FATTY ACID BLOOD LEVELS, VITAMIN D STATUS, AND PHYSICAL PERFORMANCE AND ITS RELATIONSHIP TO RESILIENCY AND MOOD IN ACTIVE DUTY SOLDIERS

A Dissertation

by

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Submitted to the Office of Graduate and Professional Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

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May 2015

Major Subject: Kinesiology

ABSTRACT

The mental health of soldiers is a growing concern as rates of depression and suicide have increased in soldiers with recently more deaths attributed to suicide than deaths due to combat in Afghanistan in 2012. Previous research has demonstrated the potential for eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), vitamin D, physical activity, and physical fitness to improve and arachidonic acid (AA) to threaten depression/quality of life scores. This study examined whether blood fatty acid levels, vitamin D status and/or physical activity are associated with physical fitness scores, measures of mood, and measures of resiliency in active duty soldiers. 100 active duty males at Fort Hood, TX underwent a battery of psychometric tests, anthropometric, fitness tests, and donated fasting blood samples. Pearson bivariate correlation analysis revealed significant correlations among psychometric tests, anthropometric, physical performance, reported physical inactivity (sitting time), and fatty acid and vitamin D blood levels. Categorical analysis revealed significant difference in levels of fatty acids and vitamin D, anthropometric, physical performance, and psychometric measures. Based on these findings, a regression equation was developed to predict a depressed mood status as determined by the Patient Health Questionnaire-9. The equation accurately predicted 80% of our participants with a sensitivity of 76.9% and a specificity of 80.5%. Results indicate that lack of physical activity and fitness, high levels of AA and low levels of EPA, DHA, and vitamin D could increase the risk of depressed mood

and that use of a regression equation may be helpful in identifying soldiers at higher risk for possible intervention. Future studies should evaluate the impact of exercise and diet interventions as a means of improving resiliency and reducing depressed mood in soldiers.

DEDICATION

To the Soldiers, Sailors, Marines, and Airmen who currently suffer from the invisible wounds of war. It is my sincerest hope that this research, no matter how small, contributes to helping mend those wounds. I would also like to dedicate this to the service members who paid the ultimate sacrifice; to you I owe a debt that will never be paid.

ACKNOWLEDGEMENTS

I would like to thank the following individuals for their help with this study: Colonel Steven Gilland and the Soldiers of 1st Brigade Combat Team, 1st Cavalry Division for their support and participation. Lieutenant Colonel Michael Walter and the laboratory staff at Carl R Darnall Army Medical Center for the phlebotomy support. Dr. Stephen Carroll for medical oversight and data collection support. Colonel (Retired) Russ Kotwal for his mentorship and support. Finally, I would like to thank my committee members, Dr. Richard Kreider, Dr. Stephen Crouse, Dr. Tim Elliott, Dr. Mike Greenwood, and Dr. Stephen Smith for their guidance during the study.

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CHAPTER I

INTRODUCTION AND RATIONALE

Background

The mental health of soldiers is a growing concern as rates of depression and suicide have increased in soldiers with recently more deaths attributed to suicide than deaths due to combat in Afghanistan in 2012 [1]. Previous research has demonstrated the potential for eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and cholecalciferol (Vitamin D), physical activity, and physical fitness to improve depression/quality of life scores. The purpose of this study was to determine if EPA/DHA, vitamin D levels, and physical activity are associated with physical fitness scores, Patient Health Questionnaire-9 (PHQ-9), and Dispositional Resiliency Scale-15 DRS-15 scores in active duty soldiers. Higher DRS-15 scores have been associated with higher success in Special Forces Assessment and Selection (SFAS) an extremely arduous military selection program with a high attrition rate[2]

Omega-3 fatty acids and vitamin D are also of particular interest in the military population as a study by Lewis et al. demonstrated that active duty military with the lowest DHA levels were 62% more likely to have committed suicide [3]. Umhau et al showed that 30% of the 900 samples taken from active duty soldiers between 2002-2008 were vitamin D deficient [4]. Increased physical fitness has also been shown to reduce soldiers' risk for depression [5]. This study examined the relationships between reported physical activity, physical performance, omega-3 and 6 fatty acids, vitamin D, and measures of resiliency (DRS-15, Big 5) in active duty soldiers to determine if diet and/or physical activity patterns related to mood/depression scores (PHQ-9) and whether individuals with different levels or categories had differing responses among these variables.

Statement of the Problem

Does physical fitness and/or blood levels of EPA, DHA, and Vitamin D relate to measures of mood and resiliency in active duty soldiers?

Purpose

The purpose of this study was to determine if a relationship exists between omega-3, vitamin D, and physical activity levels and markers of mood and resiliency in active duty soldiers. Additionally, to determine if individuals with different levels of fitness, Omega-3, and vitamin D status, and resiliency status are at different risk for mood disturbances. If so, future studies could consider manipulating diet and/or activity levels as a means to improve soldier mood and reduce the risk for depression related problems.

General Study Overview

Approximately 100 apparently healthy active duty male soldiers age 18-50 years of age were recruited to participate in this study. Soldiers were given the opportunity to attend a mass briefing in the Brigade classroom where they received a recruitment brief. Interested participants who met these general criteria were invited to a familiarization session in which the details of the study were explained, and human participants consent forms were signed. Once consent forms were signed, participants completed a form with general information concerning their military area of specialty, time in service, rank, and number of deployments, and completed the International Physical Activity Questionnaire, Big 5 Personality, and DRS-15.

Participants were instructed to fast for 8-10 hours only drinking water before testing on day 2 and notified of where to report the next day for the scheduled blood draw (Table 1). For the 2nd day of testing, participants arrived for testing fasted and underwent a blood draw where 10 ml of blood was taken for plasma fatty acid and vitamin D analysis. Participants were told to return in the next morning for the Army Physical Fitness Test (APFT).

On the third and final day of testing, participants arrived and received a instructions on the task, conditions, and standards for each event of the APFT. Participants completed 2 minutes of push-ups, 2 minutes of sit-ups, and a 2 mile run for time. Participants were allowed 10 minutes of rest between each event. Number of repetitions completed and run times were recorded for each subject. Height and weight of each subject also were measured as per standard protocol of an APFT. Overview of the study, see Table 1 on page 25, and the consent form and data collection forms can be found in Appendices A through F.

Hypotheses

H1: There is a significant relationship between depression scores (PHQ-9) and resiliency scores (DRS-15 and Big 5).

H2: There is a significant relationship between resiliency scores and physical performance scores.

H3: Blood fatty acid levels are significanlty associated with resiliency.

H4: Sitting time is significantly associated with resiliency.

H5: Higher resiliency scores will be significantly related with higher mood scores.

H6: Lower Vitamin D levels will be significantly related with higher resiliency and physical performance scores.

H7: Higher EPA levels are significantly associated with higher physical performance scores.

H8: Lower EPA levels are significantly associated with lower resiliency scores.

H9: Lower DHA is associated with lower physical performance scores.

H10: Lower DHA levels are significantly associated with higher depression scores.

H11: Higher AA levels is associated with lower physical performance.

H12: Higher AA levels are significantly associated with higher depression scores.

H13: Higher BMI category is associated with significantly lower physical fitness scores.

H14: Higher BMI category is associated with higher depression scores.

H15: Increased sitting time levels will be significantly associated with lower physical fitness scores.

H16: Increased sitting time levels will be significantly associated with higher depression scores.

H17: Increased physical fitness will be significantly associated with higher resiliency scores

H18: Increased physical fitness will be significantly associated with lower depression scores.

Null Hypotheses

H01: There will be no significant relationship between resiliency scores and number of deployments.

Delimitations

The study was conducted within the following parameters:

1. Approximately 100 apparently healthy active duty male soldiers age 18-50 were recruited to participate in this study

2. Participants were recruited at a briefing at 1st Brigade Combat Team, 1st Cavalry Division, Fort Hood Texas.

3. Testing sessions were conducted at Fort Hood Texas.

4. Participants showed up at minimum 10 hours fasted for their blood draws on day 2.

Limitations

1. All participants were recruited from the same Battalion at Fort, Hood Texas.

2. Due to no supplement intervention being utilized, only an associative relationship can be established.

Assumptions

1. Participants were honest in completing all questionnaires.

2. Participants gave max effort on the Army Physical Fitness Test (APFT).

3. The population is a normal distribution and an accurate representation of male soldiers in Battalion.

CHAPTER II

REVIEW OF LITERATURE

Mental Health and the Military

Mental disorders are the leading cause of hospital bed days and the second leading cause of medical encounters for active component service members in the U.S. military[6]. Between 2006 and 2012, the rate of PTSD in the active component of the military increased 192%, depression increased 66%, alcohol abuse and dependence increased 110%, and adjustment disorder increased 52%[6]. More than 300,000 new cases of mental health conditions occured among Operations Enduring Freedom and Iraqi Freedom (OEF/OIF) veterans between 2001 and 2007[7]. More recently a report by the Veteran's Administration found suicide rates among male veterans under 30 increased by 44 % from 2009-2011[8]

In a analyses of active duty personnel serving from 2001 to 2006, Shen and colleagues[9] reported that in 333,548 Army soldiers a deployment to Afghanistan or Iraq increased the odds of major depression by 3.52 times compared to Army soldiers who were deployed. A reported mental health concern is combat experiences during deployment might increase a service members capacity for suicide[10]. In a sample of 522 service members deployed in support of Operation Iraqi Freedom (OIF) Bryan et al.[10] reported that a greater range of combat experience, measured by a Combat Experience Scale (CES), predicts acquired capability of suicide[10]. However, a more recent and larger analyses by LeardMann et al[11] of 151,560 active duty and Reserve/National Guard with assessments in 2001, 2004, and 2007 found that combat experience, number of deployments, and length of deployment were not associated with increased suicide risk.

In a study of 18,305 Army and National Guard soldiers, Thomas and associates[12] reported a depression rate, measured by PHQ-9, with no functional impairment of 16% at 3 months and 15.7% at 12 months for active Army, and 11.5% at 3 months and 15.9% for the National Guard Soldiers deployed to Iraq. Breitbach et al.[13] surveyed 955 male soldiers in Advanced Individual Training (AIT) and reported mean PHQ-9 scores of 4.93±5.17 with 17.3% classified as having mild depression, 7.2% moderate depression, 3.2% moderate-severe depression, and 4.6% having severe depression. Luxton and colleagues[14] analyzed pre-and post-deployment data from 6,427 military males and reported depression rates, as measured by PHQ-9, of 4.48% pre-deployment and 10.05% post-deployment. Schaller and associates[15] in a 53,073 soldier sample reported a PHQ-9 adjusted mean of 7.2 in active service members, 6.7 in National Guard, and 6.5 in reservists, a deployment was not a significant risk factor for depression in active duty but it should be noted that this group included females and members from other services.

Dispositional Resiliency Scale-15 and the Military

Bartone states "*Hardiness is a personality style associated with resilience, good health, and performance under stressful conditions*"[16] Special Forces Assessment and Selection is a high-stress course with a 45-55% attrition rate[2]. In a sample of 1,138 males going through Special Forces Assessment selection, Bartone and associates[2] reported DRS-15 scores as a significant predictor ($p<0.02$) with every 1 point increase in DRS-15 score translating to a 3.3% increase in odds of graduating. Higher DRS-15 scores also have been associated with lower PTSD scores. Escolas et al.,[17] surveyed 561 service members who had been deployed for at least 30 days and found DRS-15 scores were negatively associated ($r=-0.39$; $p<0.001$) with PTSD scores measured by Post Traumatic Stress Disorder Checklist Military Version (PCL-M). Higher resiliency scores also areassociated with improved physical as well as mental health. Taylor and colleagues[18] surveyed 120 military males using the DRS-15 and Short Form Health Survey (SF-36) and reported DRS-15 scores were associated with physical and mental health markers. The relationship between resiliency and health in the military population also has been demonstrated by blood markers (IL-6, IL-12, IL4, IL-10, and neuropeptide Y). Sandvik and associates[19] reported that fluctuations in the DRS-15 scoring high overall while scoring low in one of the subcomponents of commitment, control, and challenge leading to a "unbalanced" score were associated with a less optimal immune and neuroendocrine response to stress in 21 Norwegian navy cadets during a high stress field exercise.

Omega-3 Fatty Acids and Mental Health

The evidence linking deficiencies in omega-3 fatty acids and psychiatric disorders were reviewed by the American Psychiatric Association (APA) in the treatment recommendations issued for omega-3 fatty acids in psychiatric patients[20]. The APA found that low fish consumption or a low omega-3 body compositional status was associated with increased risk of depression and other affective illnesses. In support of this finding is the fact that prevalence rates of major depression are 50 times higher among countries with little seafood consumption compared to countries with the highest consumption[21]. Three meta-analyses[20, 22, 23] reported treatment effect sizes for omega-3 fatty acids that are larger than those reported for most antidepressant pharmaceuticals. The APA recommends at least 1 gram/ day of EPA as concomitant therapy for most affective and psychotic disorders[20].

Epidemiologic data suggest that low fish consumption is a risk factor, although not a cause of depression and/or suicidal ideations. In a study that examined 1,767 participants in northern Finland reported that frequent fish consumption (twice per week or more) significantly reduced the risk of reporting depressive symptoms and of reporting suicidal thinking after adjustment for confounding variables[24]. A Belgium study reported that the seasonal variation in omega-3 plasma status closely correlated with the seasonal variation in suicide rates[25]. Lower fish consumption was associated with a doubling of the risk suicidal thinking by mothers during pregnancy, after control for 29 confounding variables in a longitudinal cohort study enrolling 14,541 pregnancies[26]. Lewis et al.[3] in a study using 800 blood samples from service members who committed suicide compared to 800 non-suicide controls reported that the risk of being in the suicide group increased by 14% per every standard deviation reduction in DHA blood levels[3]

A case-control study of 200 participants in Dalian, China, investigators found 30% lower RBC concentrations of EPA among suicide attempters and a dose-response association between low EPA status and greater risk[27]. In a study following 33 medication-free depressed participants over a two-year period found that participants with lower DHA levels and higher omega-6 to omega-3 ratios had a significantly higher risk of attempting suicide[28].

A randomized blinded placebo controlled trial in Ireland investigators reported a 45% reduction in suicidal thinking and a 30% reduction in depression among patients with recurrent self-harm recruited from an emergency room[29]. This intervention used 1.2 and 0.9 g/d of EPA and DHA respectively in a 12-week trial with 22 participants in the treatment group and 27 participants receiving the placebo. Participants receiving the EPA and DHA treatment also reported a reduced perception of daily stresses and anxiety that is likely relevant to a reduction of risk of the development of PTSD[29].

However in a study involving 78 soldiers deployed to Iraq, researchers found the omega- index, obtained by combining EPA + DHA bloods levels, was not associated with scores for anxiety, depression, or sleep[30]. All of the soldiers used in this study had mild to moderate depression that could have impacted the relationship between omega-3 levels and anxiety and depression scores. The researchers did find that the omega-3 index was associated with improved neurocognitive performance, particularly Cognitive Flexibility (CF) and Executive Function (EF) and the effect was seen most in the 81% soldiers who reported poor sleep[30]. This finding supports the concept of omega-3 fatty acids being utilized as a tool to ameliorate the negative impacts of stress and sleep loss. The evidence for the potential for omega-3 fatty acids to treat depression was strong enough for the Department of Defense to fund a $10 million, 3 year study utilizing omega-3 fatty acids as treatment for veterans who had attempted suicide[31]. Recently, three papers were published in the journal Military Medicine discussing the challenges and methods of incorporating more omega-3 fatty acids into the military food supply chain[32-34].

Omega-3 Fatty Acids and Muscle Tissue

Aside from cognitive benefits, fish oil also has demonstrated the potential to increase muscle hypertrophy and strength, both of which can be beneficial to the military population. In a study exploring insulin sensitivity and omega-3 fatty acids, six men and six women over the age of 60 were provided a 6-week isocaloric control diet, and then measurements of insulin sensitivity and inflammation were taken. The participants then underwent an 8-week experimental diet that was supplemented with 720 grams of fatty fish weekly and 15ml of sardine oil daily. The experimental diet significantly increased insulin sensitivity and lowered C-reactive protein[35].

The benefits of omega-3 fatty acids on skeletal muscle and plasma stress markers were further demonstrated in a population of 44 men and women (34± 13 years of age). Baseline measurements of body composition, resting metabolic rate, and salivary cortisol were taken. The participants then were randomly assigned to receive either 4 grams per day of safflower oil (control) or 4 grams per day of fish oil for six weeks at which time baseline measurements were repeated. The fish oil group significantly gained more muscle mass, significantly reduced fat mass and demonstrated a tendency to decrease salivary cortisol levels[36].

Smith et al. randomly assigned sixteen healthy older adults to either receive omega-3 fatty acids or corn oil for eight weeks. The rate of muscle protein synthesis was measured both pre- and post-supplementation during basal, post absorptive conditions and during a hyperaminoacidemic-hyperinsulinemic clamp. The corn oil group showed no increase in muscle protein or anabolic signaling across all testing. The omega-3 group showed no increase in the basal rate of muscle protein synthesis before and after supplementation. Howerever the omega-3 fatty acids provided a synergistic effect on muscle protein synthesis during the hyperaminoacidemia-hyperinsulinemia-induced increase in muscle protein synthesis along with greater increases in anabolic signaling of muscle mTOR and p70s6k phosphorylation[37].

Smith et al.[37] also conducted a similar study on a younger population of nine adults 25-45 years of age to ensure that the muscle growth effects of omega-3 fatty acids did not just occur in the elderly. The participants were provided four grams per day of omega-3s in the form of Lovaza® for eight weeks. Muscle protein synthesis and mTOR-p70s6k pathway were measured during basal, post absorptive conditions, and during a hyperinsulinemic-hyperaminoacidemic clamp. While neither protein synthesis nor mTOR-p70sk pathway signaling increased during the basal testing, both did significantly increase after insulin amino acid infusion[38]. The study validated the previous findings using elderly participants but also demonstrated that the same increases in muscle protein synthesis and mTOR-p70sk occur in younger healthy population.

Omega-3 fatty acids also have the ability to improve measures of strength. A study of 45 women (64±1.4 years of age) who were randomly assigned to three groups. One group strength-trained for 90 days, one group strength trained and received two grams per day of fish oil for 90 days, and one group received strength trained and received fish oil at two grams/day for 120 days and initiated fish oil supplementation 60 days prior to training. Peak torque and torque rate were calculated based on the force of the participants' isometric contraction using a strain gauge and multiplied by the distance from the attachment point to the segment joint center. Peak torque and torque rate improved for all groups but the fish oil groups gained more strength than then the strength-training only group and performed better in the functional task of chair-rising compared to the strength training only group[39].

Omega-3 fatty acids also have demonstrated anti-catabolic properties. A recent study showed that in vivo omega-3 fatty acids increased protein synthesis by 25% compared to control muscle cells of ageing rats and when cells were induced into a starvation state, EPA reduced protein breakdown by 22% compared to the control[40]. This study demonstrated that omega-3 fatty acids have the potential to be anti-catabolic during periods of caloric restriction. The ability to spare muscle during caloric restriction would make omega-3 fatty acids beneficial in high-stress military scenarios where food might not be optimal.

Vitamin D and Mental Health

Researchers also have demonstrated an association between vitamin D and mental health. In a cross-sectional study of 12,594 participants lasting four years, lower vitamin D levels were associated with depressive indicators, especially in those with a history of depression[41]. A study in the Netherlands involving 494 participants with no history of depression (controls), 790 participants with a history of a depressive episode requiring treatment, and 1,102 participants currently being treated for depression found that those currently being treated for depression had a significant lower level of plasma vitamin D compared to the control[42]. The authors also reported an inverse relationship between vitamin D levels and depression severity in those being treated for depression[42]. Ganji et al.[43] reported that in a sample of 7,970 non-institutionalized US residents aged 15-39 the odds ratio for having current depressive episodes was 1.85 (p=0.021) in those who were vitamin D deficient compared to those who were not.

Given the strong link between depression and vitamin D levels, researchers have conducted intervention trials to determine if a cause and effect relationship exists. A Norwegian study involving 441 participants supplemented with either a placebo, 20,000 IU, or 40,000 IU of vitamin D for one year reported that in the two groups receiving vitamin D, but not the placebo, there was a significant improvement in Beck Depression Inventory Scores[44]. Similarly, researchers in Sweden found that low levels of vitamin D were associated with depression in adolescents and supplementation attenuated symptoms of depression and improved measures of well-being[45].

This research demonstrates that supplemental vitamin D might serve as an intervention to combat depression. However, the depression-ameliorating impact of vitamin D has not always been demonstrated in research. In a study involving 230 participants with low vitamin D and 114 participants with high vitamin D as nested controls reported that in low vitamin D participants no difference was found in depression scores in those receiving 40,000 IU of vitamin D_3 weekly versus the placebo[46]. Given the question of effectiveness of vitamin D supplementation on depression, the cause and effect relationship needs to be further explored. Specifically, in the military population, Umhau and colleagues[4] compared 495 blood samples of service members who committed suicide versus 495 control service members and found that subjects in the lowest octile of vitamin D blood levels had the highest risk of being in the suicide group. Another key finding was more than 30% of all 900 samples were vitamin D deficient[4]. In a study of 314 Special Operation Forces (SOF) personnel, Wentz et al.[47] reported that 50% of the participants were either vitamin D deficient or insufficient. Based on these studies, adequate vitamin D levels in service members should be a concern.

Vitamin D and Muscle Tissue

Vitamin D has long been associated with attaining adequate sun exposure. In the military population, where much of the skin is covered due to uniform and equipment requirements (i.e., body armor), sunshine exposure cannot be used as a reliable source of vitamin D. Thus, as discussed earlier , a 30% decreased rate of vitamin D had been previously observed in this population [4]. This can have detrimental effects on health and bone metabolism as well as muscle growth and strength.

Moreira-Pfrimer et al., conducted a double-blind, placebo-controlled, randomized trial of institutionalized people 60 years of age or older receiving either a calcium/placebo combination or a calcium/vitamin D combination for 6 months. Vitamin D and muscle strength tests were conducted pre-and post-6 month supplementation. As expected, the vitamin D group had significantly increased plasma vitamin D levels compared to the placebo group. However, despite no strength training protocol, the vitamin D group increased hip flexor strength by 16.4% and knee extensor strength by 24.6% while no increase in strength was seen in the calcium/placebo group[48]. It is important to point out that both groups received sun exposure as plasma vitamin D concetrattions (December-May) significantly increased in both groups as the study went into the summer months, also the study was conducted in Sao Paulo, Brazil. The finding that strength increased in the supplement group despite the seasonal increase in plasma vitamin D in both groups suggests the supplemental vitamin D was acting as an ergogenic rather than just treating a vitamin D deficiency in the experimental group.

Wicherts et al. examined the association of serum vitamin D concentration with currently physical performance and its decline over three years among the elderly. The study consisted of 1,234 men and women aged 65 years and older and 979 for the longitudinal analysis. Physical performance was measured by a walking test, chair stands, and tandem stands[49]. The analysis adjusted for age, gender, chronic diseases, and degree of urbanization, body mass index, and alcohol consumption. Serum vitamin D concentrations below 20 ng/ml were associated with poorer initial physical performance and a greater decline in physical performance over the next three years[49]. Also of significance was that 50% of the group tested had concentrations of 20 ng/ml or below, demonstrating that a vitamin D intervention would be beneficial in this population.

Researchers also have demonstrated vitamin D provides similar benefits in terms of muscular hypertrophy and strength in younger individuals. Researchers investigated vitamin D levels and the degree of muscle fat infiltration in 90 post-pubertal females 16-22 years of age living in California. Women with sufficient vitamin D levels had significantly lower muscle fat than women with insufficient and deficient levels of vitamin D. The finding was independent of body mass[50]. The researchers also found that 59% of the participants were vitamin D insufficient (<29 ng/ml) and 24% of that sample was clinically deficient (< 20 ng/ml)[50]. Koundourakis and associates[51] reported that in 67 male soccer players in Greece, vitamin D concentrations were significantly correlated pre-training program with squat jump (r=0.731, p=<0.001) counter movement jump (r=0.740, p=<0.001), 10 meter sprint, (r=-0.648, p=<0.001) 20 meter sprint (r=-0.673, p=<0.001), and peak VO_2 (r=0.43, p=<0.001). Vitamin D concentration remained significantly correlated post-training with squat jump (r=0.591, p=<0.001) counter movement jump (r=0.476, p=<0.001), 10 meter sprint, (r=-0.410, p=<0.001) 20 meter sprint (r=-0.426, p=<0.001), and peak VO_2 (r=0.394, p=0.006) and the end of a 6 week off-season training program.

Androgen levels are associated with both muscle size and strength, Wehr et al.[52] looked at the association of vitamin D concetration with testosterone, a free androgen index (FAI), and steroid hormone-binding globulin (SHBG) in 2,299 men during routine coronary angiography between 1997-2000. The study revealed men with adequate vitamin D concentrations (>30ng/ml) had significantly higher levels of testosterone and FAI and significantly lower concetration of SHBG compared to insufficient (20-29.9 ng/ml) vitamin D men and deficient (<20ng/ml) vitamin D men[52]. The researchers also found that testosterone concentrations followed seasonal variations with March having the lowest concentrations for all groups and August having the peak concentrations for all groups. The study clearly demonstrated a relationship between vitamin D levels and androgen levels in men and the potential benefits if one were to supplement insufficiencies/deficiencies and during winter seasons when less sun exposure is expected.

The association of vitamin D and muscle strength were explored by Grimaldi et al.[53] in 419 healthy men and women 20-76 years of age. The strength measurements consisted of isometric and isokinetic strength in both the arms (dominant hand strength and elbow flexion and extension) and legs (dominant knee flexion and extension) using computerized dynamometry. Age, gender, systolic blood pressure, diastolic blood pressure, resting heart rate, body mass index, physical activity counts, maximal oxygen uptake, and seasonal vitamin D concentrations were controlled for using multivariate models[53]. Vitamin D concentrations were associated with both arm and leg strength when controlling for age and gender. However, when all areas were controlled vitamin D concentrations were not associated with isokinetic leg strength but were associated with isokinetic and isometric arm strength and isometric leg strength[53]. The study clearly demonstrates the importance of vitamin D for muscle strength in adults and supports the notion that adequate vitamin D intake either via sunshine, food, and/or supplementation is beneficial for muscle strength.

Two reviews on vitamin D and skeletal muscle supported the previous research findings with vitamin D being associated with optimal muscle function and improving muscle strength and function in individuals deficient regardless of strength training[54, 55]. Both papers supported the existence of a vitamin D receptor (VDR) in the skeletal muscle. In animal models where VDR is not present, muscle fibers are 20% smaller in diameter and more variable demonstrating that vitamin D has both genomic and non-genomic influence on skeletal muscle[54, 55].

Body Mass Index and Mental Health

A U.S. Department of Defense survey by Kress et al.[56] of 10,040 service members found obesity, as classified by BMI, increased the odds of depressive symptoms compared to normal weight service members. Kress et al.[56] reported 37% of the population was normal, 53% was overweight, and 10% was obese in the 7,567 active duty men in the 10,040 service members in the study. In a secondary analyses of 15,915 service members from a 2005 Department of Defense survey, Smith and associates[57] reported that among active duty military men, being obese was significantly associated with generalized anxiety disorder (GAD) symptoms (OR: 1.3, 95% CI: 1.02-1.77; $p < .05$) and being overweight was associated with serious psychological distress (SPD) symptoms (OR: 1.3, 95% CI: 1.05-1.71; $p < .05$).

However, in a study of 7,514 U.S. service members receiving psychiatric care and 85,940 healthy service members serving as controls, Wyatt et al.,[58] reported no relationship between BMI and psychiatric disorder. The reason for this contradiction is probably best explained by de Wit[59] and associates who reported the BMI and depression are not a linear association but rather describes a U-shaped curve. A sample of 43,534 subjects age 18 to 99 in a general population was used to test the U-shaped curve and the authors found a very significant ($p \leq 0.001$) U-shaped association between BMI categories underweight, normal, overweight, and obese and depression, but no significant association between depression and continuous BMI[59].

Physical Fitness and Mental Health

Increased physical fitness and physical leisure time activities are associated with higher health-related quality of life scores in military age men in Finland[60]. Vallance and colleagues[61] reported increasing physical activity and decreasing sedentary time lowered the odds of depression is a cross-sectional study of 2,862 adults[61]

Higher level of cardiorespiratory fitness is associated with increased health-related quality of life scores in US Navy personnel[62]. Poor cardiorespiratory fitness at 18 years of age has been shown as a risk factor for depression in adulthood in 1,117,292 Swedish military conscripts who were tracked for a period of 3 to 40 years[63]. Army trainees who failed a physical fitness test were at increased risk of being diagnosed with a mental disorder in their first year of service[64]. Davidson and associates[65] investigated 346 Veterans being treated for PTSD, that exercise was associated with fewer depressive symptoms along with better quality of sleep. Two Bosnian studies of 100 and 141 patients surveyed at a family medicine clinic using the IPAQ and PHQ-9 reported that an a association between higher physical activity and lower PHQ-9 stores and lower physical activity and higher PHQ-9 scores[66, 67]. A thorough meta-analysis of 30 trials by Rimer et al..[68] reported that exercise may serve as a potential treatment for depression, as exercise reduced depressive symptoms in depressed individuals when compared to no exercise[68]

Conclusion

Based on these previous findings, a relationship between physical fitness, vitamin D, omega-3 fatty acids, and mental and physical performance was established. Given that the previous reported research has only observed these variables individually, our experiment combines the variables to determine if we can achieve a stronger relationship in our population. Depending on the strength and existence of this relationship, a model might be developed to predict a soldier's mood more accurately based on this relationship.

CHAPTER III

METHODS

Participants

100 apparently healthy active-duty male soldiers from a support Battalion at Fort Hood, Texas ages of 18 to 50 were recruited to participate in this study. Inclusion criteria were not currently being treated by Behavioral Health and physically able to take the standard Army Physical Fitness Test (APFT). Exclusion criteria were currently being treated by Behavioral Health and not physically capable of taking a standard APFT. Interested participants who met these specific criteria were invited to a familiarization session in which the details of the study were explained. Participants signed consent forms in compliance with the Human Subjects Internal Review Committee at Texas A&M University and the Brooke Army Medical Center Department of Clinical Investigation Office of the Institutional Review Board.

Study

Recruitment and testing took place in the Troop area of 1st Brigade Combat Team, 1st Cavalry Division, Fort Hood, Texas. Blood samples were analyzed by Quest Diagnostics (*Quest Diagnostics, Houston TX)*. Data analysis was conducted at the Exercise & Sport Nutrition Lab at Texas A&M University.

Experimental Design

Participant recruitment and data collection were conducted over a 3-day period during the fall (Table 1). On day 1, participants were recruited from the support Battalion. Interested soldiers were given the opportunity to attend a mass briefing in the Brigade classroom where they received a recruitment brief. Participants who met the inclusion criteria for the study were invited to a familiarization session in which the details of the study were explained, and human participants consent forms were signed. Once consent forms were signed, participants completed the IPAQ, PHQ-9, DRS-15, and Big 5 questionnaire along with general information concerning their military area of specialty, time in service, rank, and number of deployments completed. The participants were instructed to fast for 8-10 hours with water being the only fluid allowed to be consumed. Participants were notified of the location of the blood draw for day 2.

On day 2, participants arrived for testing fasted and 10 ml of venous blood was obtained from an antecubital vein using standard phlebotomy procedures by a military medical staff member. Participants were instructed to report to standardized road course the next morning for the APFT.

On day 3 participants, received a brief on the task, conditions, and standards for each event of the APFT. Participants completed 2 minutes of push ups, 2 minutes of sit ups, and a 2 mile run for time using standard military APFT procedures. Participants were allowed 10 minutes of rest between each event. The number of repetitions completed and run times was recorded for each subject. Anthropometric measurements of height and weight were taken for each participant, which is standard procedure for each APFT. Consent and data collection forms are found in Appendices A through F.

Table 1: Study Overview

Day 1	Day 2	Day 3
Recruitment Brief Consent Form Background Information IPAQ DRS-15 Big 5	Blood Draw Informed of time and location of APFT	APFT Height and weight recorded

Medical Monitoring

Medical surveillance was provided during all testing sessions. At least two medics and a physician were present at all testing sessions. No adverse events were reported during the APFT assessments. Three participants screened reporting thoughts of self-harm based on data obtained in the PHQ-9. Based on established protocol, the Brigade Surgeon was notified of the participant numbers and provided the participants with referrals and the participants were screened by Behavioral Health Care and deemed not to be a threat to themselves or others. Since individuals were not actively in treatment at the time of testing data were included for analysis.

Methods and Procedures

Plasma Omega-3 and Omega-6 Fatty Acids, Plasma

Subject blood samples were analyzed by Quest Diagnostics (*Quest Diagnostics, Houston, TX*) assay extracts saturated and unsaturated fatty acids with chain lengths of between 14 and 24 carbons (C14:0-C24:1, for a total of 19 fatty acids) were isolated from plasma phospholipids. The phospholipids are isolated from the plasma using a solid phase extraction, hydrolyzed to release the fatty acids and then extracted by a liquid-liquid extraction. The fatty acids are then separated by HPLC, and detected by mass spectrometry (SIM or single ion monitoring and SRM or selective reaction monitoring) in the negative APCI mode. Results are based on peak areas, with each individual fatty acid divided by the total fatty acid areas to generate a percentage.

Calculation of ratios were made the following ways: Omega-3 index = (eicosapentaenoic acid + docosahexaenoic acid) ÷ total phospholipid fatty acids, omega-6/omega-3 = sum of 6 omega-6 fatty acids ÷ sum of 4 omega-3 fatty acids and Arachidonic acid/Eicosapentaenoic acid = % Arachidonic acid ÷ % Eicosapentaenoic acid. Omega-3 index categorical definitions for cardiovascular risk factor are omega-3 index <1.1 High risk, omega-3 index 1.1-3.3 Moderate risk, and omega-3 index >3.3 Low risk as established by previous research[69-72]. The coefficient of variation for the omega-3 and omeg-6 testing is 10%. The analytical sensitivity for omega-3 is 0.16%, omega-6 is 0.44%, arachidonic acid is 0.06%, eicosapentaenoic acid is 0.05%, and docosahexaenoic acid is 0.11%.

Vitamin D / 25 (OH) D

Participant blood samples were analyzed by Quest Diagnostics (*Quest Diagnostics, Houston, TX*). Protein precipitation of serum samples is used to release 25OH vitamin D_2 and D_3 from their binding proteins. Add this time the internal standards (deuterated 25OH D_2 and D_3) are added to correct for procedural losses. The 25OH D_2 and D_3 are separated from one another and other vitamin D analogs are separated by HPLC before being quantitated using a tandem MS analyzer run in positive mode. The area under the peak of the anaylte and the respective internal standard are used in the final quantitation using a standard curve run in the same assay 25 (OH) D levels. The test has an analytical sensitivity of 4 ng/mL for $25OHD_2$ and $25OHD_3$ and coefficient of variation of 5.8%

Army Physical Fitness Test (APFT):

The APFT provides a measure of upper and lower body muscular endurance. It is a performance test that indicates a soldier's ability to perform physically and handle his or her own body weight. The APFT consists of two minutes of push ups, two minutes of sit ups, and a 2-mile run—done in that order—on the same day. Soldiers are allowed a minimum of 10 minutes and a maximum of 20 minutes rest between events. All three events must be completed within 2 hours. The test period is defined as the period of time that elapses from the start to the finish of the three events (from the first push-up performed to the last Soldier crossing the finish line of the 2-mile run event)[73].

For the push up event, participants assumed the push up position on the command "Get Set" by placing their hands where they were comfortable for the individual. Participants' feet were allowed to be together or up to 12 inches apart. Participants body, when viewed from the side had to form a generally a straight line from their shoulders to their ankles. Participants were instructed to begin the push up event on the command "Go". Participants were instructed that a push-up consists of bending their elbows and lowering their entire body until their upper arms were parallel to the ground and returning to the starting position by raising their entire body until their arms were fully extended. Their body had to remain in a generally straight line and move as a unit for the entire repetition. At the end of each repetition, the scorer stated how many repetitions the participant correctly completed.

If the participant failed to keep their body in a generally straight line, or lower their entire body until the upper arms extend parallel to the ground, or to extend their arms completely, then that repetition did not count. The scorer repeated the number of the participant's last correct repetition until another good repetition was performed. If the participant rested on the ground or raised either hand or either foot from the ground, the event was terminated.

For the sit ups participants were instructed to assume the starting position by lying on their back with their knees bent so that the upper and lower part of their legs form a 90-degree angle. Participants were allowed to keep feet together or up to 12 inches apart while another participant held their ankles with their hands only. Participants were instructed no other bracing method could be utilized. The participants were informed the heel was the only portion of the foot that must remain in contact with the ground. Participants were instructed to interlock their fingers behind their head, and the backs of their hands must touch the ground before starting on the command of “Get Set”. On the command “Go” participants had to sit up to the vertical position were the base of their neck was directly above the base of their spine. Once the participants reached or surpassed the vertical position, they had to lower their body until the bottoms of both shoulder blades touched the ground to complete one repetition. Participants had to keep fingers interlocked behind their head and may not arch or bow their back or raise their glutes off the ground. Participants’ knees could not exceed a 90-degree angle. If participants broke any one or more of these rules, then the repetition did not count.

For the 2-mile run participants were instructed on the command “Go” to run a flat standardized 2-mile run route as fast as possible. Participants were instructed they could neither provide nor receive assistance during the run. The time started on the command “Go” and time stopped when the participant crossed the marked finish line.

Army Physical Fitness Test standards are adjusted for age, and physiological differences between the genders and score are based on established normative data[74].

Anthropometric Measurements

Height was measured using a height rod on a Detecto 439 Physician Balance Beam Scale (*Detecto Scale Company, Webb City, MO*) and recorded to the nearest half inch. Total body weight was also measured using a Detecto 439 Physician Balance Beam Scale (*Detecto Scale Company, Webb City, MO*) and recorded to the nearest half pound. Body Mass Index (BMI) was then calculated by dividing weight in pounds by height in inches squared and multiplying by a conversion factor of 703 and classified as either Normal BMI 18.5– 24, Overweight BMI 25.0-29.9, or Obese BMI 30 and above as per guidelines by the National Heart, Lung, and Blood Institute[75].

Patient Health Questionnaire-9 (PHQ9)

PHQ-9 is an established valid reference for mood/depression with an established reliability and validity[76-78]. The PHQ-9 is particularly useful in this non-clinical population for its ability to detect subthreshold depression in a general population[76]. The different scoring cutoff points for the PHQ-9 is 5, 10, 15, and 20 for mild, moderate, moderate-severe, and severe depression respectively. A score of ≥10 was used to classify participants as recommend for treatment of depression (major depression), which has been previously validated with a sensitivity and specificity of 88% when compared to structured interviews of patients by a mental health professional[77].

Dispositional Resiliency Scale-15 (DRS-15)

The DRS-15 is a measure of hardiness and has been used and validated in civilian populations, military cadets, and soldiers going through Special Forces Assessment and Selection (SFAS) as a measurement of mental resiliency[2, 16]. The test gives the individual a total resiliency score based on a 15 question, 45-point survey assessing commitment, control, and challenge each with a five-item subscale. The DRS-15 has a high reliability with an established test-retest coefficient of .78 and respective subscale category coefficients of Commitment = .75, Control = .58, and Challenge = .81[16].

The Big 5 Personality Questionnaire

The Big 5 Personality is questionnaire is used to assess Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness[79]. A cluster analysis was used by a psychologist to classify participants into three groups: resilient, undercontrolled, and overcontrolled. Based on the cluster analysis participants were coded either resilient or non-resilient.

International Physical Activity Questionnaire (IPAQ)

Physical activity patterns were assessed using the IPAQ-Long Form that is the seven day version of the IPAQ. The IPAQ-Long Form assess the intensity(vigorous or moderate) and frequency of activities for job-related physical activity, transportation physical activity, housework, house maintenance, caring for family, recreation, sport, and leisure time physical activity. The IPAQ-Long Form also assesses weekly time spent sitting. The IPAQ is considered a reliable and valid measure of self-reported physical activity with Booth et al.[80] reporting a correlation coefficient of 0.84 in the English short form of accelerometer data in participants from the United States.[80, 81]. The IPAQ has been reported to significantly overestimate activity[82].

Statistical Methods

Pearson Product Moment Correlation was run to determine if a significant relationship existed between variables. Variables with significant correlations were further analyzed by categorizing responses and analyzing them by Multivariate Analysis of Variance (MANOVA). The Wilks' Lambda p-level was used to determine the overall significance among the variables analyzed. Univariate ANOVA with Least Squares Difference (LSD) post-hoc analysis was used to determine differences among categories for each variable. Based on MANOVA results, a binary logistic regression model was constructed in order to predict mood outcomes. Hosmer-Lemeshow test was used to assess goodness of fit. All analyses were completed us IBM SPSS statistics software version 22 (*IBM Statistics, Chicago, IL*).

CHAPTER IV

RESULTS

Participant Demographics

Table 1 population data presents the means ± standard deviations and range of the participants on variables measured. Participants were active duty male service members 26±5.6 years; 69.2±3.2 inches, 185±26 pounds, and had a BMI of 27.1±3.2 kg/m^2. A total of 24 participants were classified as normal BMI between (18.5-24.9 kg/m^2), 57 were classified as overweight BMI (25-29.9 kg/m^2), and 19 were classified as obese (>30 kg/m^2). Participants were in the service an average of 5.4±7.7 years (range six months to 22 years). Out of the 100 participants studied, 37 had never deployed, 35 deployed once, 11 had deployed twice, 7 had deployed three times, 8 had deployed 4 times, one deployed 5 times, and one deployed 7 times. Ten of the participants were officers, 26 of the participants were Non-Commissioned Officers, and the remaining 64 participants were lower enlisted E-4 and below.

Fitness Assessment

Table 2 shows that the participants performed means ± standard deviations and range for push-ups 56±13.8 (69) in 2 minutes, 63±11.3 sit-ups (69) in 2 minutes, and ran two miles in 959.68±167.37 (1140) seconds. Raw results were scored on a 100-point scale based on Army Field Manual 7-22[73] that takes into account age and sex of the individual. The mean±SD for push-ups score was 77.8±13.7, sit-ups score was

Table 2. Population Data.

Variables	Mean±SD	Range	Variables	Mean±SD	Range
Age (yrs)	26±5.6	22	PHQ-9 Score	4.93±5.17	24
Height (in)	69.2±3.2	16	Commitment	9.57±3.2	14
Weight (lbs)	185±26	121	Control	12.22±3.0	15
BMI (kg/m^2)	27.1±3.2	15.68	Challenge	8.70±3.3	15
Service (yrs)	5.4±7.7	21.5	DRS-15 Score	30.5±6.7	41
Deployments	1.22±1.40	7	N-6 to N-3 Ratio	8.41±3.25	31.30
Push-ups(Reps)	56±13.8	69	Sitting Time (min/wk)	2,226±1,506	12,410
Push-up Score	77.8±13.7	53	Vit D (ng/mL)	28.6±8.7	50
Sit-ups(Reps)	63±11.3	67	N-3 Index (EPA + DHA)	1.38±.51	3.30
Sit-up Score	77.5±14.0	69	EPA (% total phospholipids)	0.205±0.16	1.10
Run time (sec)	957±167	1140	DHA (% total phospholipids)	1.17±0.43	2.50
Run Score	66.6±20.7	77	AA (% total phospholipids)	0.206±0.07	0.30
APFT score	225.6±34.6	178			

Data are depicted as means ± SD

77.5±14.0, and run score 66.6±20.7. Scoring is based on a scale of 100 established on prior normative data[74]. A score less than 60 in anyone event is considered failing.

Psychometric Assessments

Table 2 shows or the Patient Health Questionnaire-9 (PHQ), the mean and standard deviation was 4.93±5.17 with 63 participants classified as minimal depression (0-4), 24 participants classify as mildly depressed (score of 5-9), 7 participants classified as moderately depressed (10-14), 1 subject classified as moderately severe depressed (15-19), and 5 participants classify as severely depressed (20-24). The one subject classified as moderately severe was moved into the severely depressed category based on the score for MANOVA analysis. In terms of the Dispositional Resiliency Scale-15 (DRS-15), the score for commitment was 9.57±3.2, control was 12.22±3.0, challenge was 8.70±3.3, and total hardiness/resiliency was 30.50±6.69.

Physical Activity

Participants appeared to be confused by the activity questions on the IPAQ and either included or excluded work activity in their physical activity report given the MET total mean±SD was 21,958±81,577 MET-minutes/week. Given the high standard deviation and the fact that 32 participants did not report any job activity, we deemed the MET data invalid and did not use it in our analyses. However, all participants did report sitting time, so data were used in following analyses. In table 1 total sitting per week of 2,226±1,506 (12,410) minutes per week.

Hematological Analysis

Table 2 contains the mean and range of vitamin D was 28.6±8.7 (50) ng/mL with 16 of the participants classified as deficient (<20ng/mL), 39 as insufficient (20-30ng/mL), and 45 as optimal (≥30ng/mL). The definition of vitamin D deficiency and insufficiency is based on the practice guidelines of The Endocrine Society defined as a 25(OH)D below 20 ng/ml (50 nmol/liter), and vitamin D insufficiency as a 25(OH)D of 21–29 ng/ml (525–725 nmol/liter) [83]. It should be noted that this definition differs from the Institute Of Medicine concentration of 16 ng/ml (40 nmol/liter) which meet the requirements of approximately half the population, and levels of 20 ng/ml (50 nmol/liter) cover the requirements of at least 97.5% of the population [84]. There has been a debate by both Institute of Medicine and The Endocrine Society over the differing recommendations[85, 86].

The mean for Omega-3 Index was 1.38±.51 with 19 participants classified at high risk for cardiovascular disease, 80 for moderate risk, and only 1 classify in the low-risk category. The mean and range for EPA was 0.205±0.159 (1.10) percent of total blood phospholipids. The mean DHA level was 1.17±0.426 (2.50) percent of total blood phospholipids. The mean and range AA level observed was 0.206±0.07 (0.30) while the mean omega-6 to omega-3 ratio was 8.41±3.25 (31.30)

Correlational Analysis

Table 3 is the Pearson correlation between all variables with ** denoting variables that are statistically significant at $p \leq 0.05$ and * denoting variables significant at $p \leq 0.01$. There was no significant relationship between number of deployments and resiliency scores so we accept the null hypotheses H01: There will be no significant relationship between resiliency scores and number of deployments.

PHQ-9 scores were significantly correlated with DRS total resiliency scores ($r=-0.533$, $p \leq 0.05$), Big 5 resiliency ($r=-0.301$, $p \leq 0.05$), and run time ($r=-0.269$, $p \leq 0.05$). Because DRS total resiliency scores had a higher r-value, it was chosen as the psychometric test to be used in further analyses. Based on our findings we accept H1: There is a significant relationship between depression scores (PHQ-9) and resiliency scores (DRS-15 and Big 5). DRS total resiliency scores were positively correlated with run scores ($r=0.232$, $p \leq 0.05$) and negatively associated with weekly sitting time (r=-

0.202, $p \leq 0.01$). Based on our findings we accept H2: There is a significant relationship between resiliency scores and physical performance scores.

DRS total resiliency scores were correlated with arachidonic acid levels ($r=-0.205$, $p \leq 0.01$). Run scores were significantly correlated with Body Mass Index ($r=-0.200$, $p \leq 0.05$), number of push-ups ($r=.415$, $p \leq 0.05$), push-up score ($r=.406$, $p \leq 0.05$), number of sit-ups ($r=.464$, $p \leq 0.05$), sit-up score ($r=.463$, $p \leq 0.05$), and DRS commitment (-.198, $p \leq 0.05$). Vitamin D levels were associated weekly sitting time ($r=-221$, $p \leq 0.05$). EPA levels were significantly associated with number of push-ups ($r=.262$, $p \leq 0.05$) and sit-ups (.257, $p \leq 0.05$). DHA levels were significantly associated with number of push-ups (.209, $p \leq 0.05$). Arachidonic Acid levels were associated with DRS total resiliency ($r=-.205$, $p \leq 0.05$). Weekly sitting totals were also significantly correlated with DRS Commitment ($r=-.312$, $p \leq 0.05$). Based on our findings we accept H3: Blood fatty acid levels are significantly associated with resiliency and H4: Sitting time is significantly associated with resiliency.

Table 3. Pearson Correlation of Variables

	Age[a]	Ht[b]	Wt[c]	BMI[d]	Dep[e]	PU[f]	PU S[g]	SU[h]	SU S[i]	R T[j]	Rn S[k]	APFT [l]	Vit D[m]
Age[a]	1	0.112	0.183	0.120	0.507**	0.117	0.156	-0.007	0.179	-0.002	0.381**	0.280**	-0.001
Ht[b]	0.112	1	0.542**	-0.150	-0.049	-0.149	-0.129	-0.040	0.056	0.024	0.107	0.057	0.119
Wt[c]	0.183	0.542**	1	0.745**	0.124	-0.083	-.0036	-0.274**	-0.173	0.145	-0.099	-0.104	-0.049
BMI[d]	0.120	-0.150	0.745**	1	0.185	0.022	0.063	-0.280**	-0.242*	0.148	-0.200*	-0.164	-0.150
Dep[e]	0.507**	-0.049	0.124	0.185	1	0.128	0.173	0.015	0.075	0.058	0.199*	0.183	0.140
PU[f]	0.117	-0.149	-0.083	0.022	0.128	1	0.970**	0.574**	0.400**	-0.221*	0.415**	0.707**	0.005
PU S[g]	0.156	-0.129	-0.036	0.063	0.173	0.970**	1	0.523**	0.397**	-0.174	0.406**	0.710**	0.011
SU[h]	-0.007	-0.040	-0.274**	-0.280**	0.015	0.574**	0.523**	1	0.836**	-0.279**	0.464**	0.726**	0.037
SU S[i]	0.179	0.056	-0.173	-0.242*	0.075	0.400**	0.397**	0.836**	1	-0.213*	0.463**	0.737**	0.000
R T[j]	-0.002	0.024	0.145	0.148	0.058	-0.221*	-0.174	-0.279**	-0.213*	1	-0.587**	-0.272**	-0.019
Rn S[k]	0.381**	0.107	-0.099	-0.200*	0.199*	0.415**	0.406**	0.464**	0.463**	-0.587**	1	0.801**	0.077
APFT [l]	0.280**	0.057	-0.104	-0.164	0.183	0.707**	0.710**	0.726**	0.737**	-0.272**	0.801**	1	0.093
Vit D[m]	-0.001	0.119	-0.049	-0.150	0.140	0.005	0.011	0.037	0.000	-0.019	0.077	0.093	1
6/3[n]	0.033	-0.012	-0.013	-0.005	0.075	-0.145	-0.109	-0.139	-0.022	0.067	-0.071	-0.094	-0.062
AA[o]	0.175	0.009	0.082	0.113	0.029	-0.055	-0.032	-0.189	-0.104	0.111	-0.080	-0.097	-0.133
EPA[p]	0.097	-0.063	0.005	0.050	-0.145	0.262**	0.184	0.257**	0.097	-0.146	0.154	0.187	-0.145
DHA[q]	0.153	-0.025	-0.031	-0.013	-0.020	0.209*	0.179	0.164	0.059	-0.058	0.062	0.113	-0.037
N-3 [r]	0.143	-0.055	-0.014	0.029	-0.054	0.254*	0.203*	0.215*	0.075	-0.085	0.085	0.142	-0.086
PHQ [s]	-0.145	-0.146	0.052	0.167	-0.055	-0.098	-0.092	-0.142	-0.093	0.163	-0.269**	-0.184	-0.114
Com[t]	0.191	0.025	0.075	0.061	0.152	0.173	0.139	0.057	0.072	-0.142	0.198*	0.131	-0.061
Cont[u]	0.072	0.046	0.033	0.003	0.079	0.062	0.042	0.073	0.007	-0.146	0.152	0.053	-0.035
Chall[v]	-0.094	0.015	-0.107	-0.134	0.033	-0.028	-0.014	0.105	-0.041	-0.130	0.145	0.043	0.144
Tot R[w]	0.077	0.040	-0.002	-0.035	0.123	0.096	0.077	0.111	0.017	-0.196	0.232*	0.107	0.025
Sit [x]	-0.063	0.037	0.110	0.104	-0.158	-0.058	-0.047	-0.120	-0.099	-0.093	0.012	-0.081	-0.221*
Big 5[y]	0.047	0.104	0.122	0.057	0.067	0.115	0.103	0.013	-0.066	-0.201*	0.167	0.065	0.131

**Correlation significant at the p= 0.01 level *Correlation significant at the p= 0.05 level [a]Age=age in years [b]Ht=height in inches [c]Wt=weight in pounds [d]BMI=Body Mass Index [e]Dep=Number of deployments [f]PU=number of push-ups [g]PU S=push-up score [h]SU=number of sit-ups [i]SU S=sit-up score [j]R T=run time in seconds [k]Rn S=run score [l]APFT=APFT total score [m]Vit D=vitamin d in ng/mL [n]6/3=Omega-6 to Omega-3 ratio percentage of phospholipid [o]AA=Arachidonic acid levels as a percentage of phospholipids [p]EPA=Eicosapentaenoic acid levels as a percentage of phospholipids [q]DHA= Docosahexaenoic acid levels as a percentage of phospholipids [r]N-3=Omega-3 Index (EPA levels + DHA levels) [s]PHQ=Patient Health Questionnaire-9 scores [t]Com=Commitment score from Dispositional Resilience Scale-15 [u]Cont=Control score from Dispositional Resilience Scale-15 [v]Chall=Challenge score from Dispositional Resilience Scale-15 [w]Tot R=Total Resiliency Score from Dispositional Resilience Scale-15 [x]Sit=Total weekly sitting time in minutes reported [y]Big 5=Resiliency based on Big 5 Questionnaire

Table 3. (continued)

	6/3[n]	AA[o]	EPA[p]	DHA[q]	N-3[r]	PHQ[s]	Com[t]	Cont[u]	Chall[v]	Tot R[w]	Sit[x]	Big 5[y]
Age[a]	0.033	0.175	0.097	0.153	0.143	-0.145	0.191	0.072	-0.094	0.077	-0.063	0.047
Ht[b]	-0.012	0.009	-0.063	-0.025	-0.055	-0.146	0.025	0.046	0.015	0.040	0.037	0.104
Wt[c]	-0.013	0.082	0.005	-0.031	-0.014	0.052	0.075	0.033	-0.107	-0.002	0.110	0.122
BMI[d]	-0.005	0.113	0.050	-0.013	0.029	0.167	0.061	0.003	-0.134	-0.035	0.104	0.057
Dep[e]	0.075	0.029	-0.145	-0.020	-0.054	-0.055	0.152	0.079	0.033	0.123	-0.158	0.067
PU[f]	-0.145	-0.055	0.262**	0.209*	0.254*	-0.098	0.173	0.062	-0.028	0.096	-0.058	0.115
PU S[g]	-0.109	-0.032	0.184	0.179	0.203*	-0.092	0.139	0.042	-0.014	0.077	-0.047	0.103
SU[h]	-0.139	-0.189	0.257**	0.164	0.215*	-0.142	0.057	0.073	0.105	0.111	-0.120	0.013
SU S[i]	-0.022	-0.104	0.097	0.059	0.075	-0.093	0.072	0.007	-0.041	0.017	-0.099	-0.066
R T[j]	0.067	0.111	-0.146	-0.058	-0.085	0.163	-0.142	-0.146	-0.130	-0.196	-0.093	-0.201*
Rn S[k]	-0.071	-0.080	0.154	0.062	0.085	-0.269**	0.198*	0.152	0.145	0.232*	0.012	0.167
APFT[l]	-0.094	-0.097	0.187	0.113	0.142	-0.184	0.131	0.053	0.043	0.107	-0.081	0.065
Vit D[m]	-0.062	-0.133	-0.145	-0.037	-0.086	-0.114	-0.061	-0.035	0.144	0.025	-0.221*	0.131
6/3[n]	1	-0.086	-0.320**	-0.579**	-0.590**	-0.058	-0.050	-0.021	0.045	-0.011	-0.067	0.064
AA[o]	-0.086	1	0.141	0.441**	0.366**	0.075	-0.151	-0.103	-0.179	-0.205*	0.043	0.008
EPA[p]	-0.320**	0.141	1	0.523**	0.716**	0.013	0.083	0.017	-0.104	-0.004	0.070	0.119
DHA[q]	-0.579**	0.441**	0.523**	1	0.942**	-0.125	0.104	0.082	-0.049	0.062	-0.032	0.032
N-3[r]	-0.590**	0.366**	0.716**	0.942**	1	-0.064	0.100	0.088	-0.090	0.043	-0.018	0.035
PHQ[s]	-0.058	0.075	0.013	-0.125	-0.064	1	-0.495**	-0.302**	-0.337**	-0.533**	0.138	-0.301**
Com[t]	-0.050	-0.151	0.083	0.104	0.100	-0.495**	1	0.528**	0.140	0.777**	-0.312**	0.416**
Cont[u]	-0.021	-0.103	0.017	0.082	0.088	-0.302**	0.528**	1	0.122	0.756**	-0.016	0.263**
Chall[v]	0.045	-0.179	-0.104	-0.049	-0.090	-0.337**	0.140	0.122	1	0.607**	-0.098	0.263**
Tot R[w]	-0.011	-0.205*	-0.004	0.062	0.043	-0.533**	0.777**	0.756**	0.607**	1	-0.202*	0.442**
Sit[x]	-0.067	0.043	0.070	-0.032	-0.018	0.138	-0.312**	-0.016	-0.098	-0.202*	1	-0.142
Big 5[y]	0.064	0.008	0.119	0.032	0.035	-0.301**	0.416**	0.263**	0.263**	0.442**	-0.142	1

**Correlation significant at the p= 0.01 level *Correlation significant at the p= 0.05 level [a]Age=age in years [b]Ht=height in inches [c]Wt=weight in pounds [d]BMI=Body Mass Index [e]Dep=Number of deployments [f]PU=number of push-ups [g]PU S=push-up score [h]SU=number of sit-ups [i]SU S=sit-up score [j]R T=run time in seconds [k]Rn S=run score [l]APFT=APFT total score [m]Vit D=vitamin d in ng/mL [n]6/3=Omega-6 to Omega-3 ratio percentage of phospholipid [o]AA=Arachidonic acid levels as a percentage of phospholipids [p]EPA= Eicosapentaenoic acid levels as a percentage of phospholipids [q]DHA= Docosahexaenoic acid levels as a percentage of phospholipids [r]N-3=Omega-3 Index (EPA levels + DHA levels) [s]PHQ=Patient Health Questionnaire-9 scores [t]Com=Commitment score from Dispositional Resilience Scale-15 [u]Cont=Control score from Dispositional Resilience Scale-15 [v]Chall=Challenge score from Dispositional Resilience Scale-15 [w]Tot R=Total Resiliency Score from Dispositional Resilience Scale-15 [x]Sit=Total weekly sitting time in minutes reported [y]Big 5=Resiliency based on Big 5 Questionnaire

Categorical Analysis

Table 4 presents a MANOVA with Depression Category as a factor. We found that depression category had a significant Wilk's Lambda effect (p=<0.001) on all variables. A post-hoc LSD analysis reveals Depression Category had a significant Between-Participants Effect on DRS commitment, control, challenge, and total resiliency score along with APFT run score. There is also a significant difference in the BMI of those in depression category 1 and 3. Although significance was not obtained, we also found a trend in total fitness score and vitamin D and the depression categories. Based on our findings we accept H5.

Table 5 presents a MANOVA with Vitamin D category as a factor. We found that Vitamin D category had an overall significant Wilk's Lambda effect (p=<0.001) on all variables. A post-hoc LSD analysis revealed there was a significant difference in DRS Challenge score in those that were deficient compared to both participants who were insufficient and sufficient. There was no significant difference between Participants who were insufficient and those that were sufficient. There was a significant difference in Run scores and total Army Physical Fitness Test scores in participants who were insufficient compared to those that were sufficient. There was a significant difference in BMI in participants who were deficient compared to those who were insufficient and sufficient. Based on the findings we accept H6: Lower Vitamin D levels will be significantly related with higher resiliency and physical performance scores.

Table 4. Between Participants Effects with Pairwise Comparison for Depression Level by Category.

Variables	None	Mild	Moderate	Severe	p-value
N	**55**	**32**	**7**	**6**	
Commitment	10.98±2.42[*1,2,3]	8.49±2.83[*0,2]	5.86±2.91[*0,1]	6.83±4.12[*0]	0.000
Control	12.98±2.15[*1,2]	11.69±3.03[*0]	9.86±4.30[*0]	10.83±5.53	0.015
Challenge	9.27±2.97[*3]	8.58±3.25[*3]	7.86±2.61	5.17±4.58[*0,1]	0.023
Total Resiliency	33.24±5.10[*1,2,3]	28.77±5.83[*0,2,3]	23.57±5.09[*0,1]	22.83±11.20[*0,1]	0.000
PHQ-9 Total Score	1.78±1.45[*1,2,3]	6.00±1.39[*0,2,3]	10.71±0.76[*0,1,3]	21.33±2.66[*0,1,2]	0.000
EPA (% total phospholipids)	0.20±0.16	0.22±0.17	0.20±0.12	0.22±0.13	0.934
DHA (% total phospholipids)	1.17±0.42	1.25±0.45	1.00±0.19	0.93±0.52	0.264
N6 to N3 ratio	8.82±4.07	7.79±1.92	8.14±0.99	8.23±1.59	0.558
AA (% total phospholipids)	0.20±0.06	0.22±0.08	0.24±0.05	0.18±0.08	0.158
N-3 Index (EPA+DHA)	1.38±0.53	1.47±0.55	1.19±0.20	1.32±0.41	0.582
Vit D (ng/mL)	29.42±8.81	28.93±8.74	24.29±9.69	25.00±6.07	0.357
Push-ups	56.60±14.06	57.03±14.40	48.71±7.76	54.67±12.80	0.518
Push-up score	78.29±13.52	79.25±14.97	69.57±9.13	76.17±12.22	0.392
Sit-ups	64.63±12.29	62.16±11.01	59.61±5.68	61.00±6.45	0.561
Sit-up Score	79.18±14.43	75.95±14.98	72.21±8.58	75.83±7.99	0.525
Run time (Seconds)	932.94±157.39	938.30±67.41	948.63±76.25	1022.83±77.56	0.434
Run Score	70.42±16.38[*3]	70.78±13.51[*3]	67.42±14.00	51.00±16.41[*0,1]	0.032
APFT total score	227.39±38.60	229.63±28.89	212.23±25.23	202.83±26.10	0.240
BMI (kg/m²)	27.13±3.02	26.65±2.83[*3]	26.66±2.91	29.76±4.12[*1]	0.184

Data are means ± standard deviations
*Pairwise Comparisons
0 represents p<0.05 difference from no depression, 1 represents p<0.05 from mild depression,
2 represents p<0.05 from moderate depression, 3 represents p<0.05 difference from severe depression

Table 5. Between-Participants Effects with Pairwise Comparison for Vitamin D Level by Category.

Variables	Deficient	Insufficient	Sufficient	p-value
N	**16**	**39**	**45**	
Commitment	9.75±3.91	9.14±2.85	9.89±3.16	.548
Control	12.38±2.60	11.80±3.55	12.53±2.60	.527
Challenge	7.00±3.20[*2,3]	9.07±2.90[*1]	9.00±3.14[*3]	.071
Total Resiliency	29.13±7.08	30.01±7.12	31.42±6.18	.424
PHQ-9 Total Score	5.94±7.11	5.41±5.24	4.16±4.24	.380
EPA (% total phospholipids)	0.24±0.11	0.20±0.14	0.20±0.19	.675
DHA (% total phospholipids)	1.15±0.52	1.16±0.39	1.19±0.43	.914
N6 to N3 ratio	9.63±6.84	8.23±2.05	8.14±1.90	.262
AA (% total phospholipids)	0.22±0.08	0.21±0.06	0.20±0.07	.616
N-3 Index (EPA+DHA)	1.40±0.56	1.38±0.44	1.39±0.56	.995
Vit D (ng/mL)	15.06±2.95[*2,3]	26.00±2.57[*1,3]	35.76±6.16[*1,2]	.000
Push-ups	56.31±9.48	55.33±14.05	56.62±14.95	.911
Push-up score	79.00±8.95	77.21±14.66	78.02±14.48	.904
Sit-ups	59.77±6.55	63.69±10.03	64.16±13.38	.395
Sit-up Score	74.97±8.19	77.93±13.60	77.93±15.99	.743
Run time (Seconds)	962.61±65.96	947.44±174.00	928.07±89.90	.601
Run Score	66.34±14.43	64.61±15.90[*3]	74.11±15.13[*2]	.016
APFT total score	220.30±24.12	218.11±37.61[*3]	233.91±33.84[*2]	.090
BMI (kg/m^2)	28.74±3.48[*2,3]	26.76±3.19[*1]	26.82±3.04[*1]	.084

Data are means ± standard deviations
*Pairwise Comparisons
1 represents p<0.05 difference from deficient, 2 represents p<0.05 from insufficient,
3 represents p<0.05 difference from sufficient

Table 6 presents a MANOVA with EPA as a factor. EPA had a significant Wilk's Lambda effect (p=<0.001) on the variables. EPA only had a significant between Participants effect on push-ups and push-up score. Based on our findings we accept H7: Higher EPA levels are significantly associated with higher physical performance scores and we reject H: Lower EPA levels are significantly associated with lower resiliency scores.

Table 7 presents a MANOVA with DHA Quartiles as a factor. DHA Quartiles had a significant a significant Wilk's Lambda effect (p=<0.001) on all the variables. A post-hoc LSD analysis reveals there was a significant difference between sit-up scores for those who were in 3rd and 4th quartile. There was a significant difference between APFT total scores for those who were in the 3rd and 4th quartile. There was also a trend towards lower depression scores (PHQ-9) as DHA quartiles increased. Based on our finding we accept the hypothesis H9: Lower DHA is associated with lower physical performance scores and reject H10:Lower DHA levels are significantly associated with higher depression scores. However because of observed trend, significance might be obtained with greater sample size.

Table 8 presents a MANOVA with Arachidonic Acid (AA) as a factor. AA had a significant Wilk's Lambda effect (p=<0.001) on the variables. A post-hoc LSD analysis reveals AA had a significant between-participants effect on total resiliency scores. There was a significant difference in participants who were in the mean±SD and the participants who were 1 SD above the mean for commitment, challenge, and total resiliency Scores. There were also trends towards lower push-up, sit-up, run, and total

APFT scores as AA levels increased. As well as a trend towards increased BMI. Based on our findings we reject H11: Higher AA levels is associated with lower physical performance and H12: Higher AA levels are significantly associated with higher depression scores. Although higher AA levels were not significantly associated with higher depression scores, it was associated with significantly decreased resiliency scores.

Table 9 presents a MANOVA with BMI category. BMI category did have a significant Wilk's Lambda effect (p=<0.001) on the variables. A post-hoc LSD analysis reveals there was a significant difference in vitamin D levels between those participants who had a BMI classification of overweight to those who were obese. There was a significant difference in sit-up scores between those who had a BMI classification as normal compared to those who were overweight and obese. There were trends in increasing BMI classification and decreasing total resiliency scores and increasing depression scores (PHQ-9). Based on our finding we accept H13: Higher BMI category is associated with significantly lower physical fitness scores but we reject H14: Higher BMI category is associated with higher depression scores. Although a trend was observed between higher BMI categories and increasing depression scores so a larger sample size might be needed.

Table 6. Between-Participants Effects with Pairwise Comparison for EPA Levels

Variables	**Normal**	**High**	**p-value**
N	**88**	**12**	
Commitment	9.53±3.04	9.92±4.12	.693
Control	12.34±2.77	11.33±4.36	.276
Challenge	8.85±3.17	7.67±3.80	.240
Total Resiliency	30.72±6.05	28.92±10.55	.384
PHQ-9 Total Score	4.78±5.13	6.00±5.56	.447
EPA (% total phospholipids)	0.16±0.07	0.53±0.24	.000
DHA (% total phospholipids)	1.09±0.34	1.76±0.53	.000
N6 to N3 ratio	8.77±3.25	5.76±1.70	.002
AA (% total phospholipids)	0.20±0.06	0.24±0.09	.047
N-3 Index (EPA+DHA)	1.27±0.35	2.26±0.65	.000
Vit D (ng/mL)	29.24±8.71	24.25±7.92	.063
Push-ups	54.73±12.98	65.92±15.77	.008
Push-up score	76.66±13.34	86.67±13.79	.017
Sit-ups	62.67±10.65	67.69±14.92	.149
Sit-up Score	77.27±13.66	78.87±16.92	.711
Run time (Seconds)	943.51±129.03	923.81±110.91	.616
Run Score	68.76±14.99	72.12±21.67	.493
APFT total score	223.91±33.30	237.73±42.74	.196
BMI (kg/m^2)	27.16±3.29	26.69±2.67	.634

Data are means ± standard deviations
Normal=mean ± standard deviation, High= 1 standard deviation above the mean

Table 7. Between-Participants Effects with Pairwise Comparison for DHA Quartiles.

Variables	1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	p-value
N	**30**	**28**	**16**	**26**	
Commitment	8.67±2.83	10.27±2.84	9.75±3.34	9.77±3.65	.266
Control	11.57±2.47[*3]	12.29±3.26	13.50±2.22[*1]	12.12±3.53	.223
Challenge	8.60±3.32	9.03±2.96	9.06±3.43	8.27±3.49	.815
Total Resiliency	28.83±5.01	31.59±5.91	32.31±6.30	30.15±8.95	.282
PHQ-9 Total Score	5.60±6.12	5.39±5.68	4.38±3.69	4.00±4.17	.631
EPA (% total phospholipids)	0.16±0.09[*4]	0.16±0.08[*4]	0.17±0.08[*4]	0.32±0.25[*1,2,3]	.000
DHA (% total phospholipids)	0.76±0.20[*2,3,4]	1.04±0.05[*1,3,4]	1.23±0.05[*1,2,4]	1.75±0.31[*1,2,3]	.000
N6 to N3 ratio	10.62±4.85[*2,3,4]	8.26±0.93[*1,4]	7.93±0.89[*1]	6.31±1.62[*1,2]	.000
AA (% total phospholipids)	0.17±0.05[*3,4]	0.20±0.06[*4]	0.23±0.06[*1]	0.24±0.07[*1,2]	.000
N-3 Index (EPA+DHA)	0.96±0.20[*2,3,4]	1.20±0.11[*1,3,4]	1.41±0.11[*1,2,4]	2.07±0.47[*1,2,3]	.000
Vit D (ng/mL)	29.11±9.32	28.70±8.40	28.50±8.73	28.12±8.87	.981
Push-ups	53.27±12.60[*4]	57.54±13.47	49.31±11.00[*4]	61.88±14.83[*1,3]	.016
Push-up score	75.07±13.29[*4]	79.54±14.37	71.50±12.29[*4]	83.19±12.58[*1,3]	.026
Sit-ups	61.57±10.00	64.15±9.66	58.89±9.45[*4]	66.98±14.20[*3]	.106
Sit-up Score	76.40±12.24	78.98±12.32	70.84±16.21[*4]	81.11±15.33[*3]	.118
Run time (Seconds)	957.27±81.84	936.45±81.44	914.82±249.38	943.81±102.39	.752
Run Score	67.28±14.23	70.62±17.06	67.80±9.68	70.59±19.44	.808
APFT total score	221.48±31.00	229.35±35.80	209.65±27.97[*4]	236.02±38.28[*3]	.087
BMI (kg/m^2)	26.77±3.19	27.55±4.02	27.36±2.64	26.85±2.67	.776

Data are means ± standard deviations
*Pairwise Comparisons
1 represents p<0.05 from 1st Quartile, 2 represents p<0.05 from 2nd Quartile,
3 represents p<0.05 difference from 3rd Quartile, 4 represents p<0.05 difference from 4th Quartile

Table 8. Between-Participants Effects with Pairwise Comparison for Arachidonic Acid levels.

Variables	Low	Normal	High	p-value
N	17	63	20	
Commitment	10.00±1.97	9.88±3.19[*3]	8.25±3.64[*2]	.110
Control	12.41±2.29	12.35±2.89	11.65±3.84	.637
Challenge	8.65±3.26	9.20±3.08[*3]	7.20±3.49[*2]	.055
Total Resiliency	31.06±4.02	31.44±6.32[*3]	27.10±8.61[*2]	.037
PHQ-9 Total Score	5.12±6.36	4.57±5.04	5.90±4.54	.602
EPA (% total phospholipids)	0.19±0.28	0.20±0.11	0.25±0.16	.458
DHA (% total phospholipids)	0.96±0.46[*3]	1.10±0.35[*3]	1.57±0.40[*1,2]	.000
N6 to N3 ratio	8.36±2.39	8.71±3.79	7.52±1.52	.366
AA (% total phospholipids)	0.10±0.00[*2,3]	0.20±0.01[*1,3]	0.31±0.03[*1,2]	.000
N-3 Index (EPA+DHA)	1.22±0.67[*3]	1.30±0.40[*3]	1.80±0.48[*1,2]	.000
Vit D (ng/mL)	29.16±6.87	29.18±8.96	26.50±9.48	.477
Push-ups	57.94±16.75	55.68±13.41	55.70±12.60	.830
Push-up score	78.94±14.87	77.57±14.33	77.85±11.08	.937
Sit-ups	67.82±14.71	62.81±10.28	60.86±10.45	.150
Sit-up Score	81.00±14.13	76.85±14.05	76.37±13.99	.519
Run time (Seconds)	922.53±91.34	935.96±143.29	973.33±89.78	.418
Run Score	72.41±13.75	68.95±16.01	67.07±17.24	.589
APFT total score	232.71±32.41	224.99±36.61	221.34±30.33	.600
BMI (kg/m^2)	26.77±2.93	27.00±3.26	27.70±3.41	.637

Data are means ± standard deviations
*Pairwise Comparisons
1 represents p<0.05 difference from 1 standard deviation below mean, 2 represents p<0.05 difference from mean± standard deviation, 3 represents p<0.05 difference from 1 standard deviation above mean
Low=1 standard deviation below mean, Normal=mean ± standard deviation, High=1 standard deviation above mean

Table 9. Between-Participants Effects with Pairwise Comparison for BMI Category.

Variables	**Normal**	**Overweight**	**Obese**	**p-value**
N	**24**	**57**	**19**	
Commitment	9.29±2.99	9.68±3.47	9.63±2.43	.881
Control	12.75±2.23	11.88±3.40	12.58±2.48	.421
Challenge	9.29±2.74	8.71±3.38	7.95±3.47	.409
Total Resiliency	31.33±5.21	30.27±7.78	30.16±4.72	.787
PHQ-9 Total Score	4.21±5.08	4.61±4.22	6.79±7.32	.209
EPA (% total phospholipids)	0.18±0.23	0.22±0.14	0.20±0.09	.700
DHA (% total phospholipids)	1.15±0.39	1.20±0.44	1.12±0.45	.742
N6 to N3 ratio	8.88±2.06	7.89±1.90	9.37±6.29	.166
AA (% total phospholipids)	0.19±0.07	0.21±0.06	0.21±0.07	.484
N-3 Index (EPA+DHA)	1.34±0.56	1.43±0.50	1.34±0.49	.681
Vit D (ng/mL)	29.58±6.70	29.56±9.74[*3]	24.68±6.82[*2]	.089
Push-ups	59.04±14.87	54.51±13.49	57.00±13.06	.382
Push-up score	79.75±13.43	76.61±14.20	79.21±12.87	.579
Sit-ups	70.04±13.18[*2,3]	60.95±10.19[*1]	61.68±8.54[*1]	.003
Sit-up Score	84.00±13.36[*2,3]	75.51±13.76[*1]	75.05±13.62[*1]	.030
Run time (Seconds)	916.63±98.58	939.25±149.76	977.83±61.62	.288
Run Score	73.00±16.69	69.05±16.47	64.66±11.79	.231
APFT total score	237.00±34.52	222.51±36.98	220.31±24.08	.174
BMI (kg/m^2)	23.13±1.30[*2,3]	27.16±1.37[*1,3]	31.95±1.76[*1,2]	.000

Data are means ± standard deviations
*Pairwise Comparisons
1 represents p<0.05 from Normal, 2 represents p<0.05 from Overweight,
3 represents p<0.05 difference from Obese

Table 10 presents a MANOVA using sitting time quartiles as a factor. Sitting time quartiles had no significant Wilk's Lambda effect (p=0.47) on the other variables. A post-hoc LSD analysis reveals there was a significant difference in Vitamin D levels and those in the lowest sitting quartile (1st) and those in the highest sitting quartile (4th). There was a significant difference in N3 to N6 ratios between those in the 1^{st} quartile compared to those 2^{nd} and 3^{rd} quartiles for sitting. There was a significant difference in Commitment scores and those in the 1^{st} and 4^{th} sitting quartiles as well as those in the 2^{nd} and 4^{th} quartiles. There were trends towards increased depression scores PHQ9 and decreased Total Resiliency scores as sitting quartiles increased. Based on our findings we have to reject H15: Increased sitting time levels will be significantly associated with lower physical fitness scores and H16: Increased sitting time levels will be significantly associated with higher depression scores.

Table 11 presents a MANOVA using total Army Physical Fitness Test (APFT) score quartiles as a factor. APFT score quartiles had a significant Wilk's Lambda effect (p=<0.001) on all other variables. Post-hoc LSD analysis reveals a significant difference in PHQ-9 scores in those in 1^{st} quartile compared to those in the 4^{th} quartile. There was also a significant difference in Body Mass Index for those in the 1^{st}, 2^{nd}, and 3^{rd} quartile compared to those in the 4^{th} quartile. The other significant differences between variables are expected as they serve as components of the Army Physical Fitness test. Based on our finding we reject H17: Increased physical fitness will be significantly associated with higher resiliency scores but we accept H18: Increased physical fitness will be significantly associated with lower depression scores.

Table 10. Between-Participants Effects with Pairwise Comparison for Sitting Time (minutes) Quartiles.

Variables	**1st Quartile**	**2nd Quartile**	**3rd Quartile**	**4th Quartile**	**p-value**
N	**26**	**26**	**24**	**24**	
Commitment	10.12±2.73*4	10.12±3.59*4	9.65±3.03	8.33±3.07*1,3	.155
Control	12.08±2.74	12.88±2.88	12.55±3.23	11.33±3.10	.295
Challenge	8.85±3.04	9.19±3.81	7.86±3.06	8.88±3.05	.518
Total Resiliency	31.04±6.05	32.19±6.74	30.06±7.15	28.54±6.71	.265
PHQ-9 Total Score	3.77±2.90	5.19±7.17	5.13±6.03	5.71±3.34	.587
EPA (% total phospholipids)	0.16±0.10	0.23±0.22	0.20±0.10	0.23±0.19	.364
DHA (% total phospholipids)	1.11±0.40	1.26±0.49	1.21±0.47	1.10±0.33	.478
N6 to N3 ratio	9.74±5.30*2,3	7.85±2.19*1	7.93±1.72*1	8.06±2.05	.113
AA (% total phospholipids)	0.22±0.07	0.20±0.06	0.21±0.07	0.20±0.08	.415
N-3 Index (EPA+DHA)	1.27±0.44	1.53±0.58	1.42±0.52	1.34±0.47	.301
Vit D (ng/mL)	31.96±9.65*4	28.16±9.28	27.58±8.60	26.61±6.42*1	.139
Push-ups	56.85±13.94	57.65±14.53	55.17±12.61	54.42±14.38	.835
Push-up score	79.19±14.75	78.62±12.70	76.88±12.38	76.58±15.48	.887
Sit-ups	62.73±10.47	65.40±13.68	63.26±10.51	61.56±10.27	.681
Sit-up Score	78.92±13.02	76.79±16.90	78.06±13.24	76.00±12.97	.888
Run time (Seconds)	970.76±71.80	935.84±96.30	944.39±97.19	911.59±204.86	.430
Run Score	67.56±14.83	70.96±16.37	69.00±19.39	69.12±12.92	.899
APFT total score	227.15±37.66	229.62±34.04	224.94±30.97	220.10±36.66	.802
BMI (kg/m^2)	26.57±3.07	27.05±3.27	27.46±3.46	27.38±3.20	.761

Data are means ± standard deviations
*Pairwise Comparisons
1 represents p<0.05 from 1st Quartile, 2 represents p<0.05 from 2nd Quartile,
3 represents p<0.05 difference from 3rd Quartile, 4 represents p<0.05 difference from 4th Quartile

Table 11. Between-Participants Effects with Pairwise Comparison for Army Physical Fitness Test by Quartiles

Variables	**1st Quartile**	**2nd Quartile**	**3rd Quartile**	**4th Quartile**	**p-value**
N	**25**	**30**	**21**	**24**	
Commitment	9.14±3.43	9.17±3.07	10.14±2.87	10.04±3.28	.545
Control	12.21±3.54	12.07±3.07	12.05±2.87	12.58±2.52	.921
Challenge	8.51±3.34	8.50±3.10	8.81±3.31	9.08±3.46	.909
Total Resiliency	29.86±8.70	29.73±6.42	31.00±5.46	31.71±5.77	.684
PHQ-9 Total Score	6.40±6.87*4	5.23±4.80	4.43±5.07	3.46±3.06*1	.235
EPA (% total phospholipids)	0.20±0.11	0.20±0.14	0.17±0.11	0.25±0.25	.464
DHA (% total phospholipids)	1.12±0.46	1.11±0.31	1.17±0.51	1.30±0.44	.371
N6 to N3 ratio	8.50±2.05	8.23±2.06	9.72±5.85*4	7.40±1.83*3	.119
AA (% total phospholipids)	0.22±0.06	0.19±0.06	0.20±0.09	0.21±0.06	.530
N-3 Index (EPA+DHA)	1.80±0.41	1.73±0.45	1.81±0.40	1.96±0.36	.251
Vit D (ng/mL)	28.20±7.93	27.34±9.43	28.41±9.65	30.92±7.86	.505
Push-ups	46.88±8.65*3,4	49.77±8.71*3,4	59.43±12.67*1,2,4	70.58±11.27*1,2,3	.000
Push-up score	67.84±9.83*3,4	72.03±9.17*3,4	82.38±12.99*1,2,4	91.63±9.29*1,2,3	.000
Sit-ups	55.00±6.47*3,4	58.20±6.39*3,4	65.52±7.28*1,2,4	76.25±10.83*1,2,4	.000
Sit-up Score	66.04±9.04*3,4	70.63±10.94*3,4	82.67±8.26*1,2,4	93.33±7.61*1,2,4	.000
Run time (Seconds)	995.48±215.62*4	955.40±32.45*4	957.43±55.28*4	852.50±68.04*1,2,3	.000
Run Score	51.70±12.67*2,3,4	68.45±5.52*1,4	70.10±9.09*1,4	87.42±11.01*1,2,3	.000
APFT total score	182.88±19.72*2,3,4	217.00±4.95*1,3,4	235.14±9.45*1,2,4	272.38±14.02*1,2,3	.000
BMI (kg/m^2)	27.60±3.06*4	27.41±2.88*4	27.89±4.03*4	25.51±2.59*1,2,3	.043

Data are means ± standard deviations
*Pairwise Comparisons
1 represents p<0.05 from 1st Quartile, 2 represents p<0.05 from 2nd Quartile, 3 represents p<0.05 difference from 3rd Quartile, 4 represents p<0.05 difference from 4th Quartile

Regression Equation Development

Based on our MANOVA analyses in tables 12-14 we conducted a Binary Logistic Regression Analysis using Total Resiliency, BMI, Vitamin D, APFT total score, DHA, EPA, AA, and Sitting Total in order to predict whether a subject would be recommended to see Behavioral Health based on PHQ-9 cut-off score of ≥10 which has been used in previous research[77]. Our model predicted whether a subject would have a PHQ-9 score associated with being recommended for Behavioral Health or not with 80% accuracy compared to the null hypothesis model of 13%. The model has a sensitivity of 76.9%, a specificity of 80.5%, and a positive likelihood ratio of 3.94 and a negative likelihood ratio of 0.287. We repeated the analysis without blood markers using Total Resiliency, BMI, APFT total score, and Sitting total in tables 15-17. The non-blood marker model predicted whether a subject would have a PHQ-9 score of ≥10 with 79% accuracy. The non-blood marker model has a 76.9% sensitivity, a specificity of 79.3%, and a positive likelihood ratio of 3.71 and a negative likelihood ratio of 0.291.

Both models were then tested using subject data, and prediction rate matched SPSS data.

Table 12. Binary Logistic Regression Model Predicting Depression Levels Requiring Treatment

Observed	Predicted	Actual	False Positive	False Negative	Percentage Correct
No Treatment Required	70	87	17		80.5
Treatment Required	10	13		3	76.9
Overall					80.0

Table 13 Omnibus Test of Model Coefficients

Step 1	Chi-square	df	p-value
Step	32.604	8	.000
Block	32.604	8	.000
Model	32.604	8	.000

Table 14 Binary Logistic Regression Model Variables in the Equation

Variables	B	SE	p-value
Total Resiliency Score	-.237	.080	.003
BMI	.127	.137	.353
Vitamin D (ng/mL)	-.044	.049	.376
APFT total Score	-.028	.017	.101
DHA (% total phospholipids)	-3.257	1.523	.032
EPA (% total phospholipids)	-.388	4.257	.927
AA (% total phospholipids)	-1.213	7.602	.873
Sitting Total (minutes)	.000494	.000331	.133
Constant	10.648	6.152	.083

Table 15 :Binary Logistic Regression Model Predicting Depression Levels Requiring Treatment Without Blood Markers

Observed	Predicted	Actual	False Positive	False Negative	Percentage Correct
No Treatment Required	69	87	18		79.3
Treatment Required	10	13		3	76.9
Overall					79.0

Table 16 :Omnibus Test of Model Coefficients Without Blood Markers

Step 1	Chi-square	df	p-value
Step	24.079	4	.000
Block	24.079	4	.000
Model	24.079	4	.000

Table 17:Binary Logistic Regression Model Variables in the Equation Without Blood Markers

Variables	B	SE	p-value
Total Resiliency Score	-.193	.063	.002
BMI	.121	.113	.287
APFT total Score	-.021	.013	.098
Sitting Total (minutes)	.000382	.000272	.160
Constant	3.850	5.545	.397

CHAPTER V

SUMMARY

A 2014 report by the Veterans Health Administration showed that suicide rates among male veterans under 30 increased by 44 percent from 2009-2011[8]. The majority of our population fits into this category with an age mean and standard deviation of 26±5.6 with 63% having deployed at least once, and 27% having deployed multiple times. Our finding of a 13% rate of depression based on PHQ-9 scores is similar to a study of 18,305 Army and National Guard Soldiers as the rate was 16% and 11% for the Army and National Guard Soldiers deployed to Iraq respectively[12]. It should be noted that 4 of 13 participants classified as behavioral health treatment recommend in our group reported not having deployed.

Our mean PHQ-9 score of 4.93±5.17 was similar to the mean values that Breitbach et al.[13] reported (4.5±5.9) in 955 male entry military personnel. Our PHQ-9 scores are slightly higher than those found by Luxton et al.[14] in 6,427 military males pre and post deployment with a 2.26±3.31 pre deployment and a 3.62±4.37 post deployment. However, our PHQ-9 scores that were above 9 are similar to the 10.5% Luxton et al.[14] reported post deployment as ours are 9% when adjusted for those who have not deployed. More recently Schaller and colleagues[15] reported a PHQ-9 adjusted mean of 7.2 based on results from 30,033 active service members but it should be noted that this group included females and members from other services.

The mean score for commitment 9.57±3.16, control 12.22±2.99, challenge 8.70±3.25, and total hardiness/resiliency in the DRS-15 is 30.50±6.69 were comparable to the established norms for adult males by Bartone[87] for commitment 10.19±2.47, control 10.27±2.06, challenge 9.86±2.30, and total hardiness/resiliency 30.34±5.21[87]. We found that there was a strong negative relationship ($r=-0.533$, $p\leq0.05$) between DRS-15 scores and PHQ-9 scores. Similar findings were reported by Escolas et al.[17] in 561 service members with DRS-15 scores negatively associated ($r=-0.39$, $p<0.001$) with PTSD scores measured by Post Traumatic Stress Disorder Checklist Military Version (PCL-M). The mean of our population (30.50±6.69) was slightly higher than reported by Escolas et al.[17] of 28.69±6.16. We also found a significant positive correlation between DRS-15 scores and run scores ($r=0.232$, $p\leq0.05$) a negatively correlation with weekly sitting time ($r=-0.202$, $p\leq0.01$), and APFT scores by quartiles and DRS-15 scores displayed a positive trend. Our results demonstrate DRS-15 scores are associated with physical and mental health markers that were also reported by Taylor and colleagues[18] in 120 military men utilizing a Short Form Health Survey(SF-36)[18]. DRS-15 scores were similar to our population with commitment (13.7±2.3), control (11.1±1.8), challenge (7.8±2.3), and DRS-15 total (32.6±4.6) along with age(24±3.3) of participants[18].

We also found a significant difference in mean BMI among participants who were classified as mildly depressed (26.65±2.83) versus those classified as severely depressed (29.76±4.12) and identified trends in reduced hardiness (DRS-15 scores) and increased depression scores (PHQ-9) as the BMI category went from normal to obese. Our findings are similar to a U.S. Department of Defense survey by Kress et al.[56] of 10,040 service members that found obesity as classified by BMI increased odds of depressive symptoms compared to normal weight service members. Our percentage of subjects classified as normal (24%) was lower with overweight (57%) and obese (19%) being higher than 37%, 53%, and 10% rates for normal, overweight, and obese in the 7,567 active duty men reported in the study with [56]. Although we and Kress et al.[56] identified a relationship between BMI and depression, a study of 7,514 U.S. service members receiving psychiatric care with 85,940 healthy service members serving as controls reported no relationship was found between BMI and psychiatric disorder[58]. The reason for this contradiction is probably best explained by de Wit and associates[59] who reported the BMI and depression are not a linear association but rather a U-shaped curve. A sample of 43,534 subjects age 18 to 99 in a general population was used to test the U-shaped curve and the authors found a very significant ($p \leq 0.001$) U-shaped association between BMI categories underweight, normal, overweight, and obese and depression but no significant association between depression and continuous BMI [59].

Our mean for Vitamin D of 28.6±8.73ng/mL was slightly higher than the mean of 24.5±(0.5) SEM and 24.8±(0.5) SEM ng/mL in 495 U.S. service member suicide cases and 495 controls respectively reported by Umhau et al. [4]. Our numbers are slightly lower than the 30±10 ng/mL reported by Wentz at al.[47] in 314 Special Operation Forces (SOF) soldiers[47]. In our study, 16 of the subjects classified as deficient (<20 ng/mL), 39 as insufficient (20-30 ng/mL), and 45 as optimal (≥30 ng/mL) which is slightly lower than the 30% vitamin D deficient reported by Umhau[4] but similar to the over half insufficient to deficient levels reported by Wentz and colleagues[47]. Our vitamin insufficiency rates are similar to that found in the general population as 37.27% of 3,100 males age 18-39 were classified as mild to moderate hypovitaminosis D (25-70 nmol) from NHANES III data [88]. For comparison that would be 6.29-22.01 ng/mL so the majority would fall into our deficient range of (<20ng/mL). We observed a significant overall effect of vitamin D on all the variables and a significant difference in DRS control scores in those who were deficient (7.00±3.20) compared to those who were sufficient (9.00±3.14). We also observed a negative trend in vitamin D levels and depression categories with no depression (29.42±8.81 ng/mL), mild (28.93±8.74 ng/mL), moderate (24.29±9.69), and severe (25.00±6.07 ng/mL) depression levels. This trend is in accordance with previous studies cited that have reported an inverse relationship between vitamin D levels and depression[41, 42, 44, 45].

Our findings are also supported by previous research by Ganji et al.[43] who in a sample of 7,970 non-institutionalized US residents aged 15-39 found the odds ratio for having current depressive episodes was 1.85 (p=0.021) in those who were vitamin deficient compared to those who were not. We also found a significant different in BMI in participants who were deficient (28.74±3.48) compared to those who were insufficient (26.76±3.19) and deficient (26.82±3.04). This finding is similar to what Ganji et al.[43] reported that higher BMI was associated with increased risk of vitamin D deficiency.

Analogous to our findings McGill and colleagues[89] reported a modest inverse relationship between vitamin and BMI (r=-0.18, p=0.005), and multivariate regression analysis demonstrated a 0.74 nmol decrease in vitamin D per 1-point increase in BMI.

Vitamin D was significantly associated with physical performance markers as with a significant difference in run scores in the insufficient group (64.61±15.90) compared to the sufficient group (74.11±15.13) and APFT scores for insufficient

(218.11±37.61) compared to those who were sufficient (233.91±33.84). A similar finding was reported by Ardestani et al.[90] in a 200 person sample that vitamin D levels was positively correlated (r=0.29, p=0.0001) with cardiorespiratory fitness in healthy adults independent of BMI, age, and gender.   The correlation between vitamin D levels and physical performance was also reported by Koundourakis and colleagues[51] in 67 male soccer players in Greece to be significant for squat jump, counter movement jump, 10 meter sprint, 20 meter sprint, and peak VO_2 both pre and post a 6 week off season period with a mean vitamin D in pre 34.41±7.08 ng/mL and post 47.24±13.50 ng/mL.

We found DHA levels by quartiles had a significant overall effect on all the variables. Specifically DHA levels were associated with a significantly higher push-up scores 1st (75.07±13.29) to 4th quartile (83.19±12.58), sit-up scores 3rd (70.84±16.21) to 4th quartile (81.11±15.33), and total APFT scores 3rd (209.65±27.97) to 4th quartile (236.02±38.28). There was a significant difference in DRS control scores for DHA levels in the 1st quartile (11.57±2.47) compared to those in the 3rd quartile (13.50±2.22) as well as a trend toward decreasing PHQ-9 scores as quartiles increased. Our mean for DHA (1.17±0.426, % total phospholipids) was similar to the findings of Lewis et al.[3] in a sample of 800 service members who committed suicide 1.14±0.45 and the 800 service members in the control group1.19±0.47.

Our findings of higher trend towards PHQ-9 is supported by Lewis et al.[3] findings that there was 62% increase in risk in suicide in subjects who are comparing low DHA levels of those below 1.75 to those above as the mean in our 4th quartile was 1.75±0.31. However, like Johnston et al.[30] we found no significant association between

PHQ-9 scores and omega-3 fatty acid levels. This may be because a larger sample size was needed to reach statistical significance. Our DHA levels were significantly lower than the values reported by Johnston (2.61±0.65 % total phospholipids).

We did not find any association between omega-3 index scores and other pertinent variables which similar to findings by Johnston et al.[30] also found it was not significantly associated with depression in a sample of 78 soldiers reporting to behavioral health treatment in Iraq [30]. Our omega-3 index (1.38±0.51) was significantly lower than those reported by Johnston (3.5±0.7)[30]. This difference may be due to the different technique of assessing omega-3 index as Johnston and associates[30] used dried blood spot testing instead of plasma.

We also observed that arachidonic acid levels were associated with significantly decreased levels of resiliency. Participants who had arachidonic acid within the mean±SD had a DRS-15 score of 31.44±6.32 versus those who had levels above 1SD above the mean who had lower DRS-15 score of 27.10±8.61. This is similar to findings of Adams et al.[91] who found higher arachidonic acid levels to eicosapentaenoic levels were significantly associated with increased severity of depression measured on a Hamilton Depression Rating Scale. Higher arachidonic acid levels have been associated with increased depression following interferon treatment[92]. Vaz and colleagues[93] also reported that higher Arachidonic acid levels are associated with suicide risk and major depressive episodes in pregnant Brazilian women.

Weekly sitting time was significantly associated with lower commitment scores for participants in the 1st quartile (10.12±2.73) versus participants in the 4th quartile

(8.33±3.07). We also observed a trend towards higher depression scores as sitting time increased. Our findings were similar to Vallance et al.[61] who reported increasing physical activity and decreasing sedentary time lowered the odds of depression in a cross-sectional study of 2,862 adults[61] Two Bosnian studies of 100 and 141 patients surveyed at a Family Medicine clinic using the IPAQ and PHQ-9 reported that an a association between higher physical activity and lower PHQ-9 stores and lower physical activity and higher PHQ-9 scores[66, 67]. In a study of 346 Veterans being treated for PTSD, Davidson el al.[65] reported that exercise was associated with fewer depressive symptoms along with better quality of sleep[65]. A thorough meta-analysis of 30 trials by Rimer et al.[68] reported that exercise may serve a potential treatment for depression as exercise reduced depressive symptoms in individuals depressed when compared to no exercise[68]

In our investigation, we demonstrated that resiliency and physical fitness are strongly correlated with depression scores in soldiers based on the PHQ-9 assessment. The regression model we formulated serves both as a potential model for variables for a future intervention study and as a predictive tool to identify Soldiers who might be at risk for moderate to severe depression as classified by the PHQ-9. By improving resiliency in service members, we can potentially decrease the risk of mental health issues and by identifying them early we can potentially decrease the risk of a negative outcome.

Conclusion

Napoleon famously stated "*An Army marches on its stomach*"[94]. Results from this study suggests that one possible step in achieving better resiliency and health in soldiers is to is to adjust the US military diet to provide higher levels of eicosapentaenoic acid and docosahexaenoic acid more in line with diets found in traditional Mediterranean countries[95]. The military is currently exploring ways to incorporate more omega-3 fatty acids into the food supply and combat the challenge of adequate shelf stability given the nature of the fatty acids to oxidize more rapidly than more saturated fatty acids[33].

Inadequate vitamin D levels is also an issue that needs to be addressed as 55 of the 100 soldiers in our study had insufficient to deficient levels. Similar findings have been reported in the military population by Umhau et al.[4]as out of 900 of their subject samples 30% were vitamin d deficient and by Wentz et al as out of 314 Special Operation Forces(SOF) population, over half had insufficient to deficient levels[4, 47]. A supplementation strategy of utilizing vitamin D_3 would be the most effective and immediate strategy to correct insufficiencies and deficiencies[96]. Physical fitness and body composition is also a concern given that 57% of our population is considered overweight, and 19% obese based on Body Mass Index numbers. Although BMI does not take into account actual body composition, an overall rise overweight and obesity numbers in U.S. service members have been documented from 50.6% in 1995 to 60 % in 2008 [97].

Our results indicate that lack of physical activity and fitness, high levels of AA and low levels of EPA, DHA, and vitamin D is associated with increased risk of depressed mood and that use of a regression equation may be helpful in identifying soldiers at higher risk for possible intervention. The regression equations we developed have the potential to allow medical providers a relatively effective tool for identifying those at risk. The equation without blood markers could be immediately utilized as APFT scores and BMI measures are readily available for all soldiers with the only requirement being administering the 15 question DRS-15 and having soldiers report estimated week day and weekend sitting time over the last 7 days.

Future Research

More research is needed to determine if a cause and effect and/or dose-response relationship exists with our variables and depressive symptoms. However given our findings combined with previous research we can make a strong recommendation that Omega-3 fatty acid levels, vitamin D levels, and physical fitness be optimized through appropriate nutrition and training in order to improve and maintain soldier health and resiliency. Future intervention trials should be conducted to explore the relationship between eicosapentaenoic acid, docosahexaenoic acid, arachidonic acid, vitamin D, sitting time, and physical fitness on mood and resiliency to determine if and where cause and effect relationships occur.

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APPENDIX A

CONSENT FORM

Project Title: The Relationship between Omega-3 fatty acids and Vitamin D blood levels and Physical Activity on Mood, Resiliency, and Physical Performance in Active Duty Soldiers.

You are invited to take part in a research study being conducted by Dr. Richard Kreider, a researcher from Texas A&M University. The information in this form is provided to help you decide whether or not to take part. If you decide to take part in the study, you will be asked to sign this consent form. If you decide you do not want to participate, there will be no penalty to you, and you will not lose any benefits you normally would have.

Why Is This Study Being Done?
The purpose of this study is to determine the relationship between omega-3 fatty acids, vitamin D, and physical activity and Soldier's physical and cognitive performance.

Why Am I Being Asked To Be In This Study?
You are being asked to be in this study because you are a male between the ages of 18 and 50 years of age on Active Duty. You will not be allowed to participant in this study if you are currently being treated for a behavioral health

How Many People Will Be Asked To Be In This Study?
Approximately 100 people will be invited to participate and complete this study locally.

What Are the Alternatives to being in this study?
The alternative to being in the study is not to participate.

What Will I Be Asked To Do In This Study?
You will be asked to fast and provide a blood sample, fill out a series of questionnaires and complete a standard Army Physical Fitness Test. You will also be asked to record all food and drinks you eat and drink on food record forms for four days (including one weekend day) prior to the first testing session/visit. Your participation in this study will last up to approximately three days and include three testing session (sessions lasting ~ 1.5 hours). Session 1 you will fill out baseline and psychometric data. Session 2 you will show up fasted and undergo a blood draw. You will then donate approximately 15 ml (about 3 teaspoons) of fasting blood from a vein in your arm according to standard procedures. Session 3 you will conduct an Army Physical Fitness Test (APFT) and height and weight will be measured and recorded.

Day 1	Day 2	Day 3
Recruitment Brief Consent Form Background Information IPAQ DRS-15 Big 5	Blood Draw Informed of time and location of APFT	APFT Height and weight recorded

You may be removed from the study by the investigator for these reasons:

- You do not show up for the baseline T1 testing session/visit and the investigators are unable to contact you to reschedule.
- The investigators are unable to obtain a blood sample from you at either or both testing sessions/visits.

Are There Any Risks To Me?
The things that you will be doing are greater than risks than you would come across in everyday life. Although the researchers have tried to avoid risks, you may feel that some questions/procedures that are asked of you will be stressful or upsetting. You do not have to answer anything you do not want to. You will donate approximately 2-3 droplets of blood during the initial familiarization/screening visit and then approximately 15 ml (about 3 teaspoon). The blood draws are the same as one's you have experience when you joined the military and for the annual and pre and post deployment health screens.

Are There Any Benefits To Me?
The direct benefit to you participating in this study is to know more about your health and fitness status from the tests to be performed.

Will There Be Any Costs To Me?
Other than your time, there are no costs for taking part in the study.

Will I Have To Pay Anything If I Get Hurt In This Study?
If you suffer any injury as a result of taking part in this research study, you will receive the same medical treatment as you would with any military training activity. You should report any injury to Dr. Richard Kreider at 979-845-1333. You will not give up any of your legal rights by signing this consent form.

Side effects (injury) can happen in any research study. These effects may not be your fault or the fault of the researcher involved. Known side effects have been described in the "Are there any risks to me?" section of this consent form. However, side effects that are not currently known may happen and require care. You do not give up any of your legal rights by signing this form.

Will I Be Paid To Be In This Study?
No.

Will Information From This Study Be Kept Private?
The records of this study will be kept private. No identifiers linking you to this study will be included in any sort of report that might be published. Research records will be stored securely and only Exercise & Sport Nutrition Laboratory staff will have access to the records.

Information about you will be stored in locked file cabinets in a locked file room in an ID card swipe access controlled laboratory. Computer files will be protected with a password. This consent form will be filed securely in an official area.

People who have access to your information include the Principal Investigator and research study staff. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Participants Protection Program (HSPP) may access your records to make sure the study is being run correctly and that information is collected properly.

The institution(s) where study procedures are being performed (Texas A&M University) may also see your information. However, any information that is sent to them will be coded with a number so that they cannot tell who you are. Representatives from these entities can see information that has your name on it if they come to the study site to view records. If there are any reports about this study, your name will not be in them.

Information about you and related to this study will be kept confidential to the extent permitted or required by law.

Who may I Contact for More Information?
You may contact the Principal Investigator, Richard Kreider, PhD, to tell him about a concern or complaint about this research at 979-845-1333 or rkreider@hlkn.tamu.edu. You may also contact the Co-Investigator/Study coordinator Nicholas Barringer, at 254-702-2772 or nicholasbarringer@hlkn.tamu.edu.

For questions about your rights as a research participant; or if you have questions, complaints, or concerns about the research, you may call the Texas A&M University Human Participants Protection Program office at (979) 458-4067 or irb@tamu.edu.

What if I Change My Mind About Participating?
This research is voluntary and you have the choice whether or not to be in this study. You may decide to not begin or to stop participating at any time. If you choose not to be in this study or stop being in the study, there will be no effect on your military status or career.

STATEMENT OF CONSENT

I agree to be in this study and know that I am not giving up any legal rights by signing this form. The procedures, risks, and benefits have been explained to me, and my questions have been answered. I know that new information about this research study will be provided to me as it becomes available and that the researcher will tell me if I must be removed from the study. I can ask more questions if I want. A copy of this entire consent form will be given to me.

__________________________ ________________________________

Participant's Signature Date

____ ______________________________

Printed Name Date

INVESTIGATOR'S AFFIDAVIT:

Either I have or my agent has carefully explained to the participant the nature of the above project. I hereby certify that to the best of my knowledge the person who signed this consent form was informed of the nature, demands, benefits, and risks involved in his/her participation.

____ ________________________________

Signature of Presenter Date

____ ________________________________

Printed Name Date

APPENDIX B

FT.HOOD COVER SHEET

Subject #

MOS/AOC

Time in Service

Rank

Number of Deployments

APPENDIX C

PATIENT HEALTH QUESTIONNAIRE 9

Patient Health Questionnaire 9

This questionnaire is an important part of providing you with the best health care possible. Your answers will help in understanding problems that you may have. Please answer every question to the best of your ability unless you are requested to skip over a question.

DATE ____________ NAME ________________________________ AGE ______ SEX: Female Male

1. Over the <u>last 2 weeks</u>, how often have you been bothered by any of the following problems?	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
a. Little interest or pleasure in doing things	[ ]	[ ]	[ ]	[ ]
b. Feeling down, depressed, or hopeless	[ ]	[ ]	[ ]	[ ]
c. Trouble falling or staying asleep, or sleeping too much	[ ]	[ ]	[ ]	[ ]
d. Feeling tired or having little energy	[ ]	[ ]	[ ]	[ ]
e. Poor appetite or overeating	[ ]	[ ]	[ ]	[ ]
f. Feeling bad about yourself - or that you are a failure or have let yourself or your family down	[ ]	[ ]	[ ]	[ ]
g. Trouble concentrating on things, such as reading the newspaper or watching television	[ ]	[ ]	[ ]	[ ]
h. Moving or speaking so slowly that other people could have noticed? Or the opposite - being so fidgety or restless that you have been moving around a lot more than usual	[ ]	[ ]	[ ]	[ ]
i. Thoughts that you would be better off dead or of hurting yourself in some way	[ ]	[ ]	[ ]	[ ]

APPENDIX D

BIG FIVE QUESTIONNAIRE

BF Questionnaire

Here are a number of characteristics that may or may not apply to you. Please choose a number for each statement to indicate the extent to which you agree or disagree with that statement:

Disagree Strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
1	2	3	4	5

I see myself as *someone who*. . .

___ 1. is talkative

___ 2. tends to find fault with others

___ 3. does a thorough job

___ 4. is depressed, blue

___ 5. is original. Comes up with new ideas

___ 6. is reserved

___ 7. is helpful and unselfish with others

___ 8. can be somewhat careless

___ 9. is relaxed, handles stress well

___10. is curious about many different things

___11. is full of energy

___12. starts quarrels with others

___13. is a reliable worker

___14. can be tense

___15. is ingenious, a deep thinker

___16. generates a lot of enthusiasm

___17. has a forgiving nature

___18. tends to be disorganized

___19. worries a lot

___20. has an active imagination

___21. tends to be quiet

___22. Is generally trusting

___23. tends to be lazy

___24. is emotionally stable, not easily upset

___25. is inventive

___26. has an assertive personality

___27. can be cold and aloof

___28. perseveres until the task is finished

___29. can be moody

___30. values artistic, aesthetic experiences

___31. is sometimes shy, inhibited

___32. is considerate and kind to almost everyone

___33. does things efficiently

___34. remains calm in tense situations

___35. prefers work that is routine

___36. is outgoing, sociable

___37. is sometimes rude to others

___38. makes plans and follows through with them

___39. gets nervous easily

___40. likes to reflect, play with ideas

___41. has few artistic interests

___42. likes to cooperate with others

___43. is easily distracted

___44. is sophisticated in art, music, or literature

APPENDIX E

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

   ☐ Yes

   ☐ No → ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

   _____ **days per week**

   ☐ No vigorous job-related physical activity → ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

   _____ **hours per day**
   _____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

5. How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**
_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**
_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle → ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**
_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

    _____ **days per week**

    ☐ No bicycling from place to place → ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

    _____ **hours per day**
    _____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

    _____ **days per week**

    ☐ No walking from place to place → ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days **walking** from place to place?

    _____ **hours per day**
    _____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

    _____ **days per week**

    ☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐ No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**
_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**
_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**
_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**
_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?
_____ **hours per day**
_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

    _____ **hours per day**
    _____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

    _____ **hours per day**
    _____ **minutes per day**

This is the end of the questionnaire, thank you for participating.

APPENDIX F

ARMY PHYSICAL FITNESS SCORE CARD

Army Physical Fitness Test Scorecard

For use of this form, see FM 7-22; the proponent agency is TRADOC.

NAME *(Last, First, MI)*

GENDER

UNIT

TEST ONE			TEST TWO			TEST THREE			TEST FOUR		
DATE	GRADE	AGE	DATE	GRADE	AGE	DATE	GRADE	AGE	DATE	GRADE	AGE
HEIGHT (IN INCHES)	BODY COMPOSITION		HEIGHT (IN INCHES)	BODY COMPOSITION		HEIGHT (IN INCHES)	BODY COMPOSITION		HEIGHT (IN INCHES)	BODY COMPOSITION	
	WEIGHT: lbs GO / NO-GO	BODY FAT: % GO / NO-GO		WEIGHT: lbs GO / NO-GO	BODY FAT: % GO / NO-GO		WEIGHT: lbs GO / NO-GO	BODY FAT: % GO / NO-GO		WEIGHT: lbs GO / NO-GO	BODY FAT: % GO / NO-GO
PU RAW SCORE	INITIALS	POINTS	PU RAW SCORE	INITIALS	POINTS	PU RAW SCORE	INITIALS	POINTS	PU RAW SCORE	INITIALS	POINTS
SU RAW SCORE	INITIALS	POINTS	SU RAW SCORE	INITIALS	POINTS	SU RAW SCORE	INITIALS	POINTS	SU RAW SCORE	INITIALS	POINTS
2MR RAW SCORE	INITIALS	POINTS	2MR RAW SCORE	INITIALS	POINTS	2MR RAW SCORE	INITIALS	POINTS	2MR RAW SCORE	INITIALS	POINTS
ALTERNATE AEROBIC EVENT EVENT ____ TIME ____ GO ☐ NO-GO ☐		TOTAL POINTS	ALTERNATE AEROBIC EVENT EVENT ____ TIME ____ GO ☐ NO-GO ☐		TOTAL POINTS	ALTERNATE AEROBIC EVENT EVENT ____ TIME ____ GO ☐ NO-GO ☐		TOTAL POINTS	ALTERNATE AEROBIC EVENT EVENT ____ TIME ____ GO ☐ NO-GO ☐		TOTAL POINTS
NCOIC/OIC SIGNATURE			NCOIC/OIC SIGNATURE			NCOIC/OIC SIGNATURE			NCOIC/OIC SIGNATURE		
COMMENTS			COMMENTS			COMMENTS			COMMENTS		

SPECIAL INSTRUCTION: USE INK

LEGEND: PU - PUSH UPS 2MR - 2 MILE RUN
SU - SIT UPS APFT - ARMY PHYSICAL FITNESS TEST