1 (*N* = 109,484)				
Nutrition	0.04	0.01	0.0069	1.04 [1.01, 1.06]
Block 2* (*N* = 102,216)				
Nutrition	0.04	0.01	0.0089	1.04 [1.01, 1.07]

Legend:
B = unstandardized regression coefficient *SE* = standard error *OR* = odds ratio
p-value = probability to determine statistical significance *CI* = confidence interval
Note:
*Block 2 models were adjusted for sex, age, rank, race, and marital status

3.5.2 Behavioral Health Outcomes

3.5.2.1 Depression (GAT)

The GAT results indicated that Soldiers who met sleep targets had 65% lower odds of screening positive for depression compared to those who did not meet sleep targets. After adjusting for demographic characteristics, Soldiers who met sleep targets had 64% lower odds of screening positive for depression compared to those who did not meet sleep targets.

The results also showed that Soldiers who met activity targets had 69% lower odds of screening positive for depression compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met activity targets had 69% lower odds of screening positive for depression compared to those who did not meet activity targets.

Finally, Soldiers who met nutrition targets had 47% lower odds of screening positive for depression compared to those who did not meet nutrition targets. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 45% lower odds of screening positive for depression compared to those who did not meet nutrition targets.

3.5.2.2 Depression (PHA)

The PHA results indicated that Soldiers who met the sleep target had 82% lower odds of screening positive for depression compared to those who did not meet the sleep target. After adjusting for demographic characteristics, Soldiers who met the sleep target had 80% lower odds of screening positive for depression compared to those who did not meet the sleep target.

The results also showed that Soldiers who met activity targets had 74% lower odds of screening positive for depression compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met activity targets had 70% lower odds of screening positive for depression compared to those who did not meet activity.

Lastly, Soldiers who met nutrition targets had 23% lower odds of screening positive for depression compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 18% lower odds of screening positive for depression compared to those who did not meet nutrition targets. Table 9 summarizes the hierarchical regression results for the depression outcome.

Table 9. Hierarchical Regression for Depression

	GAT				PHA			
SAN Domain	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**
Reference Groups: Did not meet SAN Targets								
Block 1 (GAT *N* = 174,245; PHA *N* = 319,484)								
Sleep	-1.06	0.01	<.0001	0.35 [0.34, 0.36]	-1.72	0.03	<.0001	0.18 [0.17, 0.19]
Block 2* (GAT *N* = 166,616; PHA *N* = 304,946)								
Sleep	-1.02	0.02	<.0001	0.36 [0.35, 0.37]	-1.61	0.03	<.0001	0.20 [0.19, 0.21]
Block 1 (GAT *N* = 174,247; PHA *N* = 319,493)								
Activity	-1.17	0.03	<.0001	0.31 [0.29, 0.33]	-1.34	0.03	<.0001	0.26 [0.25, 0.28]
Block 2* (GAT *N* = 166,619; PHA *N* = 304,953)								
Activity	-1.17	0.03	<.0001	0.31 [0.29, 0.33]	-1.19	0.03	<.0001	0.30 [0.29, 0.32]
Block 1 (GAT *N* = 174,247; PHA *N* = 319,496)								
Nutrition	-0.63	0.01	<.0001	0.53 [0.52, 0.55]	-0.26	0.02	<.0001	0.77 [0.75, 0.80]
Block 2* (GAT *N* = 166,620; PHA *N* = 304,958)								
Nutrition	-0.59	0.01	<.0001	0.55 [0.54, 0.57]	-0.20	0.02	<.0001	0.82 [0.79, 0.84]

Legend:
B = unstandardized regression coefficient *SE* = standard error *OR* = odds ratio
p-value = probability to determine statistical significance *CI* = confidence interval
Note:
*Block 2 models were adjusted for sex, age, rank, race, and marital status

3.5.2.3 Hazardous Alcohol Consumption (GAT)

The GAT results indicated that Soldiers who met sleep targets had 13% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet sleep targets. After adjusting for demographic characteristics, Soldiers who met sleep targets had 22% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet sleep targets.

Additionally, Soldiers who met activity targets had 20% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met activity targets had 25% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet activity targets.

Finally, Soldiers who met nutrition targets had 25% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet nutrition targets. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 24% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet nutrition targets.

3.5.2.4 Hazardous Alcohol Consumption (PHA)

The PHA results indicated that Soldiers who met the sleep target had 32% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet the sleep target. After adjusting for demographic characteristics, Soldiers who met the sleep target had 35% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet the sleep target.

Furthermore, Soldiers who met activity targets had 13% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met activity targets had 16% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet activity targets.

Lastly, Soldiers who met nutrition targets had 26% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet nutrition targets. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 20% lower odds of screening positive for unhealthy alcohol use compared to those who did not meet nutrition targets. Table 10 summarizes the hierarchical regression results for the hazardous alcohol consumption outcome.

Table 10. Hierarchical Regression for Hazardous Alcohol Consumption

	GAT				PHA			
SAN Domain	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**	***B***	***SE***	***p*-value**	***OR* [95% *CI*]**
Reference Groups: Did not meet SAN Targets								
Block 1 (GAT *N* = 106,399; PHA *N* = 210,094)								
Sleep	-0.13	0.02	<.0001	0.87 [0.85, 0.90]	-0.39	0.01	<.0001	0.68 [0.66, 0.70]
Block 2* (GAT *N* = 100,914; PHA *N* = 199,341)								
Sleep	-0.25	0.02	<.0001	0.78 [0.76, 0.81]	-0.44	0.01	<.0001	0.65 [0.63, 0.66]
Block 1 (GAT *N* = 106,395; PHA *N* = 210,095)								
Activity	-0.22	0.04	<.0001	0.80 [0.74, 0.87]	-0.14	0.03	<.0001	0.87 [0.81, 0.93]
Block 2* (GAT *N* = 100,910; PHA *N* = 199,340)								
Activity	-0.29	0.04	<.0001	0.75 [0.69, 0.81]	-0.18	0.03	<.0001	0.84 [0.78, 0.89]
Block 1 (GAT *N* = 106,394; PHA *N* = 210,092)								
Nutrition	-0.29	0.01	<.0001	0.75 [0.73, 0.77]	-0.31	0.01	<.0001	0.74 [0.72, 0.75]
Block 2* (GAT *N* = 100,911; PHA *N* = 199,337)								
Nutrition	-0.28	0.01	<.0001	0.76 [0.73, 0.78]	-0.23	0.01	<.0001	0.80 [0.78, 0.82]

Legend:
B = unstandardized regression coefficient *SE* = standard error
p-value = probability to determine statistical significance *OR* = odds ratio *CI* = confidence interval
Note:
*Block 2 models were adjusted for sex, age, rank, race, and marital status

3.5.2.5 Post-traumatic Stress Disorder (PHA)

The PHA results indicated that Soldiers who met the sleep target had 60% lower odds of screening positive for any PTSD symptoms (mild, moderate, or severe) compared to those who did not meet the sleep target. After adjusting for demographic characteristics, Soldiers who met the sleep target had 57% lower odds of screening positive for any PTSD symptoms compared to those who did not meet the sleep target.

The results also showed that Soldiers who met activity targets had 59% lower odds of screening positive for any PTSD symptoms compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met activity targets had 56% lower odds of screening positive for any PTSD symptoms compared to those who did not meet activity targets.

Finally, there was no significant association between meeting nutrition targets and PTSD screening. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 7% higher odds of screening positive for any PTSD symptoms compared to those who did not meet nutrition targets. Table 11 summarizes the hierarchical regression results for the PTSD outcome.

Table 11. Hierarchical Regression for Post-traumatic Stress Disorder

SAN Domain	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Reference Groups: Did not meet SAN Targets				
Block 1 (*N* = 20,505)				
Sleep	-0.93	0.06	<.0001	0.40 [0.35, 0.45]
Block 2* (*N* = 18,760)				
Sleep	-0.85	0.07	<.0001	0.43 [0.38, 0.49]
Block 1 (*N* = 20,503)				
Activity	-0.90	0.05	<.0001	0.41 [0.37, 0.45]
Block 2* (*N* = 18,758)				
Activity	-0.83	0.06	<.0001	0.44 [0.39, 0.49]
Block 1 (*N* = 20,504)				
Nutrition	0.04	0.03	0.1795	1.04 [0.98, 1.10]
Block 2* (*N* = 18,759)				
Nutrition	0.07	0.03	0.0318	1.07 [1.01, 1.14]

Legend:
B = unstandardized regression coefficient *SE* = standard error *OR* = odds ratio
p-value = probability to determine statistical significance *CI* = confidence interval
Note:
*Block 2 models were adjusted for sex, age, rank, race, and marital status

3.5.2.6 Life Stressors (PHA)

The PHA results indicated that Soldiers who met the sleep target had 76% lower odds of reporting major life stressors compared to those who did not meet the sleep target. After adjusting for demographic characteristics, Soldiers who met the sleep target had 73% lower odds of reporting major life stressors compared to those who did not meet the sleep target.

Additionally, Soldiers who met activity targets had 67% lower odds of reporting major life stressors compared to those who did not meet activity targets. After adjusting for demographic characteristics, Soldiers who met activity targets had 61% lower odds of reporting major life stressors compared to those who did not meet activity targets.

Lastly, Soldiers who met nutrition targets had 16% lower odds of reporting major life stressors compared to those who did not meet nutrition targets. After adjusting for demographic characteristics, Soldiers who met nutrition targets had 17% lower odds of reporting major life stressors compared to those who did not meet nutrition targets. Table 12 summarizes the hierarchical regression results for the life stressors outcome.

Table 12. Hierarchical Regression for Life Stressors

SAN Domain	*B*	*SE*	*p*-value	*OR* [95% *CI*]
Reference Groups: Did not meet SAN Targets				
Block 1 (*N* = 319,441)				
Sleep	-1.45	0.02	<.0001	0.24 [0.23, 0.25]
Block 2* (*N* = 304,907)				
Sleep	-1.33	0.02	<.0001	0.27 [0.26, 0.28]
Block 1 (*N* = 319,436)				
Activity	-1.10	0.02	<.0001	0.33 [0.32, 0.35]
Block 2* (*N* = 304,900)				
Activity	-0.96	0.03	<.0001	0.39 [0.37, 0.41]
Block 1 (*N* = 319,444)				
Nutrition	-0.18	0.01	<.0001	0.84 [0.82, 0.86]
Block 2* (*N* = 304,909)				
Nutrition	-0.18	0.01	<.0001	0.83 [0.81, 0.86]

Legend:
B = unstandardized regression coefficient *SE* = standard error *OR* = odds ratio
p-value = probability to determine statistical significance *CI* = confidence interval
Note:
*Block 2 models were adjusted for sex, age, rank, race, and marital status

Summary: To what extent are sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes?

Some healthy SAN behaviors may be protective factors against injury and adverse behavioral health outcomes, even after controlling for demographics. For injury, Soldiers who met sleep or activity targets were less likely to be on limited duty for MSK injury or muscle pain. The GAT indicated that Soldiers who met nutrition targets were less likely to report being on limited duty due to an MSK injury. In both the GAT and PHA, Soldiers who met sleep, activity, or nutrition targets were less likely to screen positive for depression or unhealthy alcohol use. Soldiers who met sleep or activity targets were also less likely to screen positive for any PTSD symptoms in the PHA. Soldiers who met sleep, activity, and nutrition targets were less likely to report major life stressors in the PHA.

Some healthy SAN behaviors may not be protective factors against injury and adverse behavioral health outcomes, as the PHA showed that Soldiers who met nutrition targets were slightly more likely to be on profile or limited duty because of muscle pain and were more likely to screen positive for any PTSD symptoms.

3.6 Guiding Question 5: Is the interaction between sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes for Soldiers?

The project team conducted additional hierarchical (sequential) multivariable logistic regression models to assess the extent to which SAN behaviors interact to predict injury and behavioral health outcomes, controlling for demographic characteristics and other covariates. These models included injury or behavioral health outcomes regressed on all SAN domains and all demographic characteristics. Interaction terms were added to each model for all SAN domains simultaneously. Figure 15 describes the regression analyses that include interaction terms.

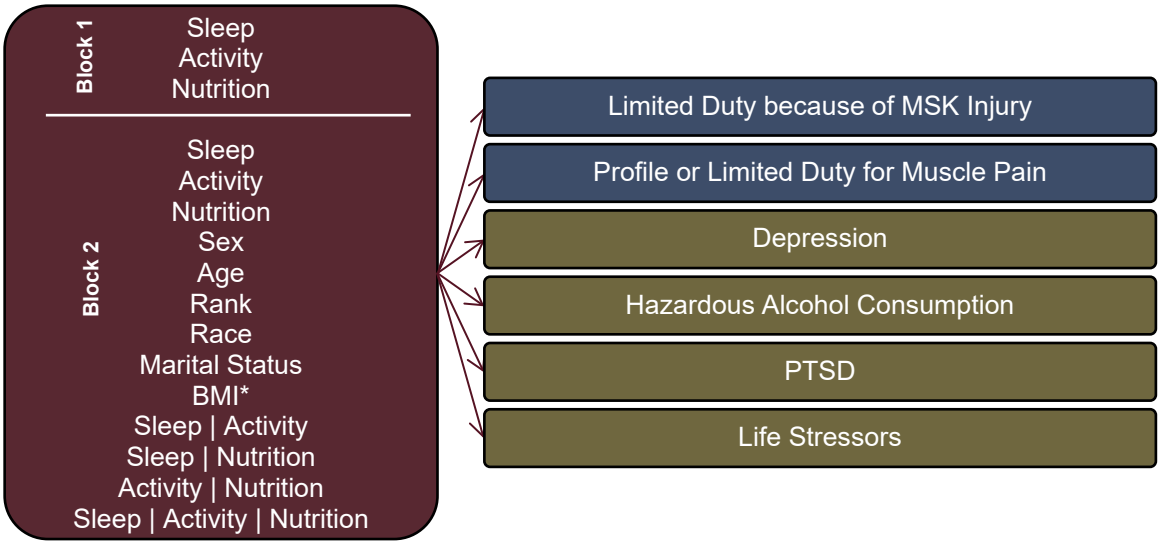

Figure 15. Hierarchical Regression Model for Injury and Behavioral Health Outcomes assessing for interaction between SAN behaviors

*For Limited Duty because of MSK Injury in the GAT

This section summarizes the hierarchical (sequential) multivariable logistic regression interaction results by injury and behavioral health outcomes of interest (See Table 13).

Table 13. Summary of Hierarchical Multivariable Logistic Regression Results

	Sleep x Activity	Sleep x Nutrition	Activity x Nutrition	Sleep x Activity x Nutrition
Reference Groups: Did not meet SAN Targets				
Injury Outcomes				
LIMDU because of MSK Injury (GAT: *N* = 161,638)	★	★	★	★
Profile or LIMDU for Muscle Pain (PHA: *N* = 102,192)	*ns*	*ns*	☆	*ns*
Behavioral Health Outcomes				
Depression (GAT: *N* = 166,605; PHA: *N* = 304,905)	★	*ns*	★ ☆	*ns*
Hazardous Alcohol Consumption (GAT: *N* = 100,907; PHA: *N* = 199,314)	*ns*	*ns*	*ns*	*ns*
PTSD (PHA: *N* = 18,758)	☆	*ns*	*ns*	*ns*
Life Stressors (PHA: *N* = 304,851)	*ns*	*ns*	*ns*	*ns*

Legend:
LIMDU = limited duty PTSD = Post-traumatic Stress Disorder
MSK = musculoskeletal *ns* = not statistically significant
Notes: Adjusted for sex, age, rank, race, marital status, and BMI (GAT injury only).

GAT PHA ☆ Statistically significant association ($p < .05$)

3.6.1 Association between Sleep, Activity and Nutrition Interaction and Injury Outcomes

3.6.1.1 Limited Duty because of Musculoskeletal Injury

The GAT results indicated statistically significant associations between 2-way sleep, activity, and/or nutrition interactions and limited duty because of MSK injury. The interactions between sleep and activity (B = -0.18, SE = 0.08, p = 0.0154), sleep and nutrition (B = -0.45, SE = 0.14, p = 0.0019), and activity and nutrition (B = -0.60, SE = 0.12, p < .0001) were statistically associated with limited duty because of MSK injury. The prevalence of being on limited duty because of MSK injury appears to be higher for Soldiers who did not meet sleep and activity targets (57%) and lower for Soldiers who met both sleep and activity targets (32%) (Figure 16).

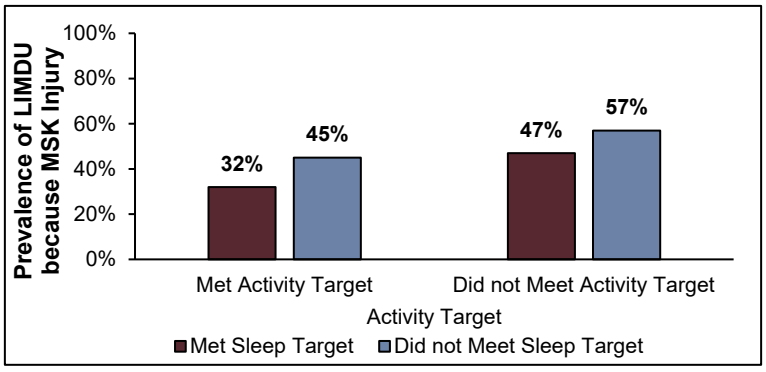

Figure 16. Sleep x Activity Interaction for LIMDU because of MSK Injury (GAT) (*N* = 161,638)

The prevalence of being on limited duty because of MSK injury also appears to be higher for Soldiers who did not meet sleep and nutrition targets (49%) and lower for Soldiers who met both sleep and nutrition targets (30%) (Figure 17). Additionally, the prevalence of being on limited duty because of MSK injury appears to be higher for Soldiers who did not meet activity targets, irrespective of whether Soldiers met nutrition targets, and lower for Soldiers who met both activity and nutrition targets (32%) (Figure 18).

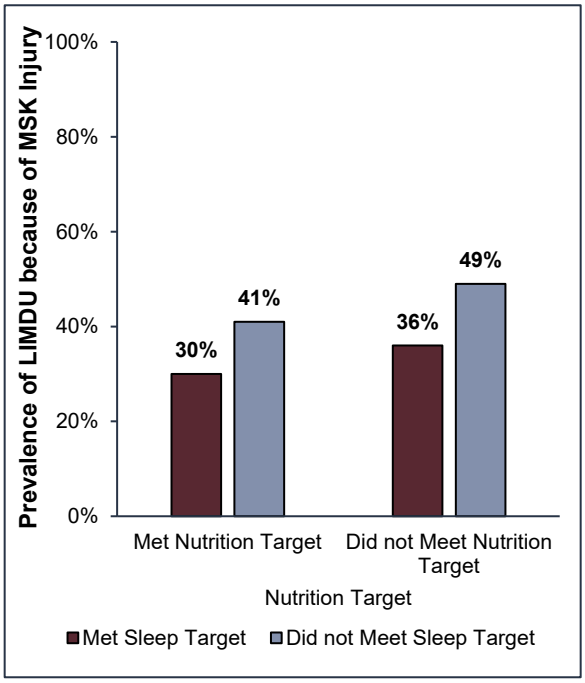

Figure 17. Sleep x Nutrition Interaction for LIMDU because of MSK Injury (GAT) (*N* = 161,638)

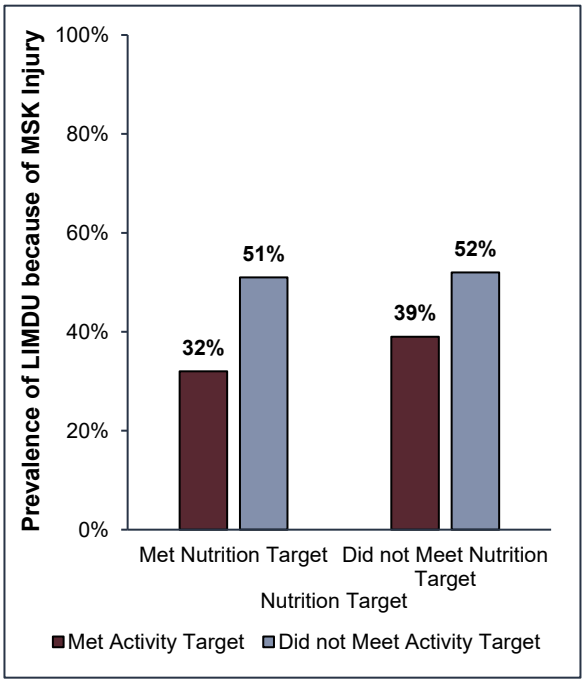

Figure 18. Activity x Nutrition Interaction for LIMDU because of MSK Injury (GAT) (*N* = 161,638)

The 3-way interaction between sleep, activity, and nutrition (*B* = 0.50, *SE* = 0.15, *p* = 0.0007) was also statistically associated with limited duty because of MSK injury. The prevalence of being on limited duty because of MSK injury appears to be higher for Soldiers who did not meet sleep and activity targets (61% and 56%), and lower for Soldiers who met sleep and activity targets (30% and 35%), irrespective of whether Soldiers met nutrition targets (Figures 19 and 20).

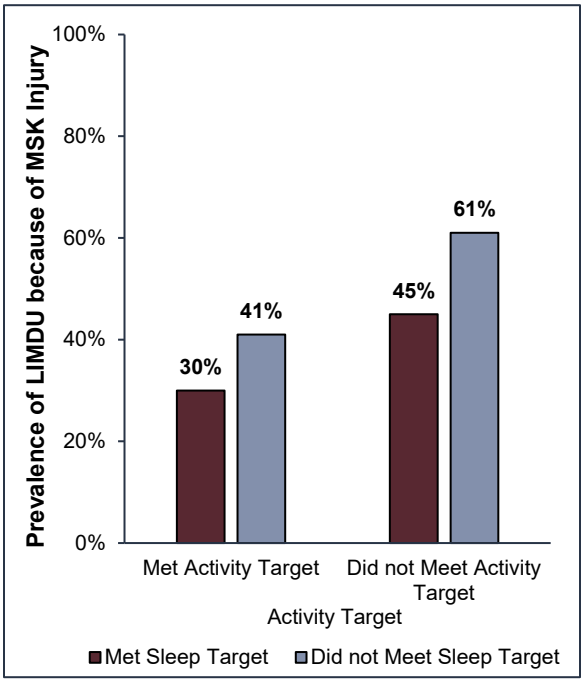

Figure 19. Sleep x Activity Interaction when Nutrition Targets are met for LIMDU because of MSK Injury (GAT) (*N* = 161,638)

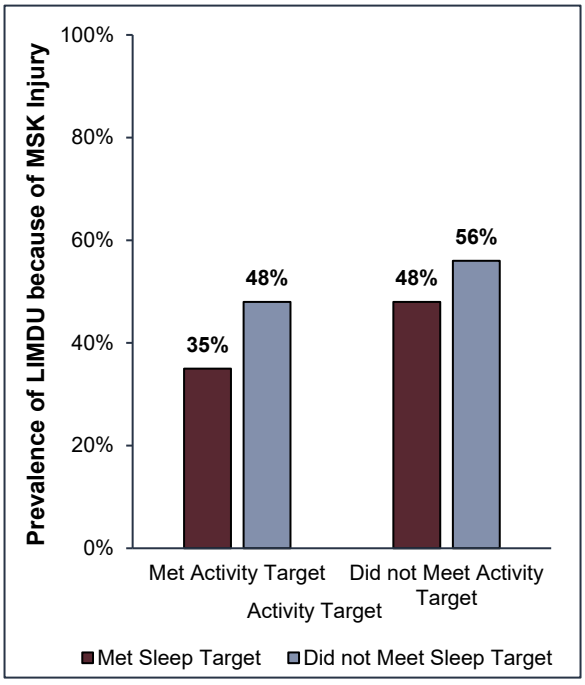

Figure 20. Sleep x Activity Interaction when Nutrition Targets are not met for LIMDU because of MSK Injury (GAT) (*N* = 161,638)

3.6.1.1 Profile or Limited Duty for Muscle Pain

The PHA results indicated a statistically significant association between a 2-way activity and nutrition interaction (*B* = -0.21, *SE* = 0.08, *p* = 0.0055) and being on profile or limited duty because of muscle pain. The prevalence of being on profile or limited duty because of muscle pain appears to be higher for Soldiers who did not meet activity targets and lower for Soldiers who met activity targets, irrespective of whether Soldiers met nutrition targets (Figure 21). All other 2-way interactions and the 3-way interaction between sleep, activity, and nutrition were not statistically associated with being on profile or limited duty because of muscle pain (*p* > .05).

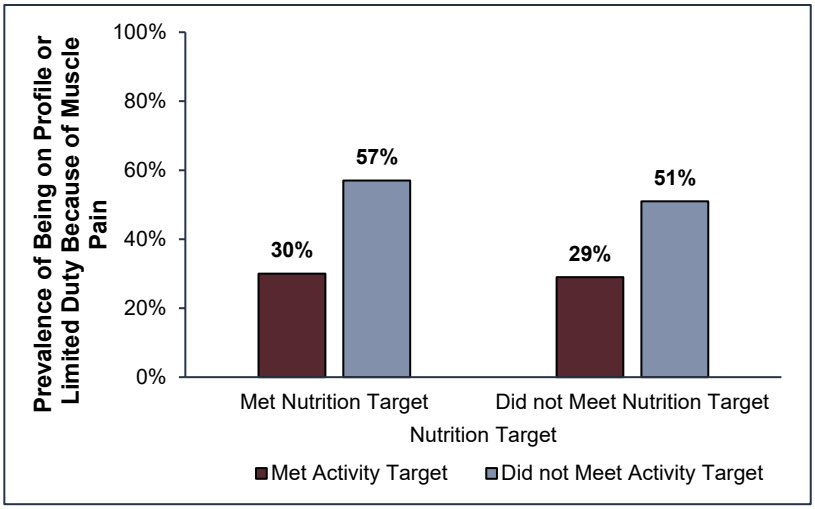

Figure 21. Activity x Nutrition Interaction and Profile or LIMDU for Muscle Pain (PHA) (*N* = 102,192)

3.6.2 Association between Sleep, Activity and Nutrition Interaction and Behavioral Health Outcomes

3.6.2.1 Depression

The GAT results indicated statistically significant associations between 2-way sleep, activity, and/or nutrition interactions and depression. The interactions between sleep and activity (*B* = -0.16, *SE* = 0.08, *p* = 0.0386), and activity and nutrition (*B* = -0.32, *SE* = 0.11, *p* = 0.0047) were statistically associated with screening positive for depression. The prevalence of screening positive for depression appears to be higher for Soldiers who did not meet sleep and activity targets (46%) and lower for Soldiers who met both sleep and activity targets (10%) (Figure 22).

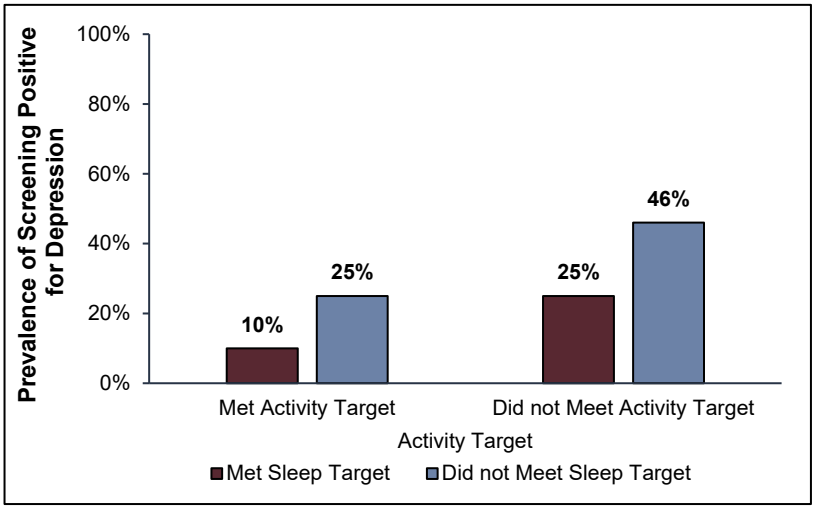

Figure 22. Sleep x Activity Interaction and Depression (GAT) (*N* = 166,605)

Additionally, the prevalence of screening positive for depression appears to be higher for Soldiers who did not meet activity and nutrition targets (36%) and lower for Soldiers who met both activity and nutrition targets (10%) (Figure 23). The 2-way interaction between sleep and nutrition, and the 3-way interaction between sleep, activity, and nutrition were not statistically associated with depression (*p* > .05).

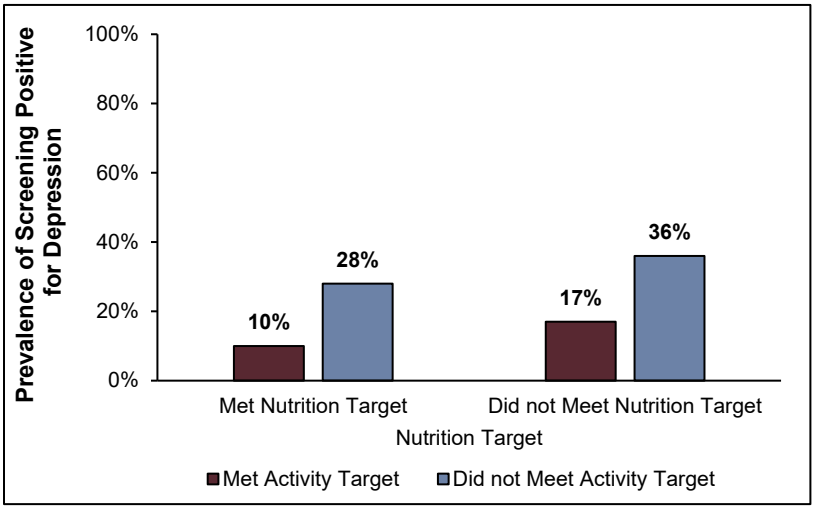

Figure 23. Activity x Nutrition Interaction and Depression (GAT) (*N* = 166,605)

The PHA results indicated a statistically significant association between a 2-way activity and nutrition interaction (*B* = -0.29, *SE* = 0.07, *p* < .0001) and screening positive for depression. The prevalence of screening positive for depression appears to be higher for Soldiers who did not meet activity targets and lower for Soldiers who met activity targets, irrespective of whether Soldiers met nutrition targets (Figure 24). All other 2-way interactions and the 3-way interaction between sleep, activity, and nutrition were not statistically associated with depression (*p* > .05).

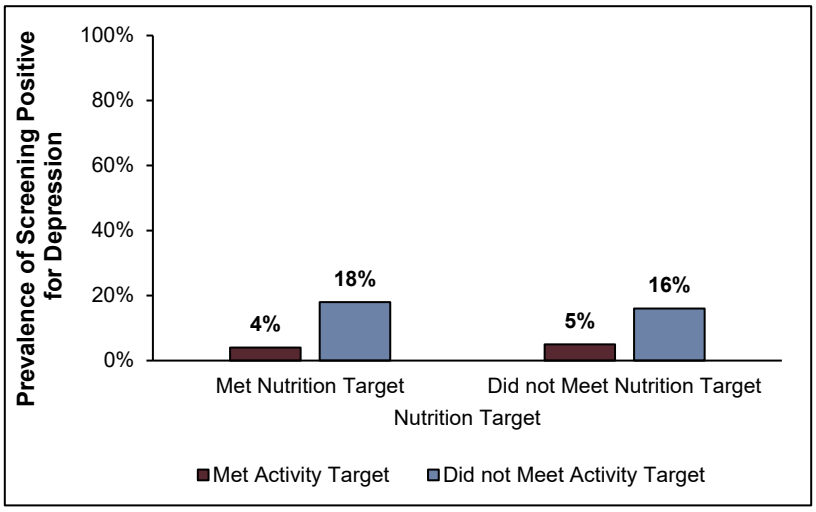

Figure 24. Activity x Nutrition Interaction and Depression (PHA) (*N* = 304,905)

3.6.2.2 Hazardous Alcohol Consumption

The GAT and PHA results indicated that all 2-way interactions and the 3-way interaction between sleep, activity, and nutrition were not statistically associated with screening positive for hazardous alcohol consumption (*p* > .05).

3.6.2.3 Post-traumatic Stress Disorder

The PHA results indicated a statistically significant association between a 2-way sleep and activity interaction (*B* = 0.66, *SE* = 0.28, *p* = 0.0190) and screening positive for any PTSD symptoms. The prevalence of screening positive for PTSD symptoms appears to be higher for Soldiers who did not meet sleep and activity targets (67%) and lower for Soldiers who met both sleep and activity targets (24%) (Figure 25). All other 2-way interactions and the 3-way interaction between sleep, activity, and nutrition were not statistically associated with PTSD (*p* > .05).

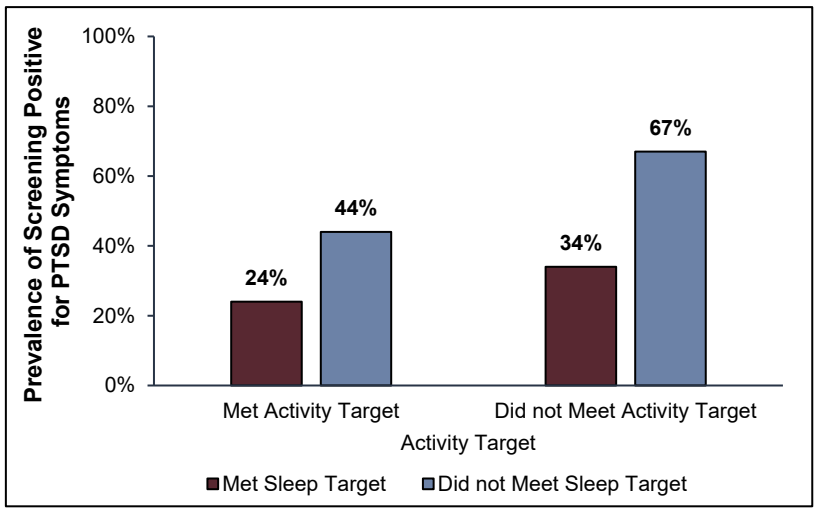

Figure 25. Sleep x Activity Interaction and PTSD Symptoms (PHA) (*N* = 304,905)

3.6.2.4 Life Stressors

The PHA results indicated that all 2-way interactions and the 3-way interaction between sleep, activity, and nutrition were not statistically associated with reporting major life stressors ($p > .05$).

Summary: Is the interaction between sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes for Soldiers?

Some interactions between sleep, activity, or nutrition were statistically associated with being on profile or limited duty because of MSK injury or muscle pain, screening positive for depression, and experiencing PTSD symptoms. Soldiers who met both sleep and activity targets may have a lower prevalence of being on limited duty because of MSK injury, depression, or PTSD. The synergy of SAN behaviors was not associated with unhealthy alcohol use or experiencing major life stressors.

4 Discussion

The project team summarized the results to answer the five guiding questions, synthesized conclusions to communicate the main takeaways, and provided study strengths and limitations.

4.1 Demographics

Frequency distributions for Soldiers' demographic characteristics were similar across the GAT and PHA. The majority of Soldiers who participated in the GAT or PHA were male, younger than 35 years of age, Junior or Senior Enlisted, White, and married. These demographic frequencies are comparable to the Army's AD population in 2018 (Military OneSource 2018).

4.2 Guiding Question 1: What are the demographic and other characteristics of Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

The demographic and other characteristics of Soldiers who met the minimum recommended thresholds for sleep, activity, and nutrition were consistent for many behaviors and were comparable to the 2022 Health of the Force Report (DCPH-A 2023). For sleep, a similar proportion of male Soldiers and female Soldiers met the recommended target of 7 hours or more of sleep. A greater percentage of Soldiers younger than 35 years of age, Officers/Warrant Officers, White Soldiers, American Indian/Alaska Native Soldiers, and Soldiers who were never married met the sleep target.

For activity, the percentage of Soldiers meeting the aerobic activity target was similar across sex and marital status groups in the GAT and PHA. The demographic differences by age and rank were inconsistent between the GAT and PHA; similarities for race differences indicated that a greater percentage of White Soldiers and American Indian/Alaska Native Soldiers met the aerobic activity target. The percentage of Soldiers engaging in resistance training 2 or more days per week consistently varied by sex and age; a greater percentage of male Soldiers and Soldiers younger than 35 years of age met the resistance activity target. The demographic differences by rank and race were inconsistent between the GAT and PHA; the percentage of Soldiers meeting the resistance activity target was similar across all marital status groups.

For nutrition, a greater percentage of female Soldiers and Officers/Warrant Officers met the target for two or more servings of fruits. The demographic differences by age, race, and marital status were inconsistent between the GAT and PHA. A greater percentage of female Soldiers, Soldiers older than 24 years of age, Officers/Warrant Officers, and White Soldiers met the target for two or more servings of vegetables. The demographic differences by marital status were inconsistent between the GAT and PHA.

4.3 Guiding Question 2: What is the prevalence of select injury and behavioral health outcomes for Soldiers who meet, and Soldiers who do not meet, the minimum recommended thresholds for sleep, activity, and nutrition behaviors?

The prevalence of select injury and behavioral outcomes was *lower* among Soldiers who met sleep, activity, or nutrition targets in both the GAT and PHA. For injury, the prevalence of being on limited duty for MSK injury or muscle pain was lower among Soldiers who met sleep or activity targets. This finding is consistent with literature associating increased physical activity and longer sleep with a reduced risk of MSK injury (Jones and Hauschild 2015; Martin et al. 2018; Grier et al. 2020). The GAT indicated a lower prevalence of being on limited duty for MSK injury among Soldiers who met nutrition targets, which is consistent with literature suggesting an

association between consuming recommended amounts of macro and micronutrients and a reduced risk of MSK injury (Close et al. 2019).

For behavioral health, the prevalence of depression was lower among Soldiers who met sleep, activity, or nutrition targets in the GAT and Soldiers who met sleep or activity targets in the PHA. Collectively, these findings align with the literature linking healthy SAN behaviors with a reduced risk of developing depression (Mammen and Faulkner 2013; Troxel et al. 2015). The prevalence of unhealthy alcohol use was lower among Soldiers who met sleep, activity, or nutrition targets in the GAT and Soldiers who met sleep or nutrition targets in the PHA. These findings for alcohol use align with studies reporting a positive association between high alcohol consumption and insomnia (Klingaman et al. 2018), though other studies found opposite or no associations (Roehrs and Roth 2001; Brellenthin and Lee 2018; Kendzor et al. 2008). The prevalence of experiencing PTSD symptoms or life stressors was also lower among Soldiers who met sleep or activity targets in the PHA. These findings are consistent with the literature linking increased physical activity with decreased risk for PTSD symptoms (Hall et al. 2015; Rosenbaum et al. 2015), but do not align with the literature that associated healthy nutrition behaviors with decreased risk for PTSD symptoms (Hall et al. 2015).

4.4 Guiding Question 3: To what extent does the prevalence of select injury and behavioral health outcomes differ between groups of Soldiers with select demographic and other characteristics?

Injury and behavioral health outcomes statistically differed by sex, age, rank, race, and marital status in the GAT and PHA. Limited duty because of MSK injury or muscle pain was more prevalent among Soldiers who were female, older than 24 years of age, Black or African American, and married or previously married. Rank may be a protective factor for these injury outcomes as Senior Enlisted Soldiers and Officers/Warrant Officers were *less* likely to report being on limited duty because of MSK injury or muscle pain.

Depression was more prevalent among Soldiers who were Asian or Pacific Islander, Black or African American, older than 35 years of age, or previously married. Rank may be a protective factor for depression as Senior Enlisted Soldiers and Officers/Warrant Officers were *less* likely to screen positive for depression. The prevalence of depression among female Soldiers and married Soldiers was inconsistent between the GAT and PHA, with a greater likelihood to screen positive for depression in the PHA and a lower likelihood to screen positive in the GAT. Hazardous alcohol consumption differences were also inconsistent between the GAT and PHA; however, age, race, and marital status may be protective factors for hazardous alcohol consumption. Soldiers who were older than 24 years of age, Asian or Pacific Islander, Black or African American, and married or previously married were *less* likely to be at risk for unhealthy alcohol use.

Post-traumatic stress disorder and experiencing major life stressors were most prevalent among Soldiers who were female, older than 24 years of age, Asian or Pacific Islander, Black or African American, and married or previously married. Rank may also be a protective factor for these behavioral health outcomes as Senior Enlisted Soldiers and Officers/Warrant Officers were *less* likely to screen positive for PTSD or report experiencing major life stressors.

4.5 Guiding Question 4: To what extent are sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes?

Healthy SAN behaviors may be protective factors against injury and adverse behavioral health outcomes, even after controlling for demographic characteristics. For injury, Soldiers who met sleep or activity targets were *less* likely to be on limited duty for MSK injury or muscle pain, which is consistent with studies associating increased physical activity and longer sleep with a reduced risk of MSK injury (Jones and Hauschild 2015; Martin et al. 2018; Grier et al. 2020). The association between nutrition behaviors and injury outcomes were inconsistent between the GAT and PHA, with Soldiers who met nutrition targets being *less* likely to report being on limited duty because of an MSK injury in the GAT while Soldiers who met nutrition targets were slightly more likely to be on profile or limited duty because of muscle pain in the PHA. The results from the GAT align with the literature suggesting an association between consuming recommended amounts of macro and micronutrients and a reduced risk of MSK injury (Close et al. 2019).

For behavioral health, Soldiers who met sleep, activity, or nutrition targets were *less* likely to screen positive for depression or unhealthy alcohol use in the GAT and PHA. These findings align with the literature linking healthy SAN behaviors with a reduced risk of developing depression (Mammen and Faulkner 2013; Troxel et al. 2015). The findings for alcohol use align with studies reporting a positive association between high alcohol consumption and insomnia (Klingaman et al. 2018), though other studies found opposite or no associations (Roehrs and Roth, 2001; Brellenthin and Lee 2018; Kendzor et al. 2008). Soldiers who met sleep or activity targets were also *less* likely to screen positive for any PTSD symptoms in the PHA; however, Soldiers who met nutrition targets were more likely to screen positive for any PTSD symptoms. These findings are consistent with the literature linking increased physical activity with decreased risk for PTSD symptoms (Hall et al. 2015; Rosenbaum et al. 2015), but do not align with the literature that associated healthy nutrition behaviors with decreased risk for PTSD symptoms (Hall et al. 2015). Additionally, Soldiers who met sleep, activity, or nutrition targets were *less* likely to report major life stressors in the PHA.

4.6 Guiding Question 5: Is the interaction between sleep, activity, and nutrition behaviors associated with differences in select injury and behavioral health outcomes for Soldiers?

Some interactions between sleep, activity, or nutrition were statistically associated with being on profile or limited duty because of MSK injury or muscle pain, screening positive for depression, and experiencing PTSD symptoms. The interactions between SAN behaviors were *not* associated with the risk of unhealthy alcohol use or experiencing major life stressors.

For injury, the interaction between sleep, activity, and nutrition was statistically associated with limited duty because of an MSK injury. The prevalence of being on limited duty because of an MSK injury appears to be lower among Soldiers who met sleep and activity targets or sleep and nutrition targets. Although the interaction between activity and nutrition was statistically associated with being on limited duty because of MSK injury or muscle pain in the GAT and PHA, respectively, the prevalence of negative injury outcomes appears to be higher among Soldiers who did not meet activity targets, irrespective of whether they also met nutrition targets.

For behavioral health outcomes, the interaction between sleep and activity was statistically associated with screening positive for depression in the GAT and experiencing PTSD symptoms in the PHA. The prevalence of screening positive for depression or experiencing PTSD symptoms appears to be lower among Soldiers who met sleep and activity targets. This finding

aligns with a recent study suggesting lower odds for PTSD symptoms for military service members who reported healthy sleep and physical activity behaviors (Perez et al. 2021). Although the interaction between activity and nutrition was statistically associated with screening positive for depression in the GAT and PHA, respectively, the prevalence of depression appears to be higher among Soldiers who did not meet activity targets, irrespective of whether they also met nutrition targets.

4.7 Strengths and Limitations

This project had several strengths, including being one of the first studies to assess the synergistic association between SAN behaviors and the injury and behavioral health outcomes for a military population, analyzing data for all consenting AD Soldiers who completed the GAT and PHA in calendar year 2018 with matching identifiers in the DMDC to capture population parameters that are generalizable to the target population, and using both the GAT and PHA tools to enhance the interpretation of consistent findings across tools. Despite these strengths, this project had a few limitations. First, the use of self-reported data for required military data collection makes the findings prone to social desirability (i.e., over-reporting desirable behaviors and under-reporting undesirable behaviors), recall bias (i.e. not accurately reporting events that occurred in the past, which may skew observed associations), and selection bias (i.e., AD Soldiers who completed the GAT or PHA may be different than the AD Soldiers who did not complete these tools). Second, statistical effects may be limited by the categorization of SAN behaviors to compare Soldiers who met recommended SAN thresholds set by the Army to those who did not meet thresholds. Third, the study is limited by the cross-sectional design of the GAT and PHA questionnaires, which does not account for potential seasonal patterns to Soldiers' SAN behaviors, such as higher levels of physical activity in the summer months and may also suggest seasonal patterns in the data rather than empirical differences. Thus, the observed associations cannot be interpreted as causal, and the bi-directional relationship between SAN behaviors and outcomes cannot be assessed with the present study.

Conclusions:

Demographic differences were observed for SAN behaviors and the prevalence of injury and behavioral health outcomes; however, healthy SAN behaviors appear to be protective factors for injury and adverse behavioral health outcomes, after controlling for demographic characteristics. Additionally, the prevalence of injury, depression, and PTSD was lower among Soldiers who met combinations of recommended SAN targets. Collectively, these results suggest that the synergy of SAN behaviors may be protective for some injury and adverse behavioral health outcomes.

5 Recommendations and Implications

Based on the study results, the project team proposes the following recommendations to improve Soldiers' SAN behaviors and scope future studies to continue investigating the synergy between SAN behaviors and their association with select health outcomes:

5.1 Recommendations to Improve Soldiers' SAN Behaviors

Promote SAN behaviors, independently and in combination, as protective factors for injury and behavioral health. Army leaders should promote SAN behaviors as protective factors for Soldier readiness. The present study suggested that the prevalence of injury and adverse behavioral health outcomes was lower among Soldiers who met SAN targets after controlling for demographics, and the combination of healthy sleep and activity behaviors may also be protective factors for injury, depression, and PTSD. The present study is one of the first studies to assess the association between the synergy of SAN behaviors and readiness outcomes; while additional studies are warranted, the present results are informative for leaders to continue communicating the importance of healthy SAN behaviors to Soldiers.

Provide focused support to demographic groups who do not meet SAN targets or experience negative injury and behavioral health outcomes. Army leaders should take tailored and specific actions to support Soldiers who consistently do not meet SAN targets and/or have higher prevalence of injury and adverse behavioral health outcomes. Given that the demographic differences for meeting SAN targets in the present study are consistent with the 2022 Health of the Force Report (DCPH-A, 2023), Army leaders should create environments and programs that foster dialogue among different demographic groups to understand their experiences and barriers to meeting SAN targets. Similarly, demographic differences observed for injury and adverse behavioral health outcomes suggests the need for targeted support to specific demographic groups. Collectively, these actions may require dedication from identified Army leaders who focus on the well-being of disproportionately impacted Soldiers and bolster resources for groups that may strengthen SAN behaviors and mitigate injury and behavioral health risks.

5.2 Recommendations for Future Study

Continue to explore SAN synergy with objective data. The DCPH-A should conduct additional studies to continue exploring the association between the synergy of SAN behaviors and outcomes of interest for Soldier readiness. The present study used the GAT and PHA, which are subject to self-reported data limitations. Future studies may use objective data sources, such as anthropometric data from medical exams, blood chemistry, and biometric tracking applications. Secondary, objective data sources would help address the limitations of the present study and validate self-reported data sources.

Design studies with different methodologies. The DCPH-A should design additional studies with different methodologies to account for potential confounders and the co-occurrence of SAN behaviors and outcomes of interest. For example, a prospective cohort study among a military trainee population or first year Soldiers would provide the opportunity to control for observed differences among demographic characteristics, such as age and rank. Additionally, a prospective assessment with AFWC clients may include daily journaling of SAN behaviors with direct measurement at the AFWCs for outcomes of interest. Additional studies with different methodologies would advance the literature and provide the opportunity to better assess bi-directional relationships between SAN behaviors and outcomes of interest.

Expand the assessment of SAN behaviors beyond the Army to other DoD Services. The DCPH-A should assess SAN behaviors across all DoD Services to better understand these health-promoting behaviors in other military populations. The next Health of the Force production cycle will expand previously reported metrics beyond the Army to other DoD Services, and the DCPH-A will summarize service members' SAN behaviors in the report. Hence, the DCPH-A should also conduct studies with other DoD Services to understand whether the statistical associations observed in the present study are found in other Military populations. Additional studies with other DoD Services would also provide the opportunity to explore how SAN behaviors may be associated with other readiness outcomes of interest.

Implications:

The P3 initiative has been instrumental to raise awareness about the importance of healthy SAN behaviors among Army Soldiers. As a Defense Health Agency organization, the DCPH-A is uniquely positioned to promote healthy SAN behaviors for other DoD Services. The present study suggests that healthy SAN behaviors, and the combination of sleep and activity, may be protective for some injury and adverse behavioral health outcomes. Future studies are needed to explore temporal associations between SAN behaviors and readiness outcomes across the DoD.

6. Point of Contact

The point of contact for this report is Dr. Stephanie Gomez. Additional information about the study methodology, analyses, and results are available upon request. For more information, please contact Dr. Gomez via email at dha.apg.Pub-Health-A.list.hpw-directorate-operations-staff@health.mil or by phone at 410-436-2303.

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Glossary

AD
Active Duty

APFT
Army Physical Fitness Test

AFWC
Armed Forces Wellness Center

APHC
Army Public Health Center

BMI
Body mass index

CDC
Centers for Disease Control and Prevention

DCPH-A
Defense Centers for Public Health – Aberdeen

DMDC
Defense Manpower Data Center

DoD
Department of Defense

GAT
Global Assessment Tool

H2F
Holistic Health and Fitness

MSK
Musculoskeletal

P3
Performance Triad

PHA
Periodic Health Assessment

PTSD
Post-traumatic Stress Disorder

SAN
Sleep, Activity, and Nutrition