HDL-C AS MOST PREDICTIVE VARIABLE OF VISCERAL ADIPOSE TISSUE IN YOUNG
MILITARY PERSONNEL OF THE NATIONAL GUARD

A Thesis
presented to
the Faculty of California Polytechnic State University,
San Luis Obispo

In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Nutrition

by
Sofia Rae Sanchez Porush
December 2018

© 2018

Sofia Rae Sanchez Porush

ALL RIGHTS RESERVED

COMMITTEE MEMBERSHIP

TITLE: HDL-C as Most Predictive Variable of Visceral
Adipose Tissue in Young Military Personnel of the
National Guard

AUTHOR: Sofia Rae Sanchez Porush

DATE SUBMITTED: December 2018

COMMITTEE CHAIR: Scott Reaves, PhD.
Professor of Nutrition

COMMITTEE MEMBER: Kari Pilolla, PhD., R.D.
Professor of Nutrition

COMMITTEE MEMBER: Andrew Schaffner, PhD.
Professor of Statistics

ABSTRACT

HDL-C as Most Predictive Variable of Visceral Adipose Tissue in Young Military Personnel of the National Guard

Sofia Rae Sanchez Porush

Twenty-two young men and women of the 49th Military Police Brigade of the California National Guard were participants of our nutrition education and health assessment program. The California National Guard has expressed concern of unsatisfactory physical and nutritional status of their personnel related to a nutrition knowledge deficit as evidenced by preliminary data of insufficient dietary intake and poor nutrition knowledge assessment scores. Our program was designed to implement a nutrition intervention including education and evaluate its effectiveness in reducing Metabolic Syndrome (MetS) risk factors, improving body composition, and providing educational lessons intended to alter lifestyle. Baseline data was quantified and analyzed for statistical significance. Participants reported consuming less than average daily recommended calories and variable macronutrient % of recommended values (%Recommended). DXA analysis revealed high %Body Fat (BF), positively correlated with high values of Visceral Adipose Tissue (VAT) in both sexes. Statistical analyses identify HDL cholesterol (HDL-C) and waist circumference as significant predictive variables of VAT, after adjusting for age and sex. Follow-up data from two participants was collected but excluded from statistical analysis due to small sample size. Exploratory (stepwise regression) analysis considering several predictive variables reveals HDL-C is the most significant predictor of VAT ($p=0.0011$), when waist circumference is excluded from the model, after correcting for age and sex. Waist circumference was excluded with the consideration that waist may be a surrogate measure for VAT. HDL-C seems to be the variable most strongly associated with VAT and HDL-C explains 67% of the variability of VAT ($RSquared=0.6741$) in the fit model after correcting for age and sex. While the impact of high HDL-C on improved body composition and reduction of cardiometabolic risk factors is well supported by literature, the significance of HDL-C on VAT deposition presented in our findings provokes continued research.

Keywords: Visceral adipose tissue, HDL cholesterol, waist circumference, military personnel, dietary intake.

ACKNOWLEDGMENTS

I would like to extend my deepest gratitude to each individual and group that has made this Thesis Project possible. I would like to thank the Baker/Koob Endowments and Hull Graduate Assistantship committee members who granted me the ability to carry out this project with the National Guard and supported the continued research and implementation of this Thesis work.

I would like to thank my advisor, Dr. Scott Reaves, for standing by me these past six years. It has been an honor to work under you and with you, and I am beyond grateful for the wealth of opportunities and experiences you have granted me. Thank you for your mentorship, support, and faith in my abilities. Thank you for being understanding and encouraging and trusting my work—I certainly would not be where I am today without your guidance.

I would like to thank the other members of my committee, Dr. Kari Pilolla and Dr. Andrew Schaffner. Thank you both for setting aside time for me, to listen, assist, and review. It has been a pleasure being your student and it has been truly remarkable to have your insight and supervision through the course of this project. I am so grateful to have developed these important relationships.

I would like to thank all of my professors and instructors at Cal Poly, for I would not have reached this day without them. Thank you, Dr. Arlene Grant-Holcomb, for pushing me forward to achieve what I now know I am meant to.

I would like to thank my overwhelmingly supportive family and friends. Thank you especially to my parents. Mom and Dad, you have put up with so much. Your endless love and support from day one has certainly set you apart and I cannot imagine reaching this accomplishment without that. Thank you for never giving up on me, and for always providing me with the words I needed to hear when I needed to hear them.

I would like to thank my partner, Nick Gusto. It has been a long time coming, but this day has finally arrived, and I would not have made it here without you.

Thank you, all, for being a part of this process. I am grateful beyond words and so fortunate to have the support, education, and comradery I do. I am confident as I step forth into my future endeavors.

TABLE OF CONTENTS

	Page
LIST OF TABLES	viii
LIST OF FIGURES	ix
CHAPTER	
1. INTRODUCTION.....	1
1.1 Statement of Research Questions.....	3
1.1.1 Objectives	5
1.2 Limitations, Issues, and Assumptions	6
2. BACKGROUND.....	7
2.1 Metabolic Syndrome.....	8
2.1.1 Triglyceride Control.....	10
2.1.2 Blood Pressure Control	11
2.1.3 Glucose Regulation and Type 2 Diabetes	12
2.2 Waist Circumference and Abdominal Obesity	13
2.3 Visceral Adipose Tissue.....	17
2.3.1 Technique of VAT Assessment	18
2.3.2 Preferential VAT Loss	21
2.3.3 VAT Deposition Effects on Risk Factors	23
2.3.4 Regional and Sex-Specific VAT Loss	30
2.4 The Concern for Military Personnel	34
2.4.1 Dietary Intake of Military Personnel	35
2.4.2 Risk of Re-enlistment	37
2.5 HDL-C	39
3. MATERIALS AND METHODS.....	42
3.1 Study Design	42
3.1.1 Participants	42
3.1.2 Project Components.....	43
3.2 Statistical Analyses	49
4. RESULTS	51
4.1 Metabolic Syndrome Criteria	51
4.2 Dietary Intake.....	52
4.3 Physical Activity	54
4.4 Anthropometric Measurement.....	54
4.5 DXA Analysis.....	55
4.6 Analysis of Blood Markers	58
4.7 Nutrition Knowledge.....	59
4.8 Sex-Specific Differences	60
4.9 Statistically Significant Findings Relevant to VAT	61
5. DISCUSSION.....	64
5.1 Indicators of MetS	65
5.2 Dietary Intake vs. Recommended Intake.....	67
5.2.1 Dietary Intake Effect on BMD	69
5.2.2 Dietary Intake Effect on VAT	70
5.2.3 Actions to Influence Military Dietary Intake	73
5.3 Important Findings Related to Body Composition by DXA.....	76
5.4 Physical Activity	77
5.5 Anthropometrics Excluding DXA Analysis	80
5.6 Biochemical Indicators of Health Status.....	81
5.7 Details of the Statistical Analyses and Indicators of VAT	81
6. CONCLUSION AND COMMENTARY.....	87
6.1 Contribution of Work to the Field.....	87
6.2 Anecdotal Follow-Up	88
6.2.1 Qualitative Assessment	89
6.2.2 Quantitative Outcomes	91
6.3 Limitations and Strengths.....	91

6.4 Future Work.....	95
BIBLIOGRAPHY	97
APPENDICES	
A. Nutrition Knowledge Assessment	102
B. International Physical Activity Questionnaire.....	106
C. 3-Day Food Record Form	109
D. Cooking Lesson and Recipes.....	114

LIST OF TABLES

Table	Page
1. Baseline Data Collection Variables of Interest.	51
2. Baseline Dietary Intake Data.	53
3. Baseline DXA Body Composition Data.	56
4. Baseline Biochemical Measurement Data.	59
5. Pre- and Post-Lecture Quiz Scores.	60
6. Statistically Significantly Different Variables, by Sex.	61
7. Statistically Significant Predictive Variables of VAT.....	62

LIST OF FIGURES

Figure	Page
1. Initial Study Design, with Red Asterisk (*) Regarding Adjustment Following Attrition.	44
2. Dietary Intake Macronutrient Percentages of Recommended Intake, by Sex.	53
3. Waist Circumference Measurement Compared to Risk.....	55
4. DXA Body Composition Data, by Sex.....	57
5. DXA Visceral Fat Data, by Sex	57
5A. DXA Visceral Fat per Total Fat Data, by Sex.	58
6. Blood Lipid Biomarkers Compared to Ideal Value, by Sex.	59
7. Leverage Plot of Body Mass (previously <i>Body Weight</i>) without Waist.	62
8. Leverage Plot of Triglyceride (TG) without Waist.	63
9. Leverage Plot of HDL-C without Waist.	63

Chapter 1

INTRODUCTION

It has become an unsettling reality that overweight and obesity rates are increasing exponentially in the United States, and the military is not immune to this trend. As such, the prevalence of overweight and obesity poses a threat to national security with 27% of American young adults between ages 17 and 24 unable to serve in the Armed Forces due to excess weight (Tanofsky-Kraff et al., 2013). Within the civilian population, the percentage of overweight body mass index (greater than or equal to 25 kg/m²) is an alarming 68.8%, including 35.5% of the population classified as obese (BMI greater than or equal to 30 kg/m²) (Flegal, Carroll, Kit, & Ogden, 2012). The rate of overweight and obesity within the active-duty military now approach civilian estimates and overweight is now the leading medical reason for failing to qualify for military service (Cawley & Maclean, 2012). Additionally, individuals who struggle to make weight for entry may be at increased risk of failing weight and/or fitness standards later in their career, eventually facing the possibility of administrative action, including discharge from the military (Tanofsky-Kraff et al., 2013). The purpose of this project originated to avoid such a series of events.

It follows that excess weight is associated with numerous costly co-morbidities, including arthritis, hyperlipidemia, cardiac problems, chronic pain, and diabetes. In assessing risk factors that result in increased risk for heart disease and other health problems, such as diabetes and stroke, the grouping of three of the following five conditions establish what is known as metabolic syndrome: (1) Abdominal obesity, excess fat in the stomach area; (2) High triglyceride level, a measure of a type of fat in the blood; (3) Low HDL cholesterol, a protective protein which removes arterial cholesterol; (4) High blood pressure, if chronic can damage the heart and lead to plaque buildup; and (5) High fasting blood sugar, which may be an early sign of diabetes. The risk of having metabolic syndrome is closely linked to overweight and obesity and lack of physical activity, and it is becoming more common due to the rise in obesity rates among adults. Individuals with metabolic syndrome are twice as likely to develop cardiovascular disease and

have a 5-fold greater risk of developing type 2 diabetes (Alberti et al., 2009). The National Heart, Lung, and Blood Institute (NHLBI, 2015) encourages that it is possible to prevent or delay metabolic syndrome, “mainly with lifestyle changes” which include physical activity as well as nutritional adequacy. Active duty personnel reported lower rates of intake of “key healthy foods” such as fruit, vegetables, and whole grains at lower rates than recommended by the *Healthy People 2020* nutritional standards (Barlas, Higgins, Pflieger, & Diecker, 2013). With the California National Guard serving on reserve duty, the superior officers and soldiers alike express concern in the need to improve their health status through improved physical performance, nutritional status, and a fundamental knowledge of lifestyle choices. It is imperative they are assisted to address the increased prevalence of obese and overweight status among military personnel.

With the correlation between lifestyle-related chronic disease and emerging interest in abdominal fat deposition, the research focus of this project is Visceral Adipose Tissue (VAT); our study aimed to identify the most predictive dietary and anthropometric measures of VAT by assessing the health and wellness of a group of soldiers in order to gain insight toward potential preventive measures. Based on risk of ineligibility for re-enlistment due to body weight, poor fitness level, or biomarkers of potential development of metabolic syndrome (MetS), type 2 diabetes, and other chronic diseases, a group of 22 soldiers from the 49th Military Police Brigade of the California National Guard were participants of our nutrition education program. Our program was implemented during their annual three-week training at Camp San Luis Obispo. Baseline collection of nutrition-related physical and biochemical assessments were coupled with dietary analyses and nutrition education, intended to promote adopted lifestyle changes assessed at monthly follow-up intervals, with final dissemination at 5 months. The intervention program transitioned into a cross-sectional study following unexpected high rates of attrition. Acknowledging limitations with sample size, statistical analyses identify HDL cholesterol (HDL-C) and waist circumference (WC) as the most significant predictive variables of VAT, after correcting for age and sex. Future research projects are encouraged to continue implementing dietary intervention with nutrition education in an effort to positively influence lifestyle change and lower chronic disease risk for National Guard soldiers as well as additional branches of Active Duty

Military. The importance of this research will provide evidence for the effectiveness in methods devised to impart the nutrition education and improve body composition through adequate dietary intake.

This project intended to serve as a pilot nutrition education program with the goal to improve the nutritional status and reduce metabolic syndrome risk factors in selected California National Guard Members who may be at risk for discharge due to body weight, physical inactivity, or biomarkers of potential development of metabolic syndrome, diabetes, and other lifestyle related chronic diseases. Baseline assessment and testing were obtained with repeated measures planned throughout the duration of the program in order to monitor progress and evaluate effectiveness. The Nutrition Program involved diet analyses, blood analyses, body composition, bone density measurements, anthropometrics, and an educational series of nutrition concepts and cooking lessons. Physical training was implemented and assessed by Army National Guard personnel during their annual field training. It is the intention that the combination of equal changes in diet and physical activity, specifically with an education component involved, will result in the ideal improvements objectified through the program. The existing knowledge deficit in the basic skills required to choose and create balanced meals and maintain optimum physical health, compounded by expressed concern in unsatisfactory preliminary data from superior military officials that suggest a lack of physical health among service personnel, have amounted to a poor standard of nutritional care among the ranks. These circumstances provide reason to implement an effective nutrition education program in the California National Guard that may ultimately be adopted nationwide with the assistance of the Cal Poly Nutrition Program.

1.1 Statement of Research Questions

Initially this project aimed to assess the health and wellbeing of a group of soldiers at baseline and evaluate the effectiveness of a nutrition education intervention. The intervention targeted dietary intake in order to improve body composition, normalize biochemical markers of cardiometabolic disease, and enhance nutrition knowledge. We planned to monitor and evaluate these targets through measurable outcomes including favorable lean muscle gain and fat loss, a

shift or maintenance of biomarkers within the normal range, and the knowledge retention of fundamental nutrition concepts as evidenced by their ability to self-sustain recommended intake once baseline assessment concluded and soldiers departed for home. Our early research questions sought to delineate dietary trends related to at-risk biochemical measures and unfavorable body composition with the intention to assess how modifications to diet in-turn affected such measures. However, as previously mentioned, the project transitioned from an intervention-based assessment to an observational cross-sectional data collection, which deterred us from the possibility of causal conclusion. The research questions then shifted to identify observed trends between dietary intake and body composition, specifically evaluating correlations between diet and VAT. The following questions have all been considered in the design, evaluation, and culmination of this project; they informed the initial objectives of this project, presented below, and have also amended the focus specifically of this Thesis work in evaluating the current literature trends regarding VAT, dietary intake, and military personnel:

1. Can nutrition education positively impact physical fitness and lifestyle wellness of a population pre-disposed by low service-related exercise regimen and limited nutrition knowledge?
2. Is a 5-month intervention a significant enough duration in order to assess changes or improvements in dietary semblance and body composition related to dietary and lifestyle changes?
3. Is the nature of the nutrition education, to impart nutrition fundamentals, meal planning and composition, cooking techniques, and individualized nutrient requirements complete in its power to promote desirable changes?
4. What additional factors should be considered as confounders with the educational component when promoting lifestyle change?
5. Are external factors not addressed through this intervention, including motivation, personal life, demographic background, occupation, and self-directed discipline regarding physical activity and dietary change significant obstacles disrupting success of the intervention?

6. Is the 3-week intervention consisting of nutrition education long enough to impart a sustainable adoption of dietary and lifestyle change? Do additional lessons need to be implemented or is monthly follow-up (24-hour Dietary Recall via telephone) adequate in ensuring adherence?
7. If physical activity is not personalized and only verbally encouraged, is dietary recommendation enough to affect improved body composition and biochemical measures?
8. What role does dietary intervention have on body composition, specifically Visceral Adipose Tissue?
9. How does dietary intake affect VAT and biochemical markers related to VAT deposition?
10. What is the most predictive variable of VAT?

1.1.1 Objectives

The California National Guard has presented the problem of unsatisfactory physical and nutritional status of their personnel related to a nutrition knowledge deficit as evidenced by preliminary data collected through survey. The initial comprehensive nutrition program was designed to implement an intervention including education and evaluate its effectiveness in reducing MetS risk factors, improving body composition, and providing educational lessons intended to alter lifestyle. The following objectives to assess the participant's health status, provide an educational series, and effect adopted behavior change for service personnel are sourced from the original proposal:

1. The primary objective was to assess current dietary intake to compare to Dietary Reference Intake (DRI) values and develop a comprehensive nutritional program that optimizes the health and physical performance of participants.
2. The secondary objective was to determine the baseline body composition of participants and quantitate changes in body composition and physical performance throughout the program.

In order to develop, implement, and evaluate the comprehensive nutritional program, the 3-week nutrition education program was devised to be incorporated into a 5-month long study

which entailed baseline dietary analyses and anthropometric and blood draw measures, a nutrition education series, repeated measures of dietary recall and analyses, and follow up with reassessment at the 5-month conclusion. Due to unexpected high attrition, the assessment presents cross-sectional data only, collected at baseline. Two participants completed the study, but culminating data was excluded from statistical analyses due to small sample size.

1.2 Limitations, Issues, and Assumption

A limitation of this study includes the small sample of 22 soldiers. It is also unclear if this was a convenience sample and not necessarily representative of the population. Being that the sample size is small and not randomized, the study was initiated under the assumption that all soldiers would participate throughout the duration of the study, maintain adherence to their individualized diets, and respond to the team outreach in order to facilitate monthly and/or bi-monthly assessments (via 24-hr Dietary Recall) of their adherence. Additionally, their readiness to change and motivation proved to be limitations being that they were selected to participate in our study as opposed to seeking out involvement in our study on their own.

Issues of this particular group being on reserve duty include their mostly-civilian lives dictating their schedule and lifestyle, as well as their uncertain adherence to adoption of physical activity and dietary recommendations.

We assumed participants would be responsive and complete the study however we commenced knowing that attrition is always a possibility.

Chapter 2

BACKGROUND

To briefly address the initial research questions of this study designed as an intervention as well as to respect the change in data collection now limited to cross-sectional observation, the following literature review is a synopsis of MetS and diagnostic criteria, dietary intake and cardiometabolic risk factors, VAT as it relates to diet and physical activity, the protective effect of HDL-C and potential interplay with VAT, and current interventions addressing the inability of military personnel to meet health and fitness standards.

An overview of work in this field begins with an understanding and presentation of diagnostic criteria of MetS. The ongoing discussion about waist circumference landmarks and thresholds continues to be at the forefront of establishing universally accepted MetS criteria which can be applied across ethnicity, age, and sex. In transition, to present the way dietary adequacy and MetS risk factors interact as they relate to other comorbidities is also important to address, considering the nutrition focus of this project. Regarding the interesting findings of this Thesis, a synopsis of what is currently known about VAT: what it is, why it is problematic, what it is doing to the body and how such deposition manifests itself through measurable risk factors will lead into what is known about how diet and exercise influences VAT amounts and deposition. Because our population seemed to have high amounts of VAT, conceding the limitations of sample size, and were reportedly consuming insufficient calories, we cannot argue that an individual can simply eat less in order to mitigate VAT depots. Instead, we must assess physical activity in addition to dietary intake and inquire what other study findings present compared to our own. While physical activity reporting could be underestimated, we are interested in high intensity exercise effects on VAT and how exercise effects compare with nutritional modification.

Current literature considering VAT and HDL-C is also of interest. Our analyses indicate HDL-C as the most statistically significant predictive variable of VAT deposition. While our study prevents us from associating the two via causation, existing research on how VAT and HDL-C relate as well as how WC and HDL-C relate are of interest, given the surrogacy of WC as a

measure of visceral adiposity. Data on VAT as measured by DXA in other studies is also important considering DXA is our chosen method in estimating VAT deposition in addition to the overall assessment of body composition of our participants. Following the change in our study design, methods to implement effective nutrition education interventions in order to reduce VAT deposition and MetS risk is explored, but likely considered in our future research. With our study sampling military personnel, limitations of re-enlistment risk related to army personnel health status along with nutrition interventions that have been implemented in similar populations are also consulted. Finally, a probe into the psychosocial aspects of behavior change as it relates to participants perceived barriers is assessed in conjunction with our limitations and future research.

2.1 Metabolic Syndrome

Metabolic syndrome (MetS) is considered a cluster of risk factors that define a metabolic disorder. The risk factors for which an individual presents 3 or more to warrant diagnosis include: high triglycerides (TG), high blood pressure (BP), large waist circumference (WC), low HDL cholesterol (HDL-C), and high fasting blood glucose (FBG) (Alberti et al., 2009). The categorical cut points have been well-argued and revised yet are still limited by universal consensus regarding cultural/ethnic and gender-based considerations particularly for waist circumference (Alberti et al., 2009). The risk factors defining MetS also pose an increased risk for heart disease including both heart attack and stroke, diabetes, renal disease, and related comorbid conditions (Alberti et al., 2009). Current research suggests several factors contribute to the development of MetS including physical inactivity, being overweight or obese, and presentation of insulin resistance (Alberti et al., 2009; Duyff, 2017; Ford et al., 2014; Li, Ford, McGuire, & Mokdad, 2007)). Moreover, abdominal obesity significantly contributes to the problem, and with increased prevalence of obesity among US adults, MetS has also become more common (Ford et al., 2014; Li, Ford, McGuire, & Mokdad, 2007).

The intentional clustering of specific cardiometabolic risk factors to define MetS was first proposed in 1998 (Alberti et al., 2009). The consultation group on the definition of diabetes for the World Health Organization (WHO) was challenged in 2001 by the National Cholesterol Education

Program Adult Treatment Panel III (NCEP ATP III) established criteria (Alberti et al., 2009). The principal difference: ATP III did not require the evidence of insulin resistance like WHO criteria, but rather determined that any 3 of 5 abnormal findings were enough to diagnose MetS (Alberti et al., 2009). In 2005, the International Diabetes Federation (IDF) and the AHA/NHLBI reconvened to discuss the still conflicting matter of necessary criteria for diagnosis. According to the Joint Scientific Statement, *Harmonizing the Metabolic Syndrome*, released by Alberti et al. in 2009, the consensus reached for criteria for clinical diagnosis of the MetS ascertain the presence of any 3 of 5 risk factors as follows with parenthetical categorical cut points: (1) Elevated waist circumference (population- and country-specific definitions), (2) Elevated triglycerides (greater than or equal to 150 mg/dL), (3) Reduced HDL-C (less than 40 mg/dL for males; less than 50 mg/dL for females), (4) Elevated blood pressure (systolic greater than or equal to 130 and/or diastolic greater than or equal to 85 mmHg), (5) Elevated fasting glucose (greater than or equal to 100 mg/dL).

The American Heart Association (AHA) recommends individuals expend at least as many calories as consumed in order to prevent and manage health issues (Adams et al., 2007). This entails awareness of energy requirements to maintain a healthy weight and encourages a goal of at least 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity, or a combination of both, each week. In order to lower BP and cholesterol, the AHA recommends 40 minutes of aerobic exercise at moderate to vigorous intensity 3-4 times/week (Adams et al., 2007). Eating a variety of fish at least twice a week, especially those rich in omega-3-fatty acids, selecting low-fat and fat-free dairy products, avoiding foods containing partially hydrogenated vegetables oils, replacing saturated and trans fats with monounsaturated and polyunsaturated fats, reducing intake of beverages and foods with added sugars, consuming no more than 2400 mg sodium per day, no alcohol or alcohol in moderation, observing portion sizes, and not smoking are all recommended by the AHA to support heart health and additionally reduce risk factors related to conditions like MetS (Adams et al., 2007).

In order to prevent or delay MetS, changes in overall lifestyle is the appropriate action to prevent, delay, or treat the underlying conditions that increase risk. The Academy of Nutrition and

Dietetics advises to first reduce the risk of Coronary Heart Disease (CHD) and second prevent the onset of type 2 diabetes (Duyff, 2017). Their recommended approach is to address all risk factors simultaneously by increasing physical activity, achieving a healthy weight, and consuming a healthy diet low in saturated fats (Duyff, 2017). Although an individual may ultimately turn to medication to aid in controlling blood glucose, blood pressure, cholesterol and triglycerides, adopting behavioral changes related to healthy diet and exercise should be implemented for long-term benefits.

2.1.1 Triglyceride Control

An abridged synopsis of nutrient metabolism as it relates to dietary intake and body composition may be explained such that calories consumed in excess, originating as carbohydrate, protein, or fat, can all be converted to the storage form of triglycerides (TG) in adipose tissue. The Academy of Nutrition and Dietetics states that being overweight, physically inactive, smoking cigarettes, excessive alcohol use, a very high carbohydrate diet, certain diseases and drugs, and genetic disorders may all increase TG levels to excess, with hypertension multiplying the risk (Duyff, 2017). Elevated TG level along with high LDL-C and low HDL-C are linked to atherosclerosis which increases the risk of heart attack and stroke (Duyff, 2017). The risk of developing heart disease increases with elevated TG levels, especially in the presence of additional risk factors (Duyff, 2017). The National Heart, Lung, and Blood Institute (NHLBI, 2015) recommends treating people with borderline-high and high TG levels by encouraging reaching a healthier weight, regular physical activity, and medication if appropriate. Maintaining or improving weight is an important step as weight loss alone may significantly lower TG levels, according to the Academy (Duyff, 2017). Reducing saturated fats and keeping trans fats as low as possible by consuming more unsaturated fats, fruits, vegetables, low-fat or fat-free dairy products, and eating oily fish, such as salmon and albacore may help lower TG. Engaging in regular physical activity and consuming less or abstaining from alcoholic beverages are all recommended by the Academy to lower TG levels (Duyff, 2017).

2.1.2 Blood Pressure Control

Maintenance of BP within normal limits (120/80 mmHg) is urgent considering the correlation between elevated BP and work rate of the heart to pump blood systemically throughout the body (Duyff, 2017). Elevated BP increases the risk of heart attack and stroke, and the risk of permanent damage to other blood vessels. Overstretched blood vessels, a consequence of high blood pressure, are more prone to rupture or tear and may result in scar tissue (Duyff, 2017). Plaque, cholesterol, and blood cells may be trapped in arterial walls, narrowing the passage for blood which restricts blood flow and increases blood pressure (Duyff, 2017). Arteries or blood vessels may become completely blocked and thrombotic tissue can potentially mobilize and cause an embolism; heart attack or stroke may follow (Duyff, 2017). Hypertension can also cause aneurysms or bulges in artery walls, particularly dangerous as these develop over several years asymptotically (Duyff, 2017). Damage to other organs may also be caused as a result of limited oxygen due to airway restriction (Duyff, 2017). For example, pressure on blood vessels in the eye can cause damage to the retina, impair vision, and even lead to blindness (Duyff, 2017). Until hypertension reaches advanced stages, it often goes undetected and therefore uncontrolled (Duyff, 2017). Duyff (2017) references 2016 CDC reports which state that 1 in 3 Americans is unknowingly hypertensive and only about half of those with hypertension are managing it.

Several conditions increase the risk of developing hypertension including diabetes, hyperlipidemia, and prehypertension (systolic blood pressure 120-139 mmHg or diastolic blood pressure 80-89 mmHg) (Duyff, 2017). In order to manage blood pressure via diet to avoid medication, recommendations include consuming whole-grains and other high-fiber foods, fruits, vegetables, low-fat and fat-free dairy products, lean meat, skinless poultry, oily fish, beans and peas, and limiting added sugars, sodium, and solid fats, along the lines of dietary recommendations by the AHA and the Academy for control over elevated triglycerides and reduction of other risk factors (Duyff, 2017). The potassium and magnesium found in many fruits and vegetables may help control blood pressure and the calcium in dairy products may be protective (Duyff, 2017). Limiting sodium to less than 2300 mg/day for those 14 years and older,

and to 1500 mg/day to further reduce blood pressure is advised and weight reduction through adoption of a healthy diet and incorporation of daily physical activity can reduce the strain on the heart and lower BP (Duyff, 2017).

2.1.3 Glucose Regulation and Type 2 Diabetes

Insulin resistance, which is closely linked to overweight and obesity, occurs when the body does not normally respond to insulin, the regulatory hormone which functions to lower blood glucose by increasing cellular uptake for energy production (Kahn & Flier, 2000). As a result, more glucose remains in the blood and blood glucose steadily rises, which can eventually develop into type 2 diabetes. With diabetes, the body struggles to appropriately use energy with ineffective efforts, as the pancreas may continue to release insulin working tirelessly to increase cellular glucose uptake, until functional insulin-producing Beta-cells eventually decrease in overall number (Donath, Ehse, Maedler, Schumann, Ellingsgaard, Eppler, & Reinecke, 2005). Blood glucose remains high and the pancreas no longer responds to the elevated blood glucose level or fails to appropriately release insulin in order to lower it (Duyff, 2017). At this point, an individual may be forced to rely on insulin injections to manage blood glucose levels, much like type 1 diabetics (Duyff, 2017).

Type 2 diabetes is also considered a metabolic disorder, in which the body does not normally respond to insulin released by the pancreas. It progresses from the insulin resistance mentioned earlier and may be diagnosed with an A1C level of 6.5% or higher on two separate occasions or a fasting blood glucose level of 126 mg/dL or higher on two separate occasions (American Diabetes Association, Rev. 2016). Blood glucose levels may be controlled through appropriate food choices, weight management, and physical activity, but the progression sometimes demands medication if A1C levels continue to rise (Duyff, 2017). Unfortunately, the prevalence of obesity, sedentary lifestyles, and an aging population has co-factored the increased rate of diabetes (Duyff, 2017). The shortcoming in increased prevalence seems to be in preventive efforts, although early detection has been a noteworthy achievement in management once diagnosis has been confirmed (Duyff, 2017). Unmanaged hyperglycemia affects energy

metabolism of all macronutrients and the body does not accurately or efficiently convert carbohydrates, proteins, and fats from foods to energy, hence its categorization as a metabolic disorder (Duyff, 2017). Similar diet and lifestyle recommendations exist for those with prediabetes or diabetes as those with preexisting conditions related to hypertension and Cardiovascular Disease (CVD). If diabetes is not managed properly, adverse health outcomes including eye problems, blindness, circulatory problems, nervous system disease, and renal disease and failure in addition to infections may result (Duyff, 2017). Blood pressure and cholesterol are also affected, increasing risk for heart attack and stroke (Duyff, 2017). The convolution of poor health outcomes is clear, and addressing management of numerous risk factors at once, as The Academy urges, is truly the ideal counter-attack (Duyff, 2017).

2.2 Waist Circumference and Abdominal Obesity

The statistical analyses of our study, albeit limited by sample size and other practicalities identify waist circumference (WC) as a significant predictor of our response variable, VAT. Alberti et al. (2009) suggest that to define and agree upon abdominal obesity thresholds, including WC, is complicated. Multiple organizations have defended their purpose and placement of landmark for WC measurement (WHO, IDF, AHA/NHLBI, NCEP ATP III). The literature presents various WC references, presumptively why Alberti et al. (2009) find it particularly important to address co-existing measures and thresholds. WC is a screening tool commonly used to assess cardiometabolic risk, but studies continue to argue the best method of measuring abdominal obesity in a clinical yet accessible setting that is both accurate and precise (Alberti et al., 2009). A consensus has yet to be reached regarding which WC landmark is validated to most accurately align with abdominal obesity assessment.

The surrogacy of WC as a measure of abdominal obesity and VAT is validated by *Trends in Mean WC and Abdominal Obesity Among US Adults, 1999-2012*, a research letter from JAMA by Ford, Maynard, and Li (2014). Their WC measure was taken just above the iliac crest to the nearest 1mm. They define abdominal obesity as a WC greater than 102 cm for men and greater than 88 cm for women, following the AHA/NHLBI recommended thresholds for the US population.

The data from Ford et al. (2014) of 32,816 men and non-pregnant women aged 20 years or older demonstrate a significant increase in age-adjusted mean WC from 95.5 cm (with 46.4% prevalence of abdominal obesity) in 1999-2000 to 98.5 cm (with 54.2% prevalence of abdominal obesity) in 2011-2012.

Ford et al. (2014) report that previous analyses of NHANES data demonstrate the prevalence of obesity according to Body Mass Index (BMI) did not change significantly from 2003-2004 to 2011-2012. Ford et al. (2014) provide that significant increases in mean WC were still documented during this general obesity plateau and they remark that reasons for increases in WC “in excess of what would be expected from changes in BMI remain speculative” and conclude that through the plateau, continued increases in WC support the clinical urge to incorporate WC as a routine measurement “in initiating the prevention, control, and management of obesity among patients”. The sustained increase in WC imparts concern that abdominal obesity persisted while the prevalence of general obesity was reasoned to have leveled out; as such, greater emphasis on WC as it relates to abdominal obesity, and on abdominal obesity as it relates to cardiometabolic risk, is argued (Ford et al., 2014).

An early paper by Li, Ford, McGuire, & Mokdad (2007) highlights the increasing trends in WC observed from the same NHANES data (Ford et al., 2014) with a focus on the earlier period 1988-2004, reporting that more than 50% of US adults had abdominal obesity in the period 2003-2004. In an assessment from the periods of 1988-1994 to 2003-2004, the age-adjusted mean WC increased from 96 cm to 100.4 cm among men and from 89 cm to 94 cm among women, with the age-adjusted prevalence in obesity increase from 29.5% to 42.4% in men and from 47.0% to 61.3% in women. The researchers report that between the period of 1999-2000 and 2003-2004, people with a BMI of 25-29 kg/m² (overweight) had a greater relative increase in abdominal obesity and Li et al. (2007) remark that some studies suggest WC may be a better predictor of the risk for myocardial infarction, type 2 diabetes, MetS, medical care costs, and all-cause mortality than BMI. Furthermore, not only is WC a simple and convenient measure of abdominal obesity, it is also a major determinant of the NCEP ATP III and IDF criteria for MetS (Li et al., 2007). They concur that it should be used as a routine screening tool in clinical cardiovascular risk

assessments and interpretation of obesity-related health risks. Li et al. (2007) define abdominal obesity as WC greater than 102 cm for men and 88 cm for women, according to NCEP ATP III criteria. Among men, the largest relative increase in the age-adjusted prevalence of abdominal obesity occurred among individuals ages 20 to 29 years (100%) and among women, among individuals ages 20 to 29 years (81.6%) (Li et al., 2007).

In an effort to distinguish whether the increase in WC reflected a general increase in body weight rather than a specific increase in abdominal adiposity, Li et al. (2007) looked at the change in mean WC and prevalence of abdominal obesity by three categories of BMI (less than 25 kg/m², 25-29 kg/m², and greater than or equal to 30 kg/m²). Among both men and women, significant increases in mean WC were observed in all three BMI categories, and both men and women with a BMI of greater than or equal to 30 kg/m² had the largest increase in mean WC. A significant increase in the prevalence of abdominal obesity was found only among men with a BMI of 25 to 29 kg/m² while a significant increase was found for women in all three BMI categories. In their discussion of results, Li et al. (2007) note that the percentage of US adults with abdominal obesity is “considerably larger than the percentage of participants with overall obesity” based on a BMI greater than or equal to 30 kg/m². Li et al. (2007) express concern regarding visceral adiposity, “which WC reasonably represents, is thought to especially increase the risk for obesity-associated morbidity and mortality” (Li et al., 2007). In recent years, the weight gain trend has been deemed an obesity epidemic, given the prevalence of overall obesity, as measured by BMI, continues to increase, and the prevalence of abdominal obesity, as measured by WC, correspondingly increased (Hruby & Hu, 2015). Li et al. (2007) acknowledge the mean WC in the recent NHANES surveys was near the cut off value of 88 cm for defining abdominal obesity in women, stating it was likely that even a small increase in WC could lead to a large increase in the prevalence of abdominal obesity.

Li et al. (2017) conclude WC may be superior to BMI in measuring abdominal obesity as opposed to overall obesity in prediction of all-cause mortality and morbidity of diabetes and CVD. With previous studies demonstrating increased mortality risk related to excess body fat due mainly to abdominal adiposity, a declaration of the need to distinguish if BMI and WC together is

a better prediction of obesity-related morbidity and mortality than either measure alone, along with an urgency to promote WC as a “vital sign” in primary care practice, is necessitated by Li et al. (2007). The review article by Shuster, Patlas, Pinthus, and Mourtzakis (2012) presents that WC was recently found to be the most reliable surrogate for visceral adiposity across a population with a high incidence of MetS, compared to measures like Bioelectrical Impedance Analysis (BIA), BMI, and waist-to-hip ratio (WHR).

In a study by Heinrich et al. (2008), a sample of an equal number of men and women who were, on average, in their early to mid-30s, married, educated, and planning to retire from the military, presented similar findings to Combest, Howard, and Andrews (2017) regarding obesity status. Heinrich et al. (2008) also compared the obesity categorizations by WC and BMI to those according to %Body Fat (%BF). For men, 180 were obese based on their %BF, 114 by WC, and 122 by BMI. For women, 225 were obese based on %BF, 73 by WC, and 49 by BMI. Given the WHO higher cut off for %BF, only 85.6% prevalence of obesity for women was reported, compared to the 98.3% prevalence with the National Institute of Health (NIH) standard. Heinrich et al. (2008) found that both WC and BMI underestimated obesity prevalence, compared with %BF. About 50% of men and 21-32% of women were classified as obese using WC or BMI and 80% of men and up to 98% of women were considered obese base on %BF. Heinrich et al. (2008) reported that their use of the TANITA scale tended to underestimate %BF when compared with the accuracy of DXA, which aligns with DXA being considered the gold standard for body composition. The importance of comparing %BF estimates by tools like DXA against anthropometric measures like BMI originates from the ability of DXA to differentiate between fat mass and fat free mass while BMI is simply calculated from weight and height measurements and is unable to distinguish muscle from fat. Therefore, individuals with greater muscle mass such as athletes and military personnel may be classified as overweight or obese, while individuals with excess fat but not excess weight may go undiagnosed for their relative risk based on apparently healthy BMIs (Heinrich et al., 2008). Our study scrutinizes this false pretense and purposely relies on the DXA assessment of body composition to lend to our assessment of overall health in a more precise manner.

Combest et al. (2017) states that there are still limitations in the use of DXA for measuring body composition and bone mineral content (BMC), lean tissue mass, and fat mass including immobility, increased expense, exposure to low-grade radiation, operator performance, and the size of the scanning area. The precision error for BMC, lean tissue mass, and fat mass by DXA is 1.8%, 1.5%, and 1.5%, respectively. In their study comparing BIA and Circumference Measurements (CMs) to DXA %BF estimates of 76 active duty military males and nonpregnant females, the average %BF of males (mean age 32.7 years) was 23.0% and their mean waist measured 95.2 cm. For females, the average %BF (mean age 36.6 years) was 34.3% with a mean waist measurement of 82.3 cm. The average BMI for males was 29.4 and 28.6 for females, putting both males and females in the overweight categories. The NIH cut points for obesity by %BF are greater than 25% for men and greater than 30% for women (Combest et al., 2017). The WHO presents a more liberal cut point for women at 35% BF to indicate obesity (2011).

2.3 Visceral Adipose Tissue

Visceral fat is the abdominal deposition of adipose tissue that is considered hormonally active and stored as such in result of excess energy (Shuster et al., 2012). Because visceral fat, or visceral adipose tissue (VAT), is hormonally active, it evokes clinical implications given the increased prevalence of obesity (Shuster et al., 2012). By possessing biochemical characteristics sensitive to the weight status of the individual, VAT is linked to metabolic disorders including MetS, type 2 diabetes, and CVD and the evaluation of VAT deposition lends to understanding the development of these various pathologies and is gaining interest in the nutrition realm. While the deposition of adipose tissue as a storage form of energy, cushion, and insulation is classically understood, the concern regarding its hormonal influence has raised interest in investigation of the factors that influence its distribution, amount, and deposition related to lifestyle and the increased rates of metabolic disorders documented in recent years.

Body fat is distributed in two main compartments, as subcutaneous and visceral adipose tissue (SAT and VAT, respectively). SAT is considered less severe and threatening, and may even be cardioprotective, with its location limited to just below the skin surface, while visceral fat

lines the intra-abdominal organs and has been linked to various medical pathologies (Shuster et al., 2012; De Larochelière et al., 2014). The review by Shuster et al. (2012) identifies that VAT accumulation has been tied to impaired glucose and lipid metabolism, insulin resistance, increased predisposition to colon, breast, and prostate cancers, and is associated with prolonged hospital stays, increased incidence of infections and non-infectious complications, and increased mortality in hospital. A powerful statement, Shuster and colleagues (2012) remark, “visceral obesity itself is an independent component of metabolic syndrome and the magnitude of obesity directly relates to the prognosis of this condition” evidencing the rising concerns for VAT independent of MetS and its diagnostic criteria, but also as it relates to its diagnosis by definition.

The terminology of “hormonally active” tissue details the release of bioactive molecules and hormones including adiponectin, leptin, tumor necrosis factor-alpha (TNF-alpha), resistin and interleukin-6 (IL-6). Shuster et al. (2012) report adiponectin is of particular interest because of its protective antiangiogenic activity—cancerous blood vessel growth—and while high levels of adiponectin in the blood is inversely related to VAT, lower levels of adiponectin is associated with type 2 diabetes, elevated glucose levels, hypertension, CVD and certain malignancies.

2.3.1 Technique of VAT Assessment

In an effort to present and define both accurate and precise indices of abdominal obesity, Shuster et al. (2012) review various techniques of VAT measurement. Crude measures including BMI, WC, BIA, hydrostatic weighing, and air displacement plethysmography (ADP) have all been used to assess visceral fat but are only indirect measures. Because CT and MRI actually take cross-sectional areas or volumetric measures of VAT, they are the only techniques that provide direct measures of VAT. Although accurate, they are not clinically accessible to the general population or mobile for the consideration of providing greater access (Shuster et al., 2012). As a compromise, DXA is considered the gold standard for efficiency and accuracy in a more appropriate setting for clinical application to a broader population (Neeland, Grundy, Li, Adams-Huet, & Vega, 2016).

Neeland, Grundy, Li, Adams-Huet, and Vega (2016) evaluated visceral fat measurement by DXA compared to MRI in the Dallas Heart Study (DHS). Because MRI is not practical in a clinical setting, the researchers set out to evaluate the DXA ability to “circumvent” the limitations of MRI. Although the average age of their cohort was older than our population at 44 years versus 27 years, their multiethnic consideration and large sample size does well to validate the DXA output of VAT compared to the accepted MRI measurement, considering the limitations of MRI for widespread use. Neeland et al. (2016) used a Hologic Inc. Discovery W DXA scanner, which has presented significant differences to the GE Lunar DXA. Both systems are highly valued and presented no significant differences when cross-calibrated (Shepherd et al., 2012), but it is important to note such variations in data exist. Neeland et al. (2016) report the Hologic DXA was found to “modestly” underestimate VAT compared with MRI at lower VAT levels, and to overestimate it compared with MRI at higher VAT levels. Otherwise, a linear relationship between DXA and MRI with $RSquared=0.82$ for females and $RSquared=0.86$ for males was reported (Neeland et al., 2016). Their results were consistent in analyses stratified by race, BMI, waist girth and body fat. Neeland et al. (2016) conclude that VAT mass quantification by DXA was both accurate and valid among a large, multiethnic cohort within a wide range of body fatness. They encourage repeat assessments over time to help determine long-term applicability, which would be urged in any similar validation.

Neeland et al. (2016) report several studies that validate the accuracy and precision of DXA measurement of VAT compared with CT imaging (strong correlations $r>0.9$) but those comparing large, multiethnic populations with high proportion of both sexes had not yet been compared with MRI. The researchers also aimed to identify sources of variability and limitations in order to “substantiate [DXAs] further use in clinical and research applications” (Neeland et al., 2016). The DHS deliberately oversamples African American adults in Dallas County and with a final sample size of 2689 participants, mean age 44 years, 55% were female, 48% were Black and 75% were overweight or obese. The researchers state this is the first and largest study to evaluate and validate DXA as a model to quantify VAT deposition against MRI. Their findings

present strong correlation and agreement between DXA and MRI across sex, race, and a wide range of BMIs, waist girth and %BF.

Although the DHS deliberately oversamples African Americans and presents an older mean age than our study, their validation against MRI in both accuracy and precision supports the strength of our use of DXA for VAT measurement. Although DXA slightly underestimates MRI-measured VAT among normal weight individuals and overestimates MRI-measured VAT among overweight or obese individuals, particularly at very high levels of VAT, the mean difference between methods for both females and males were both relatively small compared to the mean VAT observed (1.83 kg for females and 2.59 kg for males), according to Neeland et al. (2016). The researchers encourage further studies to assess the threshold of VAT mass changes that are clinically significant in relation to cardiovascular and metabolic risk. Of their surveyed participants, 31.9% of females and 28.6% of males had hypertension, 10.2% of both females and males had type 2 diabetes, 36.6% of females and 29.2% of males had MetS, and 23.7% of females and 33.2% of males were smokers. Regarding the sample body composition, the average %BF for females was $41.6 \pm 6.5\%$ and $27.9 \pm 6.2\%$ for males. Neeland et al. (2016) defined “low %BF” as less than 35% for females and less than 25% for males and “high %BF” as greater than or equal to 35% for females and greater than or equal to 25% for males. The average WC for females was 95.9 ± 16.2 cm and 98.9 ± 12.8 cm for males. “High waist girth” was defined as greater than or equal to 88 cm for females and greater than or equal to 102 cm for males (Neeland et al., 2016). Based on those cut offs, 66.3% of females and 39.9% of males had high waist girth. The average BMI for females was 30.8 ± 12.4 and the average BMI for males was 28.4 ± 4.9 . Because CT and MRI are considered the superior tools to measure VAT but present limitations in clinical settings or longitudinal research given the radiation exposure, costly equipment, and duration of scan, identifying a gold standard method that is both accurate and precise is essential for the breadth and depth of studies validating body composition technique.

2.3.2 Preferential VAT Loss

In their 2008 review of various factors affecting VAT change with weight loss, Chaston and Dixon found that percentage weight loss (%weight loss) was the only variable that influenced percentage change (%change) in VAT versus SAT. “Modest weight loss” was found to promote preferential VAT loss but the preferential loss was attenuated with greater weight loss (Chaston & Dixon, 2008). Very-low-calorie diets were described to influence significant preferential VAT loss in the short term (<4 weeks), but similarly the effect was lost by 12-14 weeks, as reported by Chaston and Dixon (2008). While the early preferential loss of VAT is noteworthy, very-low-calorie diets (those providing less than 800 kcal/day, according to the study) are difficult to maintain and typically do not provide adequate nutrients or energy. It follows that neither the diet nor the preferential VAT weight loss is maintained. Acute calorie restriction may promote “modest weight loss”, but it is preferred that individuals adopt healthy lifestyle changes that are sustainable long term, promoting long term benefits (Chaston & Dixon, 2008). With the pathogenic threat visceral fat elicits on metabolic disturbances in obesity, Chaston and Dixon (2008) present the hypothesis that weight loss interventions preferentially targeting visceral fat may aid in ameliorating obesity-related comorbidities without significant weight loss, yet no compelling evidence of an existing intervention successfully doing so is presented in their review.

Chaston and Dixon (2008) found positive results for exercise effects on reducing total abdominal fat, including findings that exercise alone reduces visceral obesity without significant weight loss. With the possibility that %weight loss is a greater predictor of %change of VAT/SAT without any additional exercise, it is challenging to identify an effect of exercise versus diet on %change if weight loss results from either. Because the researchers state that preferential VAT loss is greatest during initial moderate weight loss, investigating the method of weight loss may be argued as less important if overall %change has a greater effect. This evokes inquiry about surgical weight loss, as opposed to weight loss incurred through diet and exercise, and also imparts a discussion on moral consideration for lifestyle modification recommended by professionals (Chaston & Dixon, 2008). Drastic measures may be taken to yield great %weight loss, but they are not necessarily healthy. Studies have demonstrated preferential improvement in

hormonal and metabolic function occurring soon after modest weight loss and/or exercise and Chaston and Dixon (2008) posit a tight association of obesity comorbidity with neutral or positive energy balance. They encourage exercise for its specialized ability to counteract the insulin insensitivity associated with VAT, exert controls over VAT lipolysis through adrenergic signaling, and stimulate systemic FFA uptake and oxidation. Overall, it is suggested that modest weight loss may provide significant metabolic and clinical benefits through sustained preferential loss of VAT, and perhaps a less drastic method of adjusting to a balanced activity and dietary lifestyle is most ethically suited (Chaston & Dixon, 2008).

De Larochellière et al. (2014) found that within a population of 425 apparently healthy young adults, ages 18-35, the accumulation of ectopic visceral adiposity, specifically VAT, is associated with a worse cardiometabolic profile regardless of overweight or normal weight status by BMI. While inclusion criteria intended to define “good health” as the absence of obesity, known hypertension, dyslipidemia, diabetes or CVD, 97 participants were overweight. The researchers found that VAT was the only adipose tissue location significantly associated with more markers of cardiometabolic risk; VAT amounts above the 50th percentile of the study sample were associated with a worse cardiometabolic profile, regardless of overweight or normal weight status. The researchers identify obesity as one of the most significant risk factors for CVD stating that metabolic alterations influenced by VAT deposition can increase blood pressure, alter lipid profile, elevate blood glucose, and decrease adiponectin, all of which are believed to contribute to subclinical atherosclerosis and future CVD (De Larochellière et al., 2014). De Larochellière et al. (2014) state that VAT is evidently more pathological than SAT, and the adverse cardiometabolic profile translates to a significant progression of associated comorbidities, including subclinical atherosclerosis. De Larochellière et al. (2014) reference previous study findings that a progressively adverse cardiometabolic profile during early adulthood has a “powerful predictive value on long-term risk of CVD morbidity and mortality”, shifting the concern of risk to the younger population. In a fairly equal distribution of males and females, similar positive significant correlations between overall adiposity and almost all markers of cardiometabolic profile except adiponectin (which correlated negatively with BMI) were observed. Their findings support the

hypothesis that overall adiposity in young adults is associated with an adverse cardiometabolic profile, even without obesity a factor. This is in agreement with the notion that obesity alone is not an accurate depiction of risk (Nicklas et al., 2003) but rather a meticulous look at VAT deposition is integral. De Larochellière et al. (2014) write that their findings suggest a selective phenotype that presents itself in non-obese and apparently healthy individuals as an adverse cardiometabolic profile typical of obese individuals. Such a phenotype is of concern because, like BMI, it is considered a hidden risk. De Larochellière et al. (2014) state the limitation of overall adiposity in the cardiometabolic risk assessment of the non-obese population, as well as the potentially greater impact of specific regional adipose tissues on cardiometabolic profile.

2.3.3 VAT Deposition Effects on Risk Factors

VAT deposition is an important risk factor (RF) for cardiometabolic disease and is arguably superior to anthropometric indices of obesity including BMI or WC for “discrimination of diabetes and CVD” (Neeland et al., 2016). VAT mass measured by DXA has been associated with multiple cardiometabolic RFs including hypertension, diabetes and MetS, independent of BMI and WC in cross-sectional analyses as presented by Neeland et al. (2016) and is consistent with similar findings when VAT is measured by MRI. Limitations mentioned by Neeland et al. (2016) that would also apply to our study include not repeating DXA scans with complete repositioning of the subject between scans, which corresponds to being unable to measure precision and repeatability of the DXA VAT, an important longitudinal consideration. The researchers also state that a second large, multiethnic cohort would be ideal to fully validate the DXA VAT method for generalizable use and that, because the study design is cross-sectional, like ours, they cannot compare the accuracy of the DXA and MRI techniques for monitoring the impact of interventions targeting VAT (Neeland et al., 2016). By designing and implementing an intervention study, a comparison of accuracy would be possible, but the study importance in validating the DXA use for such future interventions is not lost.

Visceral fat has been observed to contribute to Coronary Heart Disease (CHD) RFs in healthy, non-obese individuals and there is concern that obesity alone is not a thorough

representation of overall risk, according to Nicklas et al. (2003). Nicklas et al. (2003) state that VAT deposition and amount may be the best predictor of obesity-related metabolic complications and more clinically relevant for risk assessment than obesity alone, examining the quantity of total body fat, or other anthropometric measurements. Although De Larochellière et al. (2014) demonstrate that men may accumulate more VAT, VAT deposition may be more detrimental for women in regard to CVD health as the relative risk of death from CVD is reported to increase eight times in women with the highest waist-to-hip ratio (WHR), but only two times in men with the highest WHR, according to studies by Lapidus et al. (1984) and Larsson et al. (1984). Although WHR is not a direct measure of VAT deposition, more recent findings have also supported greater VAT deposition in men than women of sampled populations generating investigations of variable VAT deposition by sex, and resulting health implications (De Larochellière et al., 2014).

Nicklas et al. (2003) designed their study to assess 233 peri- and postmenopausal women, estimating VAT by DXA and CT in an effort to establish a VAT critical cut point. Their study included women at least 45 years old which already exceeds our study mean age, but is still valuable, as Nicklas et al. (2003) report that women in the lowest VAT quintile of their population sample (less than or equal to 105 cm^2) had significantly higher concentrations of HDL and HDL₂ cholesterol than women in the other four quintiles ($p < 0.05$ - 0.001). Women in the second lowest VAT quintile had higher HDL and HDL₂ cholesterol than women with a VAT greater than or equal to 163 cm^2 ($p < 0.05$). The researchers conclude that women with a VAT level of 106 - 162 cm^2 are ~2.5 times more likely to have a low HDL cholesterol concentration whereas women with a VAT greater than or equal to 163 cm^2 are ~5.5 times more likely to have a low HDL-C concentration compared to women with a VAT less than or equal to 105 cm^2 . Thus, a VAT greater than or equal to 106 cm^2 is associated with a significantly elevated risk and a VAT greater than or equal to 163 cm^2 is associated with an even greater risk for these metabolic CHD RFs, according to the researchers. Nicklas et al. (2003) also found that WC was positively correlated with VAT even after accounting for the observed variability in WC for a given VAT level.

Nicklas et al. (2003) reference a 1996 study by Williams et al. (1996) mentioning their critical VAT cut point of 106 cm^2 is similar to the 110 cm^2 established by Williams et al. (1996) to

be associated with elevated RFs for CHD including high total cholesterol and TGs, low HDL-C, and elevated BP in women. The researchers relate these to the findings by Després and Lamarche in 1993 that identify 100 cm² as the cut point associated with metabolic RFs for type 2 diabetes and CHD in younger women. Despite the age difference to the study by Nicklas et al. (2003), the younger age group in the report by Després and Lamarche (1993) may be more applicable for our sample of younger women at least, if not younger men as well. With a consistent range of 100-110 cm² for a VAT value predictive of adverse lipid and glucose RFs in women, these studies remain important references for VAT cut points despite their early dates of publication. The early research to establish VAT cut points should also be considered cautiously given the more recent validation of DXA measurements of VAT by Kaul et al. (2012).

It is generally agreed that abdominal obesity has a strong correlation with CVD and is closely linked to type 2 diabetes and other metabolic diseases and it is becoming increasingly important to acknowledge VAT assessment when describing abdominal obesity. Després, Arsenault, Côté, Cartier, and Lemieux (2007) describe the accumulation of VAT in particular as a major correlate of MetS, stating the association of abdominal obesity with the development of CVD and type 2 diabetes is largely recognized “beyond the contribution of overall obesity”. The authors also note that the high prevalence of the metabolic complications of abdominal obesity greatly explains the CVD risk related to the hyperglycemic state observed in individuals with MetS or type 2 diabetes. According to Després et al. (2007), in 1947, it was first suggested by Jean Vague from the University of Marseille that the regional distribution of body fat may be more important overall than excess fatness in correlation with obesity complications. Després et al. (2007) state this initial proposition was supported by Björntorp and Kissebah in the early 1980s who reported metabolic and epidemiological data acknowledging that the proportion of abdominal fat is indeed a key correlate of diabetogenic and atherogenic metabolic abnormalities. These early remarks confer that BMI aside, a greater WHR is predictive of an increased risk of ischemic heart disease and of type 2 diabetes. That is to say, “a high proportion of abdominal fat predicts cardiovascular events beyond the risk associated with excess body fatness” (Després et al., 2007). The cross-sectional IDEA study confirmed that WC predicted CVD and diabetes at any

BMI level and similarly the EPIC-Norfolk study reported the same prediction of CAD risk at any BMI level increasing with increased WC (Després et al., 2007). The INTER-HEART study reported that an increased proportion of abdominal fat reflected in high WHR was associated with a significant increase in the odds ratio for myocardial infarction (Després et al., 2007). These epidemiological studies present estimates for risk but require intervention studies to confirm such estimates.

Després and colleagues (2007) also stated that the CVD risk resulting from an elevated WC may be a consequence of excess visceral adiposity. They suggest a mechanism that the accumulated VAT may act as a “large endocrine gland”, with the tendency to become inflamed and release cytokines resulting in an insulin resistant/proinflammatory state, which consequently increases CAD risk (Després et al., 2007). An important distinction between SAT and VAT is presented by the EPIC-Norfolk study, in which SAT, the peripheral fat depot, was found to be cardioprotective (Després et al., 2007). They supplement this notion that lower body subcutaneous fat may store excess energy in an effort to protect other organs and coronary arteries against harmful lipid deposition in the abdominal region. The metabolic efficiency of the individual is then considered. In caloric excess, individuals who can efficiently clear the excess energy are at reduced risk compared to those who store the excess energy in visceral depots (Després et al., 2007). The increased VAT deposition increases their ectopic fat storage, which increases their CAD risk (Després et al., 2007). They conclude, “visceral obesity, the form of abdominal obesity with a large accumulation of intra-abdominal fat, could be a marker of the inability of the body to store excess energy in the protective subcutaneous metabolic sink” (Després et al., 2007). Després et al. (2007) propose that excess VAT deposition could be a marker of “dysfunctional” adipose tissue associated with ectopic fat deposition, as fat is stored at undesired sites including the liver, heart, skeletal muscle, and pancreas. Després and colleagues (2007) developed a clinical approach to identify viscerally obese patients with dysfunctional adipose tissue by their phenotype coined as “hypertriglyceridemic waist”, in which increased WC and elevated TGs are simultaneously present. The researchers state their clinical approach of this phenotypic assessment may be useful for the early identification of individuals who are likely

to be viscerally obese and often characterized by atherothrombotic inflammatory abnormalities (elevated TGs) increasing the risk of CAD and type 2 diabetes (Després et al., 2007).

In a final word on the management of abdominal obesity, the authors regard the importance of involving dietitians, kinesiologists, and behavior modification specialists in order to reshape poor nutritional and sedentary habits (Després et al., 2007). The multidisciplinary approach is urgent in the clinical management of CVD risk factors, particularly the newly prioritized abdominal obesity. They also encourage societal changes and public health policies that will target early behavior change, and large stakeholders to create favorable environments and implement powerful preventive efforts (Després et al., 2007).

In their large community- and population-based cohort, Lee, Pedley, Hoffmann, Massaro, and Fox (2016) assessed data from the third generation of Framingham Heart Study participants to investigate the relationship between changes in quantity and quality of adipose tissue with changes in incident CVD RFs. Their observational assessment of longitudinal data collection presented that general increases in fat volume and decreases in fat attenuation were correlated with adverse changes in CVD RF profiles. Lee et al. (2016) also note that with each additional 500 cm³ increase in SAT and VAT volume from baseline to follow-up (6-year interval), the odds of incident CVD RFs generally increased. In their discussion, Lee and colleagues pose their findings suggest that “adverse changes in fat quantity and attenuation are associated with changes in CVD risk factors above and beyond the contribution of generalized adiposity, abdominal adiposity, or absolute levels of respective fat volume” (2016). They reference the 2013 finding by Matsushita et al. in which a greater increase in abdominal VAT volume was correlated with an increase in incident metabolic RFs, including low HDL-C, in a large Japanese population. Lee et al. (2016) explicitly present the finding that several risk factors including low HDL-C were associated only with VAT volume change, in support of other studies which have presented that greater VAT may be detrimental while greater SAT may be protective, as Després et al. (2007) also discusses. Lee et al. (2016) present that VAT may be a primary culprit in the “manifestation of cardiometabolic disease” based on its close association with CVD RFs and lipid metabolism.

Although our study did not investigate SAT associations with MetS RFs, we did observe similar correlations between high VAT and low HDL-C.

Complementary to their observational assessment of the longitudinal association between SAT and VAT and incident CVD RFs, Lee et al. (2016) also investigated changes in body weight, abdominal fat volume, and fat attenuation in the 6-year follow-up period. Increases in body weight were reportedly associated with decreases in SAT and VAT attenuation, after adjusting for fat volume change (Lee et al., 2016). Lee et al. (2016) write, “decreasing fat attenuation (a measure of fat quality) and increasing abdominal fat volume are associated with worsening CVD RFs beyond associations with generalized or central adiposity”. Their earlier findings report increased VAT attenuation in the weight stable and weight loss groups, and decreased VAT attenuation in the weight gain group only, while SAT attenuation decreased over time across all groups. In follow-up, SAT attenuation was more likely to decrease than VAT attenuation, with mean SAT attenuation decreasing and mean VAT attenuation actually increasing over the 6-year period (Lee et al., 2016). The researchers identify the need to understand fat attenuation as a measure of fat quality according to the region.

Assessments of fat quality are less typical than quantity, but perhaps a more equal consideration of both quality and quantity should be adopted. From their observations, more negative attenuation of CT fat may reflect worsening fat quality, which in turn increases cardiometabolic risk (Lee et al., 2016). Weight loss intervention studies that reduce abdominal fat volume and elicit associated improvements in CVD RFs are important when considering both quality and quantity of adipose tissue acting to influence the cardiometabolic profile. However, as mentioned, surgical weight loss interventions may complicate such generalizations. With our intervention geared toward implementing a sustainable lifestyle change through appropriate nutrition and physical activity recommendations, lifestyle intervention studies reflecting such intentions that assess changes in quality and quantity of adipose tissue must be carried out. The strength in the study by Lee et al. (2016) of longitudinal assessment over a 6-year period identified that abdominal fat volume and attenuation are associated with “concurrent incidence and change in traditional CVD RFs”. Future studies incorporating the nutrition education

approach should consider such findings when investigating key dietary changes which may directly affect VAT attenuation in an effort to improve CVD RFs. The important associations identified by Lee et al. (2016) are paramount in VAT research, and future studies should reference such mechanisms in a lifestyle intervention that is sustainable and generalizable to additional large community- and population-based cohorts.

In their application of the SYNERGIE lifestyle-intervention program, Nazare et al. (2013) observed greater reductions in body weight, waist circumference, fat mass, and VAT among participants showing higher levels of both diet quality (DQ) and physical activity (PA). Nazare and colleagues (2013) implemented a “novel” DQ-score adapted from the DASH and AHA recommendations which integrates “traditional features of nutritional recommendations (fruits and vegetables, whole grains, fats and unsaturated fats, fish) while devoting particular attention to processed meat, legumes and nuts, and added sugars or sodium”. The researchers also describe the unique personalization of both nutritional and exercise programs for their participants aided by registered dietitians and kinesiologists. Although limited to a population of viscerally obese men, the findings that those with the highest PA and DQ presented the most benefit (and improvement) in measures of body composition/fat distribution compared with participants with the lowest PA and DQ (Nazare et al., 2013).

Additionally, an important finding from the SYNERGIE intervention describes the physiologic change in muscle composition: after one year of the intervention, participants presented a significant reduction in quantity of low-attenuation (LA) muscle denoting lower muscle fat content and increased quantity of normal-attenuation (NA) muscle denoting greater lean muscle content. Nazare et al. (2013) describe the improvements in muscle composition associated with higher levels of DQ and PA claiming that the combination of DQ and PA on reshaping fat distribution and muscle composition may have contributed to improvements in insulin sensitivity and the cardiometabolic risk profile. They reference the Oslo Diet and Exercise Study as the only other known investigation regarding DQ, exercise, and body fat distribution in a lifestyle intervention design. The Oslo study used WC as a surrogate measure for visceral adiposity and similarly created a DQ score (Nazare et al., 2013). In agreement with the findings

from the SYNERGIE intervention, the Oslo study reported that the greatest improvements in DQ were associated with the most significant decreases in body weight and WC, caloric intake aside (Nazare et al., 2013). Nazare et al. (2013) state that with their findings and those from the Oslo study, particular attention may be drawn to the *qualitative* features of diet, with quantitative components still of traditional importance, when combined with increased levels of PA. Like the recognition Lee et al. (2016) grant to the effects of fat quality in addition to quantity, a shift in perspective on diet quality is also provoked. Nazare and colleagues (2013) present that although an overall caloric reduction (with a significant reduction in percentage of fat intake) was adopted by the participants, the diet modifications did not specifically contribute to changes in body composition or fat distribution. They reference other studies also reporting reductions in body weight or WC, body fat, VAT, or liver fat regardless of relative macronutrient proportions in reduced-energy diets. This complicates our early research question which seeks to isolate a proprietary dietary component that is most predictive of VAT deposition, aiding to our intention to manipulate such a component in intervention.

2.3.4 Regional and Sex-Specific VAT Loss

De Larochellière et al. (2014) report a sex-specific accumulation of adipose tissue among their sample, with men having more VAT, ectopic adipose tissue (EAT) and hepatic fat fraction (HFF) than women. MRI-quantified EATs were significantly associated with markers of cardiometabolic profile (De Larochellière et al., 2014). In regional application, VAT had the strongest association with markers of cardiometabolic profile and greater VAT identified a poorer cardiometabolic profile even in normal weight apparently healthy young men and women (De Larochellière et al., 2014). The researchers provide that non-obese and apparently healthy young men therefore accumulate a “detrimental” type of adiposity and may be more at risk, despite the multitude of factors which may contribute to observed sex differences in the cardiometabolic profile including hormones. Thus, the difference in adipose deposition by sex in non-obese and apparently healthy young adults may be an important consideration moving forward. The researchers note that previous studies including young obese individuals have provided early evidence that increased VAT is associated with alterations in cardiometabolic profile (De

Larochellière et al., 2014). By excluding obese individuals and still obtaining similar findings with VAT positively correlated to most cardiometabolic profile markers, the contribution of VAT to the variance of cardiometabolic markers remained significant. De Larochellière et al. (2014) conclude that VAT is therefore the adipose tissue more strongly associated with markers of disease and they suspect that “underlying subtle metabolic alterations already in place (due to sex) may increase the cardiometabolic risk” even before VAT deposition reaches excess and cardiometabolic markers raise concern.

Based on their findings that markers of compromised health were higher in the overweight-high VAT group compared to the overweight-low VAT group, a suggested “synergistic effect” of BMI and VAT in the presence of overweight status is regarded by De Larochellière et al. (2014). The researchers discuss the potential role in evaluating visceral abdominal obesity among non-obese and apparently healthy young adults, considering VAT accumulation even with normal BP and normal fasting lipids and blood glucose is associated with a worse cardiometabolic profile. Like our study, De Larochellière et al. (2014) report cross-sectional observations which do not imply causality and with a relatively homogenous population, their findings may not be applicable to young adults from other ethnic populations. However, the strong correlations lend to the conclusion that among regional adipose tissues, visceral fat remains the adipose tissue with the strongest association to markers of the cardiometabolic profile, regardless of weight status (De Larochellière et al., 2014).

In the study by Gallagher et al. (2014) and the MRI Ancillary Study Group of the Look AHEAD Research Group, the authors present that improvements in CVD RFs were observed after one year of the intentional weight loss study (the Look AHEAD trial) but the question as to whether such improvements are due to the weight loss itself or the specific compartments in which muscle and fat changes take place remains unanswered. In agreement with other studies and the current literature, higher amounts of VAT and Intramuscular AT (IMAT) have been associated with poor biomarkers such as hyperlipidemia, elevated blood glucose and insulin, and impaired glucose tolerance (Gallagher et al., 2014). Larger amounts of lower-body AT amounts, including SAT have been presented as cardioprotective (De Larochellière et al., 2014; Després et

al., 2007) and Gallagher and associates (2014) set out to investigate the changes between metabolic markers and regional AT deposition. Their devised study compares an intensive lifestyle intervention (ILI) for weight loss with a “control” diabetes support and education (DSE) in overweight and obese diabetics. Gallagher et al. (2014) identifies that overweight and obese status is typical of type 2 diabetics and they report that studies have demonstrated AT distribution is significantly different compared with nondiabetic controls. Larger amounts of VAT and IMAT and smaller amounts of SAT have been reported in type 2 diabetics compared with nondiabetic controls, which is believed to be associated with the “aggravation of insulin resistance” (Gallagher et al., 2014). As SAT is less adept at absorbing excess energy in obese patients, also proposed as the individual variation by Després et al. (2007), the transfer of excess energy is stored in other depots including VAT and IMAT which increases metabolic risk, according to Gallagher et al. (2014).

In the ILI group, both sexes lost more SAT than VAT as a percentage of total adipose tissue (TAT). Females lost 86% TAT from SAT and 17% from VAT while males lost 70% from SAT and 27% from VAT. While VAT loss was preferential in males and SAT loss was preferential in females, there was no regional difference in regard to SAT loss. It is interesting that men may generally have higher amounts of VAT, yet women preferentially store VAT with age, and in this study by Gallagher et al. (2014), men preferentially lost VAT. The weight loss in their ILI population was strongly associated with reductions in fasting plasma glucose and HgbA1C, alluding to the improvement of glycemic control following weight loss.

Gallagher et al. (2014) examined whether changes in body weight were “reliably” associated with changes in metabolic variables, reporting that for eight of the nine metabolic markers measured in their population, such an association was true. They report that 6 of the 8 associations between body weight change and metabolic variable change was “qualified by group or sex” (Gallagher et al., 2014). Similar to our statistical analysis, Gallagher and colleagues report a negative regression coefficient between HDL-C and metabolic markers, indicating that decreases in AT depots are associated with increases in HDL-C (2014). This was established without controlling for changes in body weight. In their third set of statistical models, the

researchers tested for associations between changes in a specific AT depot and metabolic markers, after accounting for changes in body weight reporting that VAT and cholesterol/HDL ratio only approached significance ($p=0.058$, std. beta=0.16) (Gallagher et al., 2014).

Reports by Lapidus et al. (1984), Larsson et al. (1984), De Larochellière et al. (2014), and Nicklas et al. (2003) have presented an interest, and arguably an important consideration, in testing for existing sex differences in preferential loss of VAT. Gallagher and associates (2014) report no sex difference in preferential VAT loss when adjusting for initial compartment size, despite the more favorable loss of VAT observed in men compared with women. Hallgreen and Hall (2008) proposed the relationship could be described through an allometric model in which the change of VAT to the change of fat mass (FM) is proportional to the initial ratio of VAT to FM, with a constant of 1.3, appearing to fit various weight-loss interventions regardless of sex. Both Gallagher et al. (2014) and Hallgreen and Hall (2008) follow the meta-analysis by Chaston and Dixon (2008) who reported no sex differences, but rather a trend in which VAT was preferentially lost greatest with modest weight loss and attenuated or absent when large amounts of weight were lost (Gallagher et al., 2014). De Souza et al. (2012) did report significant differences in preferential VAT loss according to sex. By applying Hallgreen and Hall's 2008 allometric model in their POUNDS LOST trial and after adjusting for baseline ratios of visceral to total FM, de Souza et al. (2012) report that women lost more visceral fat than men. Gallagher et al. (2014) concluded that such coexisting reports keep the issue of preferential VAT loss "unresolved".

VAT change was significantly associated with changes in eight biomarkers, four of which approached or exceeded significance after accounting for total weight change (Gallagher et al., 2014). Gallagher et al. (2014) report their findings are consistent with cross-sectional associations of VAT with serum glucose, lipids, and BP. It still remains unclear if such relationships are causal or merely correlated, according to Gallagher and colleagues (2014). While their findings are statistically, clinically, and practically relevant, future studies are urged to unveil a more distinct relationship with additional populations to contribute subsequent data in support.

2.4 The Concern for Military Personnel

Military personnel in Saudi Arabia were the subjects of an evaluation of the National Guard Health Promotion Program for Chronic Diseases and Comorbid Conditions in 2016. The prevalence of a more than 10% risk of developing CVD in the next 10 years, was lower (9%) among military personnel in Saudi Arabia compared to 11% for the general population. Aljasir, Al-Mugti, Alosaimi, and Al-Mugati (2017) evaluated the National Guard Health Affairs program that was established to target the reduction of modifiable RFs through community-based outreach. The comprehensive health promotion program details CVD and type 2 diabetes prevention and includes health outcome measures and health education specific to each RF (Aljasir et al., 2017). The researchers used the Framingham risk score of the participants to estimate the 10-year CVD risk according to their modifiable and nonmodifiable RFs. While establishing measurable outcome indicators to gauge improvement in disease and respective RFs, the researchers also wanted to assess participant satisfaction of the program in order to evaluate the services and health care organizations involved (Aljasir et al., 2017). Measuring participant satisfaction is an important consideration we also worked to implement in the design of our study, but requested feedback qualitatively instead of quantitatively, which may be noted as an additional limitation.

Without a detailed explanation of what the program entailed, the researchers found that the acquisition of new knowledge about diseases described the lowest participant satisfaction (Aljasir et al., 2017). The researchers remark that it may be more strategic to focus on applied knowledge that encourages participants to shift their attitudes and behaviors as opposed to overwhelming participants with new knowledge that may be less targeted and therefore less retained or not as well-received. Targeting the health education message on an individual basis is emphasized by Aljasir et al. (2017) and a component of personalized nutrition our study prioritized. The consideration for unique needs and individual circumstances is transitioning to the forefront of the nutrition profession as knowledge retention, behavioral aspects, and emotions vary greatly on an individual basis. The assessment of the community-based program for preventing CVDs by Aljasir et al. (2017) presented statistically significant improvement in RFs including BMI, WC, FBG, and TC and a nonsignificant modest change in Framingham risk score.

Of the 267 male military personnel, it is difficult to extrapolate the findings, not only because the program details were not disclosed, but also because the population is very homogenous (Aljasir et al., 2017). An important takeaway is the implementation and evaluation of such a program, which should be more commonly incorporated by National Guard and military organizations worldwide.

2.4.1 Dietary Intake of Military Personnel

The Army Regulation release of Nutrition Standards and Education (AR 40-25) effective 2001 revises the nutrition responsibilities of the Surgeons General of the Army, Navy, and Air Force, applying to the active and reserve arms of the Army, Air Force, Navy, and Marine Corps, the Air National Guard, and the Army National Guard (Marriott, 1994). The introductory chapter (1) outlines the responsibilities of the Surgeons General of the Army, Navy, and Air Force to:

Develop and implement programs in line with the U.S. dietary recommendations, in support of a healthy and fit force, to— (a) Influence food preferences to ensure mission needs are met without sacrificing morale. (b) Educate commanders, soldiers and families, and food service staffs about mission specific nutrient requirements and strategies that will ensure eating habits will not adversely affect mission accomplishment... (d) Meet scientifically based weight control and physical fitness principles.

The chapter provides details on nutrient standards, information, and education directed toward medical, personnel and logistics communities of all services. The most current Military Dietary Reference Intakes (MDRIs) are adapted from the Food and Nutrition Board's Recommended Dietary Allowances (1989, 1997, 2000) (Marriott, 1994).

The Nutritional Standards chapter (2) with energy allowances provided are “designed to maintain desirable body weights for healthy military members under varying levels of physical activity in a temperate environment” (Marriott, 1994). The MDRIs for energy are calculated as the average needs of individuals with reference body heights and weights, representing the 50th percentile of military men and women (Marriott, 1994). The reference measures for height and weight of military members are 174 lbs and 69 inches for men and 136 lbs and 64 inches for

women. The document states that military personnel doing heavy work or those involved in prolonged, vigorous physical training may have energy requirements that exceed 125% of the MDRI for energy (Marriott, 1994). MDRI may also need to be adjusted for environmental factors (Marriott, 1994). Regarding macronutrients, 50-55% of total calories consumed is recommended to be from carbohydrate sources (Marriott, 1994). MDRI for protein are based on RDA levels and depend on engagement in intense physical activity, ranging from 0.8-1.5 g protein per kg body weight (Marriott, 1994). In accordance with reference measures for weight, the protein range equates to 63-119 g/day for men and 50-93 g/day for women (Marriott, 1994). The document indicates that in military dining facilities, menus are to be designed with 30% or less of total calories from fat, limiting saturated fat to 10% of total calories (Marriott, 1994). Cholesterol should not exceed 300 mg/day (Marriott, 1994). For operational and restricted rations as provisioned on a mission-specific basis, a higher fat ration may be necessary in order to increase caloric density while minimizing ration weight, according to document and such rations are to be approved by TSG, DA (Marriott, 1994). Fluid requirements are heavily regarded to avoid dehydration and maintain optimum performance with “cool water... the beverage of choice” (Marriott, 1994). Specifications of carbohydrate-electrolyte beverage allowances in certain conditions are provided with criteria of the beverage contents also specified (Marriott, 1994).

Chapter 2 also outlines reduced-calorie menus to support military weight control programs, in which military dining facilities will offer 1500-1600 kcal/day menus reflecting the Food Guide Pyramid (Marriott, 1994). Although outdated given the Pyramid reference, the idea of supporting such programs for weight control while still respecting recommended daily servings of food groups and consideration of energy intake based on activity provides great references for military personnel. The document also provides recommendation for facilities serving populations with high energy needs with 1800-2100 kcal/day menu options for initial entry trainees, for example (Marriott, 1994).

The Nutrition Education chapter (3) policy is to “provide all military members with a fundamental knowledge of nutrition to maximize performance, maintain long-term good health, and sustain morale” (Marriott, 1994). Consistency and implementing effective education

techniques with current nutrition knowledge is intended to complement the variety of healthy food choices provided in military food establishments in order to “reinforce the nutrition message and maintain healthy eating habits” (Marriott, 1994). To support military weight control programs, assessing readiness for change, individualized lifestyle changes, nutrition counseling, self-monitoring, behavioral training, physical activity and relapse prevention are all minimum requirements to include, according to the document (Marriott, 1994). Registered Dietitians along with other qualified personnel are appointed to develop and provide nutrition education for military treatment facilities, the DoD work site, and military food service occupational specialty curriculum (Marriott, 1994).

Despite the MDRI and AR 40-25 lagging in update, the general direction and attention paid to recommendations of proper nutrition for military personnel is vital to the longevity of healthy and fit DoD arms. The construction of such a document that outlines the responsibilities of the Army hierarchy to implement education, provide nutritional foods at onsite dining facilities and for mission-specific rations, and establishes MDRI that individuals may work with a Registered Dietitian in order to devise their personal requirements is extremely valuable and deserves continued revision to uphold standards and feasible requirements of military personnel.

2.4.2 Risk of Re-enlistment

An investigation by Harrow, Cordovés, and Hulette (2006) was designed to evaluate U.S. Army Reserve Soldiers' attitudes and behaviors toward intentional weight loss during annual training (AT). A survey on attitudes about weight loss and weight loss behavior while on AT was provided for voluntary completion on the last day of AT before soldiers returned home. Before AT, 50% of reserve soldiers completing the survey reported they thought about losing weight while on AT, according to Harrow et al. (2006). During AT, 62% reported they were trying to lose weight and 25% of soldiers reported they skipped meals (Harrow et al., 2006). Soldiers who considered themselves overweight or thought about losing weight prior to AT were at increased risk for skipping meals (Harrow et al., 2006). Skipping meals, a restricted intake of carbohydrates, and taking minimal food to eat despite signing for meals all elicited concern among military staff after

a soldier developed exhaustion, near-syncope, and nausea during a category 3 heat spell on the 2nd day of the 14-day AT exercise (Harrow et al., 2006).

Impairing soldier performance and increasing their likelihood to fatigue, particularly in extreme environmental conditions on top of the demanding AT training, the practice of such restricted diets and meal-skipping behaviors resulted in the design and administration of the survey, according to Harrow et al. (2006). Although the average age of soldiers who completed the survey is older than our study average at 38.5 years with a 47:53 male to female ratio, the reflected attitudes and beliefs are of interesting being that our baseline data collection of our participants led us to consider if personal attitudes affected the reported under-consumption in our population, or if it was more strongly the influence of the knowledge deficit we originally suspected. Harrow et al. (2006) report that 18% of soldiers responding had ever been on weight control in the past, 50.5% of all soldiers responding had contemplated losing weight on AT and 25% responding had skipped meals. Sixty-two percent of soldiers responding were trying to lose weight while on AT by some method, most commonly via increased physical activity (58%), a low-carbohydrate diet (27%), smaller portions (26%), or a high-protein diet (21%) (Harrow et al., 2006). According to the report, the Army deliberately warns soldiers against reducing their energy intake or intentionally trying to lose weight while on deployment, suggesting the Army may have “institutional knowledge of this behavior” (Harrow et al., 2006). While we had not considered asking in the initial study design—and likely would need to acquire special approval to inquire despite ensuring anonymity—collecting data on soldiers’ self-perceptions and efforts to lose weight before or during their National Guard AT would be interesting to compare against dietary recalls. It would also be important to note if those who perceive themselves as being overweight or who reportedly were trying to lose weight were actually overweight or obese according to their measured body composition. Such a comparison would sacrifice the anonymity if soldiers wished to maintain it, which would of course be respected, but if soldiers granted permission to consider all factors, the insight on how self-perceptions manifest in manipulations of diet or exercise would be extremely valuable in our efforts to assist these individuals. That being said, even without pairing survey responses to anthropometric and dietary data, it would be just as valuable to

assess averages and identify any trends existing between lower caloric intake or low meal frequency, overweight/obesity, and reported efforts to lose weight or self-perceptions of “needing” to lose weight.

It is unfortunate that actions such as skipping meals and restricting intake are taken by reserve soldiers in an effort to lose weight during AT. While overweight and obesity prevalence may be epidemic among the general population (Hruby & Hu, 2015), which reserve soldiers may distantly classify among considering their reserve duty, the potential risk they inflict upon themselves by engaging in behaviors during AT is gravely concerning. The increased energy expenditure through rigorous training and additional environmental factors, both of which are experienced in such extremes on a yearly basis may present themselves as a shock to the system of these reserve soldiers, particularly if their self-reported activity is fairly sedentary. Limiting energy intake in an effort to lose weight results in poor performance, increased fatigue and susceptibility to injury, all of which may negatively affect metabolism and performance (Harrow et al., 2006). The soldiers may risk completion of AT and put their ability to re-enlist in jeopardy (Harrow et al., 2006). These actions are evident of the need to provide proper education on how to fuel and balance adequate intake with regular activity. The physiological snowball effect that starvation inflicts on the body is dangerous, particularly in increased energy expenditure scenarios like AT. Soldiers may be more prone dehydration and heat or exertional casualty, according to the researchers (Harrow et al., 2006). The purpose of this article in a sense is directed toward commanders, dietitians, and medical personnel, who must be cautious and not ignorant to the “intentional weight loss phenomenon” adopted by soldiers surrounding AT (Harrow et al., 2006).

2.5 HDL-C

Our most interesting finding from the cross-sectional statistical analysis of our study was that HDL-C is the most statistically significant predictor of VAT, with a strong inverse relationship. This may be a novel discovery, and the direction of influence provokes future research. This guides the literature review to evaluate current research on HDL-C and VAT, but as with most

VAT research, large-scale studies and reviews are limited. We are prompted to investigate more generally any existing relationships between HDL-C and WC or HDL-C and other DXA data as they relate to VAT deposition.

Classically rereferred to as “The Good Cholesterol”, HDL-C values reflect the efficiency of high-density lipoproteins. A low concentration of HDL-C is considered a positive risk factor for CVD, while a high concentration is considered a negative risk factor (Duyff, 2017). HDL-C demonstrates cardioprotective effects through reverse cholesterol transport, acting on endothelial cells, and demonstrating antioxidant properties (Assmann & Gotto, 2004). The antiatherogenic properties of HDL-C in reverse cholesterol transport enable it to travel through the blood stream, collect excess cholesterol from peripheral tissues, and track it to the liver for excretion (Assmann & Gotto, 2004). In regard to endothelial function, HDL-C has been deemed an “autonomous protective factor for the endothelium”, an important role in the early stages of atherosclerosis (Assmann & Gotto, 2004). Endothelial dysfunction in the early stages is characterized by decreased bioavailability of NO and increased affinity of the endothelial surface for leukocytes (Assmann & Gotto, 2004). The antioxidant properties of HDL-C are evidenced by the inhibition of LDL oxidation (Assmann & Gotto, 2004). While Assmann and Gotto (2004) note that low HDL-C has been observed as independently associated with increased risk for CAD according to large prospective epidemiological studies like the US Framingham Heart Study and the Europe PROCAM study, the associated risk of low HDL-C is typically accompanied by other factors of concern. Often lipid abnormalities associated with low HDL-C include those characteristic of MetS. Low HDL-C is one of 5 major risk factors for CHD and the NCEP ATP III guidelines recommend physical activity in order to raise HDL-C levels, “particularly in patients with MetS” (Assmann & Gotto, 2004). The difficulty in isolating HDL-C in order to understand its potential is that pharmacological interventions that increase HDL-C also tend to lower LDL-C and TG levels, complicating its sole effects and the association of low levels of HDL-C with other risk factors for atherosclerosis complicate the assessment of increased HDL-C levels on CAD directly (Assmann & Gotto, 2004). Therapeutic lifestyle changes recommended by NCEP ATP III in order to

increase HDL-C levels include exercise, smoking cessation, weight loss, and reducing the amount of saturated fat and cholesterol in the diet.

Roussell and Kris-Etherton (2007) review lifestyle interventions to increase HDL-C noting that a healthful diet low in saturated fat (7-10% of total calories) and sufficient in unsaturated fat (15-20% of total calories), regular exercise, attaining a healthy weight, moderate alcohol consumption and smoking cessation have demonstrated beneficial effects on HDL-C. They acknowledge from their findings that overall lifestyle changes which combine a healthy diet with weight loss and physical activity can increase HDL-C 10% to 13% and when combined with interventions that positively affect other CVD RFs, the increase in HDL-C may contribute to an overall reduction in CVD risk (Roussell & Kris-Etherton, 2007).

It is challenging to present an all-encompassing review of the literature considering the range of topics that should be addressed in this Thesis, as well as the limitations of current and relevant research. This review presents primary studies and selected reviews that provide important insight on study design and outcomes related to our own research. To cover all topics ranging from a background on metabolic syndrome to current trends between VAT and HDL-C is challenging to achieve in a succinct manner, and additional references are included in the Discussion, where our important findings more overtly relate. This literature review is brief and does not investigate the breadth or depth of what is available as much as is desirable in order to establish a complex assessment of all missing areas. However, the idea to present foundational background information in addition to current important findings is achieved in order to establish the value of this study, its shortcomings, its contributions to current research, and the future needs of continued research.

Chapter 3

MATERIALS AND METHODS

3.1 Study Design

This study was designed as a multi-faceted project that included nutrition education, dietary analyses, and biochemical and anthropometric measures.

Men and women from the California Army National Guard 49th Military Police Brigade were recruited to take part in our comprehensive nutrition program. Selected participants were assessed identically at two different time points in the study: at baseline, just prior to the start of the California National Guard's annual field training and our comprehensive program, scheduled to occur from June 2016 in San Luis Obispo, and at 5-months follow-up (November 2016). Outcomes assessment were planned to occur between June and December 31st, 2016. Measurements were taken to observe metabolic syndrome risk factors including waist circumference, resting blood pressure, fasting blood measure of lipids, glucose, insulin, HgA1c, iron, and C-Reactive Protein (CRP), body composition and bone density using dual-energy x-ray absorptiometry (DXA), height, weight, and muscle glycogen. Blood draws and analyses were completed by Central Coast Pathology and DXA scans were conducted by licensed DXA technicians. See *Figure 1* for an overview of the study.

The 3-week nutrition education program was led by Cal Poly Nutrition student research assistants under the supervision of nutrition professors. Participants arrived in San Luis Obispo in June 2016 to complete a Nutrition Knowledge quiz before and after the delivery of fundamental nutrition education lecture. Participants engaged in two cooking lessons over the next two weeks as nutrition students assessed the reported dietary intakes. Participants were provided an assessment of their current dietary intake and a personalized Ideal Meal Plan before departing.

3.1.1 Participants

Participants included 22 soldiers from the 49th Military Police Brigade recruited by the California National Guard Officers. Each participant underwent physical assessments including

DXA scan, anthropometric measurements, blood draws, muscle glycogen, and resting blood pressure at baseline and two participants completed the study by returning for the follow-up that included a repeat of all measures. The initial testing for each participant began just prior to the start of the California National Guard's annual field training and our Sports Nutrition Program's nutrition instruction/consulting arm of the intervention. For the two participants who completed the study, the effects of the nutrition programs were assessed by comparing results of both time points (June vs. March) to track their individual changes. Group averages were calculated for baseline measurements.

3.1.2 Project Components

Informed Consent

Prior to participating in this study, each participant signed a Consent Form approved by the Cal Poly Human Subjects Institutional Review Board. It was explained to participants that their participation in the study is voluntary and they may choose to decline participation or opt out at any time without any repercussions from their superior officers or our research team.

Nutrition Knowledge Assessment

In place of adopting a standardized Nutrition Knowledge Assessment (NKA) Tool, we developed our own tool that included generalized and basic nutrition questions. Participants were given a sports nutrition presentation and nutrient requirement lectures developed by Dr. Reaves and Dr. Pilolla in June 2016. General nutrition information was presented as well as sport-specific and gender-specific nutritional guidelines. An overview of the upcoming project including a timeline was also presented to participants and supervisors during the initial presentation. The nutrition lecture was devised to deliver fundamental concepts that would provide an introductory level of understanding and improve participant knowledge. The nutrition lecture introduced macronutrient dietary sources and discussed the importance of adequate intake to properly support participants' energy requirements. Scores of correctly answered questions were compared as pre- and post-nutrition lecture in order to assess enhanced knowledge in a "recency" paradigm (see Appendix A).

Figure 1. Initial Study Design, with Red Asterisk (*) Regarding Adjustment Following Attrition.

Physical Activity Questionnaire

The standardized International Physical Activity Questionnaire (IPAQ) was used to assess the current physical activity status of study participants (see Appendix B).

3-Day Food Records

A standardized 3-day Food Record form and instructions were sent out to the organizing officer and distributed to participants a week prior to their arrival at Cal Poly for the baseline assessment. Participants were instructed to complete the 3-day form so as to include two weekdays and one weekend, in order to obtain a relative understanding of any differences between the standard work week and weekend dietary choices. The 3-day Food Records were entered into ESHA software by student research assistants and quantified to produce an average dietary intake for each participant. 21 of 22 participants completed a 3-day form, and one participant completed a 24-hr Dietary Recall.

Dietary Tracking, Analyses and Consultations

Standardized dietary assessment procedures were utilized throughout the study. 3-Day Food Record Forms were sent out to officer command via email and distributed to participants a week prior to their arrival. Directions and the Food Record Form may be found in Appendix C. Participants were asked to record two weekdays and one weekend day. The Food Records were collected upon their arrival for their first day of assessment with the Nutrition Team. Food Records were input into ESHA software, which analyzes dietary information via USDA references. The values of macro- and micronutrients, and overall caloric intake, were averaged between the three days and used as the baseline dietary data documented for each participant. The baseline data was used for reference to recommend dietary changes based on personalized ESHA profiles: each participant profile was created with their anthropometrics, age, sex, and a generalized “lightly” or “moderately active” activity level, based on their IPAQ reports and communicated physical activity engagement. ESHA automatically generates “recommended” values based on Dietary Reference Intakes (DRIs) of the National Academy of Sciences, Institute of Medicine, Food and Nutrition Board.

Following dietary analyses, student research assistants, under advisement of Dr. Reaves and Dr. Pilolla, contacted each participant to discuss results and provide guidance on ways to improve their dietary intake to meet specified goals. Each participant received several individualized diet plans based on their food preferences and designed to meet their nutritional requirements. Individualized “Ideal Meal Plans” based on these generated recommendations would closely follow the recommendations with changes including: a caloric reduction compared to ESHA recommendation of 250-500 kcals for participants needing to lose weight; protein recommendations ranging 1.8-2.0 g/kg BW; carbohydrate recommendations ranging 5-7 g/kg BW; fat recommendations approximately (no more than) 25% total caloric intake with equal saturated/monounsaturated fatty acid/polyunsaturated fatty acid values; fiber approximately 40-60 g/day to incorporate more whole grains, fruit, and vegetables; micronutrient requirements (DRI) met; and 5-6 meals per day. Participants completed preference sheets upon arrival, and these were used to personalize the Ideal Meal Plans, based on likes and dislikes, food allergies/aversions, frequented restaurants/grocery stores, and dietary concerns individually expressed. As Ideal Meal Plans were created (1 day completed and sent out June 2016; 2-3 days completed and sent out July 16, 2016), participants were informed that these recommendations are assuming daily exercise. Participants were also recommended to reference our sports nutrition lecture for eating around workouts.

Cooking Lessons

As part of the nutrition education arm of the study, participants received 2 cooking lessons in the Food Science and Nutrition Department kitchen facilities (Building 24 Room 103). Each lesson was theme-based (Balanced Dinner Plates and On-the-Go Snacks) and included healthy dinners and snack options. The dishes and snacks highlighted in the cooking lessons were chosen based on their nutritionally balanced, affordable, accessible, and ease of preparation ingredients (see Appendix D).

Cooking lessons included the instruction of food safety, proper food handling techniques, knife skills, and the instruction of easy-to-make, affordable, nutritionally adequate meals and

snacks. The first cooking lesson included two dinner dishes, salmon and sweet potatoes and chicken and brown rice, with green beans and mushrooms on the side. The second cooking lesson included various snacks, breakfast ideas, and easy on-the-go dishes that can be prepared in advance as part of a “meal preparation” instruction. Nutrition students worked hands-on with participants during all aspects. Information from the sessions was included on quizzes and activities given to participants to assess their acquisition and application of nutrition and food knowledge.

Participants were divided into the 6 kitchens located in the Cal Poly Food Processing building. A student research assistant was assigned to each kitchen team to observe and assist, ensuring safety and proper food handling. Participants received verbal instruction prior to their release into the kitchens, and recipes to reference for ingredient preparation, time and temperature measurements for doneness, and recommended cooking methods. Participants were encouraged to work together and use their creativity in seasoning, cooking, and plating the ingredients. Kitchen teams were encouraged to engage in friendly competition, judged based on best-looking dish, best-tasting dish, best adoption of safe food handling and proper knife skills, and best creativity.

Anthropometric, Blood Pressure and Heart Rate Measurements

Anthropometrics including BMI, height (in), weight (lb), waist circumference (in), hip circumference (in), muscle glycogen and waist-to-hip ratio (WHR) were measured and calculated as part of physical testing. Waist circumference measures were taken as exactly midway between the iliac crest and lowest ribs, wrapped around the waist of the participant, to better define abdominal obesity according to the American Diabetes Association (Ma et al., 2013). An inelastic tape measure was used, and repeated measures were not taken. Weights and measurements were conducted using the same beam scale and tape measure for all subjects. Resting heart rate and blood pressure were also measured. Resting blood pressure and pulse was taken using an Omron automated blood pressure cuff following 5-10 min of seated rest. Participants were seated and resting their arm on the table in front of them. Repeated measures were not taken.

Body Composition Testing

Body composition was assessed with DXA scans at the Food Science and Nutrition Department's Nutrition and Health Assessment Lab. Before DXA testing, participants read a DXA introductory information sheet explaining any minimal risks of radiation, and outlining acceptable clothing for test purposes. Immediately prior to testing, participants read, signed and submitted a Cal Poly State University Waiver Release Form. Participants then underwent a 5-7 minute total body scan on the Lunar iDXA system (GE Lunar, Madison, WI). Participants were given a copy of their scan results and informed that the sharing of results with superior officers, trainers, medical professionals or others is strictly voluntary and up to the discretion of the participant. A "Study ID Number" was used for the DXA file to ensure each participant's privacy.

Fasted Blood Draws

During the first week of training (May 31-June 6) and again 9 months after the training (March 2017), participants had their blood drawn and analyzed by Central Coast Pathology (San Luis Obispo, CA). Participants were instructed to arrive to Central Coast Pathology following a 12-hr fast. Blood (~40 ml; ~3 Tbsp) was drawn by venipuncture in the antecubital fossa by a skilled and licensed phlebotomist. Samples were analyzed for serum levels of total cholesterol, HDL cholesterol, LDL cholesterol, fasting blood glucose, insulin, iron and CRP.

Measurements of Muscle Glycogen

Muscle glycogen measurements were performed according to the instructions and training provided by Musclesound (musclesound.com). The novel, noninvasive, ultrasound method of glycogen measurement provides an alternative to the traditional muscle biopsy method (Hill & Millan, 2014; Millan, Hill & Wischmeyer, 2015; Nieman et al., 2014). The ultrasound method was not believed to present any technical issues. Muscle glycogen was measured in the left and right leg muscles rectus femoris (front of thigh), gastrocnemius (calf) and hamstrings (posterior thigh). Measurements were done before any exercise.

Project Personnel

Four student research assistants selected from Cal Poly junior and senior Nutrition major undergraduates consistently worked with the group of participants. In addition, Registered Dietitian and Nutrition Professor, Dr. Kari Pilolla, PhD, RD and Mary Oates, M.D., a physician with expertise in DXA analysis and metabolic disorders, were project investigators. The project and all personnel were under the direction of Dr. Scott Reaves and Dr. Kari Pilolla. All DXA scans were performed by Dr. Reaves or Dr. Pilolla because of their experience in DXA testing and possession of a limited X-ray license from the state of California. All testing for this study was conducted in the Food Science & Nutrition Department's Nutrition and Health Assessment Lab on the campus of Cal Poly aside from blood draws conducted at Central Coast Pathology (San Luis Obispo, CA).

3.2 Statistical Analyses

Following all baseline data collection, stepwise linear regression models with age and sex fixed in the model were used to examine the effects of anthropometric, biochemical, and dietary intake (e.g. total calorie intake, total fat intake, total protein intake, total carbohydrate intake, and total meals all averaged per day from 3-day Food Record) variables on the participants' amount of VAT, as measured by DXA. An understanding of statistically significant predictive variables of VAT, as VAT amount relates to abdominal obesity and overall risk of chronic disease, was prioritized in the formation of statistical models. By investigating the VAT measure as a response variable, our exploratory analyses findings suggest HDL cholesterol most powerfully explains the VAT data collected from our sample. Current research is limited in VAT predictive factors and our findings present an interesting direction for future exploration, particularly with the opportunity to re-design our study, with the intention to fulfill the initial intervention. All analyses were performed using JMP version 14.0.0 (SAS Institute Inc., Cary, NC).

In future studies, a general linear model may be used to examine the relationship between changes in body composition, specifically in VAT amounts, and changes in dietary intake and nutrition education. Differences in dietary nutrient intake and patterns would be

analyzed to assess effectiveness of our nutrition education, as well as to determine significant relationships between dietary change and biochemical and anthropometric measures.

At the end of the study, the two returning participants received their results from each of the tests and dietary analyses with a summary of their information and changes tracked over time. De-identified blood measure results were sent out once analyzed by and received from Central Coast Pathology. Due to the returning sample size ($n=2$), statistical analyses of change from baseline to completion was not conducted.

Chapter 4

RESULTS

As a primarily quantitative study, it is an acknowledged limitation that we are without qualitative assessment or a collection of demographic data. Table 1 presents quantitative data with baseline measures collected for all soldiers ($n=22$). The following subsections, **4.1-4.8**, organize quantitative findings, presented alongside Tables and related *Figures* for visual aid for select data. Subsection **4.9** presents statistically significant results following the statistical analyses described in Chapter 3 METHODS.

Table 1. Baseline Data Collection Variables of Interest.

Variable	Male		Female		Total	
	$n=13$		$n=9$		$n=22$	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Age (yrs)	28.6	9.0	24.6	3.0	27.0	7.3
Height (in)	68.6	2.7	64.8	2.5	67.2	3.3
Weight (lbs)	200.1	24.0	164.8	21.7	185.7	28.7
BMI (kg/m ²)	29.8	3.0	27.6	2.1	28.9	2.9
Waist (in)	37.0	3.2	32.7	1.7	35.2	3.4
Hip (in)	42.5	3.2	41.9	2.4	42.2	2.8
Waist-to-Hip	0.9	0.1	0.8	0.0	0.8	0.1
Systolic BP (mmHg)	133.8	16.6	111.1	12.8	124.5	18.7
Diastolic BP (mmHg)	76.6	7.7	69.7	4.6	73.8	7.4
Heart Rate (beats/min)	64.5	6.4	66.0	8.5	65.1	7.2

4.1 Metabolic Syndrome Criteria

We identified only two subjects presenting 3 MetS risk factors that may warrant diagnosis. Three other subjects presented 2 MetS risk factors, putting them at increased risk for MetS qualification. Several participants ($n=9$) presented elevated systolic and/or diastolic blood pressure, reduced HDL cholesterol ($n=6$), and large waist circumference ($n=5$). Only one participant presented elevated triglycerides (174 mg/dL) and no participants presented high FBG.

4.2 Dietary Intake

For each participant, 3-day Food Records were distributed for the week prior to their arrival and planned to be collected at baseline and entered into The Food Processor nutrition analysis software version 11.1 (ESHA Research, Salem, OR) for assessment. Additionally, during their time on-site, 1-day Ideal Meal Plans were created for each participant based on age, height, weight, sex, and activity level with DRI recommended values for daily calorie, fat, protein, and carbohydrate intake used as reference. Two additional days of Ideal Meal Plans were sent via email in July 2016. Twenty-one participants completed the distributed 3-day Food Records and one participant completed a 24-hr Dietary Recall. The 3-day intakes were used to determine an average intake reflective of a typical daily intake for each participant. The individual who completed the 24-hr Dietary Recall was still included in analysis because of the already small sample size. In assessing the participant's values compared to the population mean intake of overall calories, macronutrients, and meals per day, the individual's values did not reach a level of statistical significance when examined visually on leverage plots from the fitted models. Therefore, although the dietary intake collection method differs from the other participants', the individual's data is still included in assessment of all dietary intake data.

The average daily intake for each nutrient was determined using ESHA software and compared to its ESHA recommendation based on the individuals determinants including age, sex, height, weight and activity level. All participants were recommended 5-6 meals to be consumed throughout the day. Dietary intake data are shown in Table 2 and *Figure 2*. All bar graphs contain standard deviation error bars.

While fruit, vegetable and whole grains servings intake was not assessed by the research team, the saturated fat (sat. fat) values participants reported may be of interest and have been calculated. The overall average % of total calories made up by sat. fat intake at baseline was 10.9%, compared with the recommended 6.1%. Females consumed on average 10.7% compared to the recommended 5.5% and males consumed on average 11.0% compared to the recommended 6.5%.

Table 2. Baseline Dietary Intake Data.

Variable	Male		Female		Total	
	n=13		n=9		n=22	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Avg. Daily Fat Consumption (g)	71.3	24.6	57.1	20.9	65.7	23.6
Avg. Daily CHO Consumption (g)	216.9	105.5	217.3	98.9	223.3	100.3
Avg. Daily Protein Consumption (g)	102.5	24.1	64.4	20.3	87.2	29.0
Avg. Daily Calorie Consumption (kcal)	1939.4	560.3	1619.2	522.8	1838.3	545.6
Avg. Meal Frequency (meals)	3.4	1.0	2.7	0.7	3.1	0.9
Avg. % of Recommended Fat Intake	100.5	37.2	103.2	42.7	102.8	38.9
Avg. % of Recommended CHO Intake	70.3	32.5	89.3	35.4	79.6	34.6
Avg. % of Recommended Protein Intake	68.0	16.6	48.7	13.1	60.6	17.6
Avg. % of Recommended Calorie Intake	80.2	24.9	83.3	24.6	82.8	24.6
Avg. % of Recommended Meal Frequency	59.1	18.1	45.6	11.1	53.3	16.8

Figure 2. Dietary Intake Macronutrient Percentages of Recommended Intake, by Sex.

4.3 Physical Activity

At baseline, participants completed an International Physical Activity Questionnaire (IPAQ). In analyzing the completed questionnaires, the response option for participants to record “I don’t know” at the sedentary activity level resulted in several participants not providing a standard amount of time that could be converted into MET-mins/week. Because the IPAQ requires the calculation of activity reported in minutes (average/day) to MET-min (per week), we faced inconsistencies in the data reported. Additionally, similar to issues of self-report with dietary intake Food Frequency Questionnaires (FFQs) and Dietary Recalls, the over- or under-reporting of activity could also impact our data. It may be inferred that with the pre-selection of this group based on poor physical fitness as identified by the National Guard, over-reporting of physical activity in the IPAQs could have been an issue with the IPAQ assessments finding very high levels of activity in the participants.

Excluding the low intensity exercise which is confined to walking and sitting, most participants self-reported moderate to high ranges of activity calculated in Met-mins/week. For exercise categories in which participants responded “Don’t know/Not sure” regarding time spent engaging in the activity, values were uncalculatable. The only category in which all participants answered with numerical data was for moderate physical activity engagement. The average moderate physical activity for our population was 1119.09 Met-min/week. This would be the equivalent of an average of about 40 mins of moderate physical activity per day.

4.4 Anthropometric Measurement

Although BMI is a controversial measure to report the health of an individual because it does not directly consider body composition, it may be used to categorically note the degree of obesity where generally appropriate. Noting the lack of ability to identify body composition as DXA does, only one participant classified as normal BMI (18.5-24.9 kg/m²) at baseline. Eleven subjects classified as overweight (25.0-29.9 kg/m²) and 10 subjects classified as obese class I (30.0-34.9 kg/m²), per ACSM guidelines (Whaley et al., 2006). The average BMI of participants

was 28.9 kg/m². On average, females presented a BMI of 27.6 kg/m² and males presented a BMI of 29.8 kg/m².

In regard to waist circumference and waist-to-hip ratio (WHR), the total average waist circumference for participants was 35.2 in. Females averaged 32.7 in and are considered at risk (NHLBI Obesity Health Initiative, 2000) when measuring greater than 34.6 in. Males averaged 37.0 in and are considered at risk when measuring greater than 40 in (NHLBI, 2000). The average WHR for females was 0.78, with females considered at risk when greater than 0.85 (NHLBI, 2000). Average male WHR was 0.87 and considered at risk when greater than 0.85 (NHLBI, 2000).

Figure 3. Waist Circumference Measurement Compared to Risk.

4.5 DXA Analysis

Assessing DXA outcomes and measurements allows researchers and healthcare professionals to obtain a better understanding of the body composition and therefore overall health as it relates to metabolic efficiency. This method is more accurate than assessing body

composition or overweight/obese status through BMI or waist circumference alone. DXA data is included in Table 3, Figure 4, Figure 5, and Figure 5A.

Bone Mineral Density (BMD) was also measured via DXA. The total average BMD (g/cm^3) was 1.306, with female average BMD of 1.263 g/cm^3 and male average BMD of 1.336 g/cm^3 . Also referenced by t-score, which is the number of standard deviations from the mean, the total average t-score for all participants was 1.8, with the female average t-score 1.346 and male average 1.532.

Table 3. Baseline DXA Body Composition Data.

Variable	Male		Female		Total	
	<i>n</i> =13		<i>n</i> =9		<i>n</i> =22	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Body Mass (lbs)	200.1	24.0	164.8	21.7	185.7	28.7
Region (%) Fat	29.6	5.8	37.2	3.7	32.7	6.2
Lean (lbs)	133.0	11.8	97.6	12.9	118.5	21.4
Fat (lbs)	60.1	16.9	61.3	11.2	60.6	14.5
Visceral Fat (lbs)	2.0	1.0	1.3	0.9	1.7	1.0

Note. **Body Mass (lbs)** is total mass or total body mass and includes everything. It is the sum of Fat + Lean + BMC. It includes everything and is close to scale weight as long as the person fits within the DXA scan area. **Region % Fat** equals fat (lbs) divided by total body mass (lbs). It is the most commonly used %Body Fat (%BF) value for DXA studies and it is used in this study to represent the average %BF across the entire body. **Lean (lbs)** is the sum of all muscle and lean soft organ tissue. It excludes bone even though bone is lean. **Fat (lbs)** includes all fatty tissue in the body, within and surrounding the organs of the body, as well as subcutaneous fat under the skin.

Figure 4. DXA Body Composition Data, by Sex.

Figure 5. DXA Visceral Fat Data, by Sex.

Figure 5A. DXA Visceral Fat per Total Fat Data, by Sex.

4.6 Analysis of Blood Markers

Lab values pertaining to Metabolic Syndrome diagnosis were of particular interest but additional measurements were obtained to assess overall health status. Table 4 contains blood marker data and *Figure 6* compared sample data to ideal values of blood lipids. The ideal values for Triglycerides and HDL-C come from the National Cholesterol Education Program Guidelines and the ideal values for total cholesterol and LDL-C come from the American Heart Association Guidelines for Risk of Heart Attack or Stroke.

Table 4. Baseline Biochemical Measurement Data.

Variable	Male		Female		Total	
	n=13		n=9		n=22	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Total Cholesterol (mg/dL)	145.8	21.0	125.9	16.0	137.7	21.2
TG (mg/dL)	87.1	32.0	60.6	15.2	76.2	29.2
HDL-C (mg/dL)	45.4	6.4	53.1	9.6	48.5	8.6
LDL-C (mg/dL)	83.1	20.8	60.6	12.5	73.9	20.9
FBG (mg/dL)	87.3	6.8	83.9	5.0	85.9	6.3
HgbA1c (%)	5.2	0.3	5.0	0.2	5.1	0.3
Iron (ug/dL)	94.6	41.1	83.2	23.1	90.0	34.7
CRP (mg/dL)	0.3	0.0	0.3	0.0	0.3	0.0
Insulin (UIU/mL)	3.8	1.9	3.8	2.3	3.8	2.0

Note. **TG**=Triglyceride, **HDL-C**=HDL cholesterol, **LDL-C**=LDL cholesterol, **FBG**=Fasting Blood Glucose, **HgbA1c**=Hemoglobin A1c, **CRP**=C-Reactive Protein.

Figure 6. Blood Lipid Biomarkers Compared to Ideal Value, by Sex.

4.7 Nutrition Knowledge

A Nutrition Knowledge Assessment (NKA) tool was designed and implemented to quiz our participants on basic nutrition knowledge before and after the education component was

delivered within our intervention. The quiz included 25 questions developed by Nutrition professors which tested basic nutrition concepts the participants may or may not be familiar with. All participants completed the quiz before the informational presentation on nutrition fundamentals provided by Dr. Reaves and Dr. Pilolla. Following the presentation, the participants once again completed the quiz. The purpose of this was to assess their retention of learned concepts with a quick turn-around. The results of pre- and post-lecture quiz scores are presented in Table 5.

Table 5. Pre- and Post-Lecture Quiz Scores.

Variable	Male				Female			
	<i>n</i> =13				<i>n</i> =9			
	Mean	Std. Dev	Min	Max	Mean	Std. Dev	Min	Max
Pre-Lecture Quiz (25 pts)	11.5	3.3	6.0	19.0	11.0	2.2	8.0	15.0
Post-Lecture Quiz (25 pts)	16.5	4.1	11.0	23.0	15.2	2.5	12.0	20.0

Table 5. Continued

Variable	Total			
	<i>n</i> =22			
	Mean	Std. Dev	Min	Max
Pre-Lecture Quiz (25 pts)	11.3	2.9	6.0	19.0
Post-Lecture Quiz (25 pts)	16.0	3.5	11.0	23.0

4.8 Sex-Specific Differences

In running a t-test, the evaluation of statistically significant differences in all variables by sex allows us to account for the small groups. For variables in which we do not find a difference by sex, the lack of difference may be a result of either there not being a difference, or the inability to detect the difference due to the small sample size. In the following Table 6, the level of significance is Prob > |t| <0.05.

Table 6. Statistically Significantly Different Variables, by Sex.

Variable	Male		Female		Prob > t
	n=13		n=9		
	Mean	Std. Error	Mean	Std. Error	
Height (in)	68.8	0.8	64.8	0.8	0.0019
Weight (lbs)	200.1	6.6	164.8	7.2	0.002
Waist (in)	37.0	0.9	32.7	0.6	0.0005
Systolic BP (mmHg)	133.8	4.6	111.1	4.3	0.0018
Diastolic BP (mmHg)	76.6	2.1	70.0	1.5	0.016
Body Mass (lbs)	200.1	6.6	164.8	7.2	0.002
Region (%) Fat	29.6	1.6	31.2	1.2	0.0014
Lean (lbs)	133	3.3	97.6	4.2	<0.0001
LDL-C (mg/dL)	83.1	5.8	60.6	4.2	0.0049
Waist-to-Hip	0.9	0.0	0.8	0.0	0.0002
Avg. Daily Protein Consumption (g)	102.5	6.7	65.1	6.7	0.0008
Avg. Daily Protein Consumption (% of Total Calories)	22.0	1.7	16.4	2.0	0.0501

Note. A t-test was also run for Pre- and Post-Lecture Quiz scores to investigate statistically significant differences by sex. No significant differences were found.

4.9 Statistically Significant Findings Relevant to VAT

An overall model with several predictive variables of interest was statistically analyzed. Exploratory (stepwise regression) analysis reveals that HDL-C is the most significant predictor of VAT ($p=0.0152$), when waist circumference is excluded from the model, after correcting for age and sex. Waist circumference was excluded to examine alternative predictive variables, with the consideration that waist circumference may be a surrogate measure for VAT.

When running a best-subsets procedure without waist in the model, body weight, TG, and HDL-C are all predictors of VAT; HDL-C being most significant ($p=0.0011$). HDL-C has the largest overall effect, evident by the steepest looking slope in leverage plot (*Figure 9*), and numerically by std. beta=-0.5224. Table 7 contains p-values and std. beta values for models with and without waist.

When waist is locked in the model, waist and HDL-C are significant, but TG and body weight are not. HDL-C loses some magnitude of effect (std. beta=-0.425). Waist becomes the most statistically significant ($p=0.0044$) and also has a stronger effect (std. beta=0.607).

From the above two models, HDL-C seems to be the variable most strongly associated with VAT. HDL-C explains 67% of the variability (RSquared=0.6741) in the fit model after correcting for age and sex.

Table 7. Statistically Significant Predictive Variables of VAT.

Variable	Waist Included		Waist Excluded	
	RSquared=0.8003		RSquared=0.8287	
	p-value	Std. Beta	p-value	Std. Beta
HDL-C (mg/dL)	0.01517	-0.42534	0.00109	-0.5224
Waist (in)	0.00444	0.607314	N/A	N/A
Body Mass (lbs)	N/A	N/A	0.03211	0.3513
TG (mg/dL)	N/A	N/A	0.01685	0.47524

Figure 7. Leverage Plot of Body Mass (previously *Body Weight*) without Waist.

Figure 8. Leverage Plot of Triglyceride (TG) without Waist.

Figure 9. Leverage Plot of HDL-C without Waist.

Chapter 5

DISCUSSION

It has been observed that greater numbers of soldiers are not meeting health and fitness standards and the interest in establishing a nutrition intervention came about when we were contacted by National Guard personnel. While we encourage regular physical activity, the foundation of our program focuses on nutrition education and personalized dietary assessment in order to provide material that these individuals can retain and take back with them. With the increased prevalence of obesity, the shift from solely exercise-focused weight management to the incorporation of teaching adequate nutrition is essential. This need unveils itself from a knowledge deficit, the result of the reality that nutrition education is not a standard component in military training. Perhaps it should be. Being on reserve duty, the National Guard particularly benefits from the enhanced knowledge as they must incorporate a greater degree of accountability away from military regimen. Our intention is that these individuals will retain such knowledge and implement it in their everyday lives.

According to Gagnon and Stephens (2015), to remain on active military service, individuals are required to maintain a certain level of body composition and physical fitness. With 90% of those entering the military under age 25, the importance of establishing and maintaining healthy lifestyles should be imprinted early on (Gagnon & Stephens, 2015). The researchers report that in 2003, 18,054 of 234,447 total applicants were not accepted because of weight-related Military Entrance Processing Stations (MEPS) codes. While this only equates to 7.7%, the sheer number of applicants turned down is striking. In 2005, 8.2% of applicants were failed. Fortunately rates of failed entry have dropped in years following. A discussion of our findings as they relate to other existing studies follows, although it is apparent that, as presented in the literature review, various limitations prevent a direct comparison of groups and therefore of study outcomes. For each important finding of this study, a presentation of any particularly interesting or relative studies are mentioned. Our study provides further evidence that a much deeper discussion of the need and direction for future research is warranted.

5.1 Indicators of MetS

Current research studying and collecting data on the prevalence and existing trends of MetS factors in military personnel is limited. Further, it is challenging to find studies with comparable design and sample populations to use for the discussion of findings in our own sample population. Within the studies gathered for this discussion, variances in age, sector of military, sex, and geographical location all prevent a direct comparison between our sample population data and data presented in other studies. Having identified the inability to directly assess the averages in a discussion of how our groups findings compares to others, relevant studies are used in discussion with acknowledged differences specified accordingly.

Two of our study participants presented three risk factors that would warrant follow-up for reduction and/or control over levels of concern. Despite the pre-selection of this group, a limited number of participants presented 3 risk factors for diagnosis of MetS. Three participants presented 2 MetS risk factors. Several participants ($n=9$) presented elevated systolic and/or diastolic blood pressure, low HDL cholesterol ($n=6$), and large waist circumference ($n=5$). Only one participant presented elevated triglycerides (174mg/dL) and no participants presented high FBG. All of these observations come from baseline data collected in cross-sectional assessment at the start of this project.

In a study of the gendarmerie and Republican Guard from Ile-de-France, Ceppa, Merens, Burnat, Mayaudon, and Baunduceau conducted an epidemiological study in 2008 to assess the number of MetS risk factors presented in 2,045 surveyed military personnel. Nine percent of all surveyed subjects presented three or more MetS criteria, according to the NCEP ATP III criteria. The researchers found that those presenting at least 3 of the 5 criteria were 42.2 years of age on average, significantly older than subjects not presenting at least three criteria, who were on average 37.3 years. Both groups were on average older than our sample population. The 9% also had a higher BMI than subjects not presenting at least three criteria (averaging 29.5 compared to 24.8), and a greater body weight at age twenty (75.4 kg compared to 70.4 kg) (Ceppa et al., 2008).

Our study evaluated the younger National Guard soldiers with the consideration that those entering military service may be of metabolic risk even without the preferential increased risk with age. Elevated BP was the most common criteria presented by Ceppa et al. (2008), followed by TGs and WC, then low HDL-C, and finally high FBG. Similarly, our population presented elevated BP most commonly, but followed with low HDL-C before large WC. As previously mentioned, our population differs by region, age, and sex, and it is therefore challenging to compare on equal footing, but the trends presented for their subjects who met at least three of the five criteria are important. Ceppa et al. (2008) present that interventionist surveys have demonstrated the importance of lifestyle change according to improvements in diet and physical activity. Albeit limited by the cross-sectional and epidemiological follow-up, the suggestion of lifestyle intervention is in agreement with our own proposition for sustainable modifications that reduce risk long-term.

A study by Herzog, Chao, Eilerman, Luce, and Carnahan (2015) explored the prevalence of MetS retrospectively by examining electronic health data collected on military personnel between 2009-2012. Their 2015 report of enrolled Military Health System adults categorized three populations of nonactive duty, active duty, and Air Force duty in an effort to provide values of MetS components representative of each respective population. The active duty sample was the only group that had all five components (BMI or WC, blood glucose, TG, HDL-C, and BP) measured which complicates our means of comparison as the nonactive duty population would be a more similar group to our own (Herzog et al., 2015). Herzog et al. (2015) report MetS component prevalence stating that the active duty population completes a medical evaluation before entry, with conditions including diabetes and obesity grounds for disqualification for US military service; the resulting “selection bias” in the active duty subpopulation lead these researchers to stratify their statistical analyses by active and nonactive duty populations.

In discussion, Herzog et al. (2015) summarize their findings as a decreasing trend in MetS prevalence in the active duty sample between 2009 and 2012. Comparing the 2010 active duty AF sample to the 2010 US population, Herzog et al. (2015) observe the active duty AF sample was significantly lower in MetS prevalence for both men and women in every age group

above 20 years. For both genders in the active duty population, the component threshold prevalence was described to increase with increasing age for all components except HDL-C while the trend for the nonactive duty population was less clear, making a reference to our study observations difficult. Herzog et al. (2015) report active duty MetS prevalence was higher among men and highest in the 45-64 age group for both genders in the active duty sample. An important comment by the researchers described the strength in the study recognizing the “impact of the healthy worker effect in active duty on MetS prevalence” which followed with their separation of active and nonactive duty populations for analyses (Herzog et al., 2015). Although the nonactive duty sample was not representative of the nonactive population, the study importantly reported that trends of prevalence which still elucidate the percentages of the populations exceeding various MetS component thresholds which the researchers hope will lend to future “effective prevention, intervention, and disease management strategies” (Herzog et al., 2015).

Due to attrition, the two participants who presented three risk factors did not return for follow-up in order to assess control of presented risk factors at baseline. Ethical consideration for the seriousness of their diagnosis of MetS if such factors were sustained is not taken lightly, but poor communication and loss of contact did prevent the research team from investigating any improvement in their criteria status.

5.2 Dietary Intake vs. Recommended Intake

The average daily calorie intake for all participants of our study was 1838.3 kcals, and amount that appears to be low when compared to the average recommended amount of 2242.5 kcals. On average, our participants consumed 32.2% of total calories from fat. Females on average consumed 30.6% of total calories from fat, and males on average consumed 33.1% of total calories from fat. Our participants consumed a lower than recommended number of calories but a higher than recommended percentage of those calories from fat, as the average recommended amount is <25% of total calories from fat.

Although we did not quantify the average daily servings of food groups consumed by participants, some data on military consumption is available. According to the 2008 Department

of Defense (DoD) Survey of Health Related Behaviors Among Active Duty Military Personnel, including the National Guard and Reserves, 13% of military personnel consumed three or more servings of fruit per day and 14% consumed three or more servings of vegetables per day (Bray, 2009). For men ages 19+ and women ages 19-30, 2 cups of fruit are recommended per day, and 1.5 cups for women ages 31+ (USDA MyPlate). For men ages 19-50, 3 cups of vegetables are recommended per day and 2.5 cups for men 51+ (USDA MyPlate). Two and a half cups of vegetables are recommended per day for women ages 19-50, and 2 cups are recommended for women 51+ (USDA MyPlate). Recommendations from MyPlate are considered appropriate for sedentary individuals who engage in less than 30 min/day of moderate physical activity (USDA MyPlate). One cup of fruit or 100% fruit juice, or ½ cup of dried fruit may be considered 1 cup, or 1 serving, from the Fruit Group, according to USDA's MyPlate.

The Survey also reports that civilian baseline data indicate higher consumption of fruit and vegetables per day than is consumed by military personnel, an interesting consideration when we take into account the National Guard duty status as living mostly civilian lives (Bray, 2009). In 2008, 22% of all males in all military services reported intake of lean proteins at least 3 times per day which is significantly higher than the intake reported by females (17%) (Bray, 2009). Seventeen percent of females reported intake of fruit and vegetables at least 3 times per day, which is higher than the percentages reported by males (12% for fruit and 14% for vegetables) (Bray, 2009). The Survey presents that approximately 1/5 of personnel from all services (19% of males and 20% of females) reported intake of whole grains at least 3 times per day in 2008 and nearly 1/5 of personnel from all services (17% of males and 19% of females) reported intake of low-fat dairy products at least 3 times per day in 2008 (Bray, 2009). In future studies, assessing our sample intake according to average daily servings may be a strategic adoption to encourage participant consumption of adequate amounts of all food groups, which will translate to appropriate caloric and macronutrient intake in an alternative manner.

5.2.1 Dietary Intake Effect on BMD

The ability to assess bone mineral density (BMD) by DXA allows us to identify relationships between dietary intake and the bone health of our population. Although we did not prioritize BMD specifically, the broad assessment of body composition importantly links nutritional adequacy with the consideration of skeletal density. Carlson, Smith, and McCarthy (2013) assessed the dietary intake, physical activity, and BMD in combat service support soldiers before and after a 12-month deployment to Iraq. Their participants completed the 110-item 2010 Block Food Frequency Questionnaire and the Baecke Habitual Physical Activity Questionnaire. Twelve male and seven female soldiers completed the study, average age 23.13 ± 3.4 years (Carlson et al., 2013). Baseline average dietary intakes are as follows (mean $\pm$ SD): 3231 ± 2215 kcal, 117 ± 90 g protein, 409 ± 252 g carbohydrate, 120 ± 99 g fat. Post-deployment values are as follows: 3009 ± 1609 kcal, 113 ± 113 g protein, 387 ± 198 g carbohydrate, 120 ± 74 g fat. Dietary intake of male soldiers during deployment compared to the Institute of Medicine's Dietary Reference Intakes (IOM DRIs) are as follows: 3381 ± 1686 kcal (121% DRI), 129 ± 53 g protein (230% DRI), 420 ± 203 g carbohydrate (323% DRI), 141 ± 78 g fat (131% DRI). Dietary intake of female soldiers during deployment compared to the IOM DRIs are as follows: 2373 ± 1346 kcal (108% DRI), 85 ± 39 g protein (185% DRI), 329 ± 192 g carbohydrate (253% DRI), and 85 ± 54 g fat (110% DRI). Male and female soldiers met and exceeded DRIs for all macronutrients, and the authors note their intentional use of IOM DRI versus Military DRIs (MDRIs) given the outdated status of MDRIs (Carlson et al., 2013). The energy intake for males and females was derived for the Department of Agriculture's dietary guidelines for Americans' estimated energy intake for moderately active persons (Carlson et al., 2013). The researchers did not split up baseline intake by sex which challenges our ability to compare averages. However, the general dietary trend of the combat service support soldiers did not change significantly from baseline through deployment. Compared to our sample dietary intake, the combat service support soldiers were around the same age and consumed more calories and more of all macronutrients on average, daily. A number of factors may contribute to the greater reported intake including the possibility that these soldiers had higher daily demands in military duty than our National Guard soldiers.

5.2.2 Dietary Intake Effect on VAT

The measure of VAT deposition provides insight on the potential cardiometabolic risk or overall health of an individual, which influences necessary recommendations to adjust dietary adequacy. Based on our general understanding of adequate dietary intake as well as our findings from our study population, we argue that eating less is not appropriate for reducing VAT deposition even if a reduction in weight follows. A study by Murphy et al. (2011) examined any difference in the effect of exercise versus a calorie-restricted diet on the reduction in intramuscular adipose tissue (IMAT) and VAT amounts. By implementing a 1-year trial of calorie restriction, exercise, or control in sedentary individuals between 50-60 years old, the researchers found that both calorie restriction and exercise-induced weight loss resulted in decreased IMAT and VAT volumes, but exercise promoted a preferential reduction in these depots. Although their sample was composed of sedentary older participants, the preferential VAT loss resulting from the exercise-induced weight loss relates to our initial inquiry about the correlation between exercise intensity related and VAT deposition: if high-intensity PA is associated with lower amounts of VAT or with preferential VAT loss. Their findings provoke further inquiry on what may be deemed “sufficient” in exercise volume, which is likely on an individual basis, and whether the exercise-induced weight loss can and must be maintained at such a volume in order to reduce the VAT deposition (Murphy et al., 2011). Murphy and colleagues (2011) report their findings contribute to the current literature that exercise may provide greater benefits than the adoption of a calorie-restricted approach to weight loss. This supports our standpoint that exercise is an important component in promoting healthy lifestyle change and should not necessarily be paired with a generalized “calorie-reduction”, but rather an adequate dietary intake unique to the individual. The physiologic mechanism by which vigorous exercise stimulates reduction in VAT depots is explained by Murphy et al. (2011) as the sympathetic adrenergic activity, following the vigorous exercise stimulus, of which VAT is particularly sensitive. The lipolytic activation the adrenal system imparts on the adipocytes is presented as a contributing factor to the preferential VAT reduction as a result of vigorous exercise reported in their study (Murphy et al., 2011). With any qualitative finding, the generalizability of a prescription—be it vigorous exercise or dietary

intake—should always be taken with caution. Although trends may apparently relate two variables favorably, the unique application of individual prescription is ultimately the generalizable solution.

There is limited research on a specific macronutrient profile that correlates with VAT, either directly or inversely. We feel some evidence suggests the under-consumption of overall calories as well as the infrequency of meals may contribute to the high amounts of BF and associated VAT observed in our sample, as a result of a survival state physiological response. However, the metabolic mechanism by which any macronutrient consumed in excess will be stored as triglyceride in adipose tissue does not aid in identifying which macronutrient our dietary intervention should target if participants do intake excess energy. Recommending the appropriate amount of each macronutrient as they relate to total caloric intake is important to individually establish, and we attempted to obtain evidence about which macronutrient is the most predictive of VAT deposition. Our study did not provide conclusive evidence and at this point additional studies are needed.

In their investigation of lifestyle factor association with abdominal adiposity, Molenaar et al. (2009) present that while VAT is more strongly associated with metabolic risk factors (RFs) than subcutaneous adipose tissue (SAT), it is important to identify whether VAT is also more correlated with lifestyle factors such as dietary quality, physical activity, smoking, and alcohol consumption. While our study primarily imparted a nutrition intervention, physical activity should be a priority, and demographic data collection of additional lifestyle factors including smoking and alcohol consumption should not be ignored. Our study did not collect demographic data from our participants, but future projects should gather such baseline data as existing correlations become more elucidated. Molenaar et al. (2009) examined the relationship between lifestyle factors and SAT and VAT volumes of participants of the Framingham Heart Study to determine if adherence to dietary guidelines as recommended by the 2005 Dietary Guidelines Adherence Index, as well as greater physical activity, were inversely associated with SAT and VAT.

For women and men, a diet more closely following the healthy guidelines was associated with lower SAT and VAT (Molenaar et al., 2009). An inverse relationship was also observed for

both women and men regarding higher physical activity and both SAT and VAT and an increasing number of healthy lifestyle factors overall was associated with lower SAT and VAT volumes for both women and men (Molenaar et al., 2009). Molenaar et al. (2009) validate earlier research with similar findings but contribute to the literature with their diet quality-adiposity association on a population-based level. They warrant further research to investigate whether various dietary components, not only total energy intake, are differentially associated with SAT and VAT volumes (Molenaar et al., 2009).

A recent systematic review (Verheggen et al., 2016) sought to differentiate the independent effects of diet versus exercise on weight loss versus VAT decrease, as assessed by radiographic imaging (CT or MRI). The meta-analysis included 117 studies and found that while both exercise and diet result in VAT loss, diet promoted greater weight loss while exercise trended toward a larger VAT decrease. Changes in weight and VAT showed a strong correlation after diet and a modest correlation after exercise (Verheggen et al., 2016). Because total body weight loss does not clearly reflect changes in VAT, it is important to consider both separately and to consider diet and exercise independently (Verheggen et al., 2016). The participants in our study were under-consuming but perhaps were also under-exercising, the combination of which would possibly result in weight loss but not an improvement in VAT. Similarly, not consuming an adequate diet in addition to not engaging in regular exercise would not promote improvements in VAT, instead it may result in a manifestation of unfavorable blood markers in addition to weight gain (Verheggen et al., 2016). The contradictory outcome of maintaining or even gaining weight despite restricted intake is common and supports the idea of adequate nutrition coupled with physical activity to promote a healthy weight and body composition.

Fischer, Pick, Moewes, and Nöthlings (2015) found that in 43 research articles, several aspects of diet were related to VAT and/or SAT including the quantity and quality of carbohydrates, protein, fat, and dietary fiber, in addition to intake of calcium, alcohol, phytochemicals, probiotics, cereal-based foods, sweets, sugar-sweetened beverages, between-meal snacks, and dietary patterns. Their findings included the suggestion that an inverse relationship for both VAT and SAT exists between intakes of medium-chain triglycerides and

“dietary patterns recognized as healthy”; for VAT alone, an inverse relationship was suggested with dietary fiber, calcium, and various phytochemicals, and a direct correlation was suggested with “unhealthy” dinner-type dietary patterns and likely with intakes of fructose and alcohol (Fischer et al., 2015). Fischer et al. (2015) caution that the differing study designs included in their review, whether observational or intervention, should be taken into consideration with their findings.

5.2.3 Actions to Influence Military Dietary Intake

It appears that authoritative accountability for military personnel has great influence not only in combat, but also in the dining room (Crombie et al., 2013). In 2013, researchers investigated the effects of modifying foodservice practices in military dining facilities (DFACs) based on the 2005 Dietary Guidelines for Americans. Particularly interested in intakes of energy and total fat and percent energy from fat and saturated fat, the intervention by Crombie et al. (2013) increased availability of fruit, vegetables, and whole-grain foods, reduced availability of foods with high dietary fat and sugar, offered one main entrée at lunch and dinner that was a lean meat or vegetarian dish and served without added fat, offered low-fat or fat-free milk as the standard milk beverages, color-coded nutrition information cards related to recommended servings of food choice, and educated DFAC staff members. The researchers implemented such specific intervention items based on the findings that only 12.6% and 14.2% of military members were meeting Healthy People 2010 recommendations for intakes of fruits and vegetables, respectively, and only 20% were meeting recommendations for intakes of whole grains (Crombie et al., 2013). With approximately 74% of nondeployed military personnel reportedly consuming at least one meal/day at DFACs, the intervention was purposely implemented in this dining environment to encourage healthy food choice and healthy eating behaviors among a large group of military personnel in a confined and controlled targeted place, according to Crombie et al. (2013).

At 6 months, the intervention DFACs reported lower intakes of energy, total fat, and discretionary fat, as well as percent energy from fat and saturated fat compared with the control

DFACs. At 12 months, DFAC intakes of protein contributed less to total energy with a higher percent of energy from carbohydrate compare to the control. From baseline to 12 months, a 90-kcal difference in energy, 3% from total fat, and 1% from saturated fat was observed in the meals consumed in the intervention DFACs (Crombie et al., 2013). The researchers regard that with such a high percentage of nondeployed military personnel consuming at least one meal per day in military DFACs, the modest reductions in energy, fat, and saturated fat can be beneficial long term, even if they seem negligible in raw form (Crombie et al., 2013). Because a reduced prevalence of obesity and improved lipid profiles may result from modifications to diet reducing overall energy, % energy from fat and saturated fat, the added potential to reduce CV and metabolic disease risk favors the implementation of similar worksite nutrition and physical activity interventions (Crombie et al., 2013). Despite overall improvements in the course of the study, researchers note that intake of total fat, saturated fat, and percent energy from fat remained high even at 12 months (Crombie et al., 2013). This study documents only one meal of the day for these soldiers taking place at the DFAC and it would be interesting to observe how an average daily intake may also change, considering soldier retention of education implemented in the DFAC, if all other meals were not consumed there. Crombie et al. (2013) remark that efforts to enhance fruit and vegetable intake should be prioritized in the future considering low intake remains prevalent among military personnel. National Guard soldiers attend their training on a monthly basis and are less likely to be exposed to such influence. Perhaps more community outreach at dining facilities which specifically attracts the National Guard or which provides some incentive to entice National Guard soldiers to gather under similar nutritional influence would do well to maintain similar accountability for those not accessing military dining facilities daily.

An interesting assessment of attrition related to not meeting fitness standards is presented by Bartlett and Stankorb (2017) who implemented a performance nutrition initiative for Air Force trainees at Joint Base San Antonio-Lackland. The concern that dietary intake of military initial entry trainees is inadequate and contributes to poor performance in Basic Military Training (BMT) led to this intervention in which two squadrons of trainees either received a nutrition snack bar before bed or did not. The structured food environment, lack of snacking, and meal time

constraints are all believed to contribute to inadequate intake which may increase risk of injury, poor performance, and attrition from training, according to Bartlett and Stankorb (2017). At the end of 8 weeks of training, both squadron groups presented similar rates of attrition and graduation, and both groups' fitness measures improved as a result of the training. The snack squadron presented significantly greater improvement in all Physical Performance Assessment (PFA) categories and were 1.62 times more likely to pass the PFA at 4 weeks than the squadron not receiving the snack bar. Bartlett and Stankorb (2017) conclude that a modest nutritional supplement improves military trainees' fitness and supports that optimizing overall nutrition would benefit all trainees.

From a financial standpoint, attrition from BMT costs the US Air Force up to \$22,000 per trainee lost while the receipt of one nutrition bar per day per trainee during BMT is afforded at \$34, presented by Bartlett and Stankorb (2017). With improved fitness and a lower cost, the benefit of incorporating the nutrition bar demonstrates a positive intervention, both cost-efficient and health-effective. Eating frequently throughout the day in the form of small meals or complementary snacks was verbally communicated and actualized in the personalized meal plans in our nutrition intervention to keep blood glucose levels stable, sustain energy through adequate intake, offer a variety of foods to meet macro- and micronutrient requirements and recommendations, and aid ongoing metabolic reactions. Small frequent meals are not always realistic, but the recommendation promotes adequate intake and energy balance. While the commercially available snack bar in the study by Bartlett and Stankorb (2017) provided only 120 additional calories, 24 g from carbohydrate and 4 g from protein, soldiers were instructed to consume it before bed. The snack squadron was able to reduce their fasting time between dinner and breakfast the following morning compared to the squadron that did not receive the snack bar. At week 4 of the 8-week training period, the other squadrons requested and received the snack bar. While 96.7% of trainees received the nutrition bar more than 5x/week, only 65.5% reportedly consumed the snack bar each day. Although the nutrition bar did not appear to affect attrition rates, speculated by the researchers that it did not provide enough calories to compensate for their energy expenditure, or that timing of snack bar consumption in relation to physical activity

was not optimized, it did improve trainees' fitness measures (Bartlett & Stankorb, 2017). With medically-related instances stated as being the most common reason for attrition, optimizing nutritional status with the potential to reduce injuries and minimize attrition from initial entry trainings is to be encouraged in all sectors (Bartlett & Stankorb, 2017). We observed that our study sample consumed low amounts of meals and snacks throughout the day, which was reflected in overall poor dietary intake of calories and macronutrient composition. Their infrequent intake throughout the day may also relate to poor fitness performance as a result of insufficient energy. A more calorie- and nutrient-dense snack bar and more control over compliance of snack bar consumption or the adjustment of timing may lend to an improvement for future studies and policies implemented if such studies support the added benefits from added nutrition. Appropriate feeding regimens to optimize recovery surrounding training exercises in addition to ensuring overall adequate intake during entry training are also important considerations to mitigate injury and attrition and improve performance during initial entry training.

5.3 Important Findings Related to Body Composition by DXA

The 2012 comprehensive Anthropometric Survey of US Army Soldiers (ANSUR II) completed in 2012 by Natick Soldier Research, Development and Engineering Center collected 94 directly measured dimensions, 39 derived dimensions, and 3 3-D head, foot and full-body scans (Gordon et al., 2014). ANSUR II did further breakdown Total Army to Active Duty, National Guard, and Army Reserve Soldiers with measures from 4082 men and 1986 women. Although pooled together, 1962 National Guard and Reserve males and 966 National Guard and Reserve females contributed data to the Survey, with an average body weight of 149.38 lbs (67.76 kg) for females and 188.55 lbs (85.52 kg) for males, an average stature (height) of 64.11 in for females and 69.12 in for males, and an average waist circumference of 33.89 in for females and 37.03 in for males (Gordon et al., 2014). Our female participants weighed more on average regarding total body weight, and our male participants weighed slightly less on average. Although the greatest number of males and females participating were in the 21-25 age group (28% and 30%, respectively), perhaps the broad distribution of ages, and the high number of participants within each age group, influenced the difference in body composition numbers from our own.

5.4 Physical Activity

As noted in Chapter 4, the quantification of an accurate reflection of physical activity of our group of participants was challenging considering the response types and options in the self-reported IPAQ. With the limitation identified in the Results section, the average moderate physical activity for our population was 1119.09 Met-min/week. This would be the equivalent of an average of about 40 mins of moderate physical activity per day. There is also a large degree of variability in individual data considering the array of careers and lifestyles of our participants. Being National Guard Soldiers, our participants lack uniformity in employment and thus activity varies not only in their personal exercise engagement, but also in the physical demands of their job and daily life. Some participants reported high levels of vigorous activity and others reported close to none. Although physical activity data is an important variable in our discussion of VAT deposition, the variability in our sample's distribution of reported engagement compromises its reliability and validity for the purpose of comparison to other studies.

According to the 2008 Department of Defense (DoD) Survey of Health Related Behaviors Among Active Duty Military Personnel, 63% of DoD services and 62% of All Services reported engaging in vigorous exercise (Bray, 2009). While the Survey states this finding is not surprising "given the emphasis the military places on physical fitness as part of an overall goal of military readiness", it may be argued that such emphasis is less generalizable for the National Guard (Bray, 2009). In 2008, an estimated 83% of All Services indicated they engaged in 20 minutes or more of moderate or vigorous physical activity at least 3 days per week (Bray, 2009). Approximately three out of four personnel (76%) indicated engaging in 30 minutes or more, and 39% reported engaging in 60 minutes or more of moderate or vigorous physical activity at least 3 times per week (Bray, 2009). However, specific details of the National Guard soldiers' physical activity were not apparent as they are grouped in the "Army" umbrella category.

In assessing overall physical activity for their group of combat service support soldiers via the Baecke Habitual Physical Activity Questionnaire, Carlson et al. (2013) added work, leisure and sport codes to quantify activity on a scale of 1-15, with 1=low, 7.5=moderate, and 15=high

activity. Overall physical activity scores at baseline averaged 7.55 ± 1.35 and 7.37 ± 1.40 post-deployment. The researchers found that overall diet and physical activity were quite stable during the 12-month study period, but with a small sample size of 19 soldiers who completed the study, the results may not be representative of all combat service support soldiers, a limitation according to Carlson and colleagues (2013). Individual diet varies like food accessibility by location of deployment, according to Carlson et al. (2013). Similarly, physical activity varies based upon missions, available facilities, and scheduling and the lack of control over exercise engagement without an intervention further complicates the ability of interpreting results without drawing conclusions (Carlson et al., 2013).

A study by Cederberg et al. (2010) examined the independent effect of physical activity on CV RFs in young men undergoing military training. In their population-level follow-up study, 1112 young Finnish men, mean age 19.3 years, in active military service with a structured exercise training regimen, measures of endurance performance and muscle fitness performance (MFP), body composition by BIA, blood pressure and biochemical markers were assessed at baseline and follow-up at 6, 9, or 12 months. The researchers found both endurance performance and MFP improved during follow-up, which was correlated with a reduction in weight, BMI, WC, fat mass and %BF, visceral fat area (VFA, cm^2), and diastolic blood pressure (DBP). Cederberg et al. (2010) conclude that associations between improved exercise performance and reduction in BP, as well as changes in lipid levels, were attributable to reductions in weight and VFA.

While physical activity may attenuate but not eliminate adverse effects of obesity on CVD, it is a crucial component for any lifestyle intervention to promote weight loss for individuals not maintaining a healthy weight or healthy lifestyle habits. A primary research question for Cederberg and colleagues (2010) was to evaluate whether exercise alone without dietary intervention can effectively reduce CVD RFs in young adults, which they found to be effective, but limited to their fairly homogenous population of young Finnish active men. Their data revealed HDL-C had significantly increased and VFA significantly decreased, as both significant increases in endurance performance and MFP were observed from baseline to follow-up (Cederberg et al., 2010). A significant inverse Pearson correlation was noted between VFA change and HDL-C, but

fat mass (kg) was actually the most significant correlation observed in regard to VFA change (Cederberg et al., 2010). We observed a similar relationship between HDL-C and VAT amounts, minding that no change in either variable would be distinguishable from our cross-sectional assessment. In follow-up, significant reductions in weight, fat mass, %BF, and VFA were observed and systolic blood pressure (SBP) decreased and HDL-C increased significantly (Cederberg et al., 2010). Cederberg et al. (2010) also found that DBP, total- and LDL-C and TGs increased. If dietary intake data were available from their sample of young Finnish active male participants, it would be interesting to investigate possible relationships existing therein that may explain or suggest relationships between diet and adverse RF changes over time, such as the increase in TGs. The researchers attribute the improvements in SBP and lipid levels with increased exercise to weight loss in this study, and it is recommended to implement a similar exercise regimen paired with a dietary intervention in future studies in order to direct the focus on implementing an adequate diet to further reduce CVD RFs (Cederberg et al., 2010).

Because indices and standard reference values of obesity by %BF have yet to reach consensus, it is consistently difficult to find a VAT standard of reference which to compare our sample population findings. Given that limitation, we hope to contribute to future research studies aimed at establishing an average reference or record in order to evaluate the status of military and civilian populations. Our findings are interesting as far as the current understanding of diet and VAT deposition goes. While the direct association of excess energy (in caloric consumption) being stored as visceral fat sets the stage for obesity status, our data collection evokes questioning for such a concrete concept. Our population, on average, under-consumed their daily intake when compared to average recommended values yet our population also presented (high) values of VAT which we associate with their higher %BF when compared to similar populations. High intensity exercise is believed to target VAT. With our population presenting lower intake but higher VAT, perhaps we must focus on their exercise. If they are engaging in high amounts of PA or PA at high intensity, they may be less likely to present high amounts of VAT. The under-consumption of foods, both nutrient-dense and not, may lend to poor body composition, just as the overconsumption of foods, both nutrient-dense and not, may just as directly. Finding the

proper balance of intake and expenditure must be determined on an individual basis. Our findings of PA also suggest that our population was not successful in engaging in appropriate levels of daily exercise. The IPAQ reports suggest individuals engaged in moderate amounts of activity, on average, but we must be cautious when considering the accuracy of any self-reporting measure particularly when their body composition suggests other trends.

5.5 Anthropometrics Excluding DXA Analysis

With the admission that BMI is a controversial measure of health, in convention with DXA analysis, our baseline measures indicate only one participant classified as “normal” BMI (18.5-24.9 kg/m²), 11 subjects classified as overweight (BMI 24.9-29.9 kg/m²), and 10 subjects classified as obese class I (BMI 30.0-34.9 kg/m²), per ACSM guidelines. The average waist circumference for females was 32.67 in and females are considered at risk when >34.6 in. The average male waist circumference was 37.0 in, and males are considered at risk when >40 in. The presentation of WC as a surrogate measure for VAT, as supported by our own statistical analyses, is in agreement with current literature (Ford, Maynard, & Li, 2014).

According to the 2008 Department of Defense (DoD) Survey of Health Related Behaviors Among Active Duty Military Personnel, the prevalence of overweight (BMI greater than or equal to 25.0) among personnel aged 20 or older remained consistent at 62% since 2005 (Bray, 2009). These measures are based on self-reports of height and weight “and may not be completely accurate”, according to the Survey report (Bray, 2009). The prevalence of obesity in the military was 13% in both 2005 and 2008 (Bray, 2009). In 2008, 60% of all DoD services personnel were classified as overweight, according to their BMI, and 13% of all DoD services personnel were classified as obese (Bray, 2009). In 2008, 15% of males and 20% of females in all military services reported that they have had difficulty meeting their service weight and/or body fat standard (Bray, 2009).

According to the 2008 Department of Defense (DoD) Survey of Health Related Behaviors Among Active Duty Military Personnel, the findings related to overweight and obese status, vigorous physical activity engagement, and fruit and vegetable intake are indicative that the high

prevalence of overweight among military personnel may be more due to issues in diet than lack of exercise (Bray, 2009). The 2008 Survey compares their data and findings to *Healthy People 2010* objectives for a variety of health behaviors. The eligible population for the 2008 HRB Survey consisted of all active duty military personnel except recruits, Service academy students, personnel absent without official leave (AWOL), and personnel who were incarcerated at the time of data collection (Bray, 2009). Thus, comparable data should mind the difference in National Guard soldiers not representing active duty personnel. Additionally, data assessed in the Survey was gathered from anonymously completed self-administered questionnaires, which as previously stated may introduce issues of validity and accuracy (Bray, 2009).

5.6 Biochemical Indicators of Health Status

The average Triglyceride (TG) and Total Cholesterol (TC) values for all participants were well below the threshold values of 150 mg/dL and 200 mg/dL, respectively. The average HDL-C value for all participants was low compared with the recommended amount >60 mg/dL. The average LDL Cholesterol value for all participants was also within normal limits. The average Fasting Blood Glucose (FBG), HgbA1c, Iron, CRP, and Insulin value for all participants all fell within the reference ranges for their respective measures.

According to the 2008 Department of Defense (DoD) Survey of Health Related Behaviors Among Active Duty Military Personnel, 16% of all military personnel had been told that they had high blood pressure, and 15% had been told that they had high cholesterol, since entering the military (Bray, 2009). Therefore, findings from our study are comparable except for our population reporting TC levels within normal limits, after acknowledging that National Guard soldiers are grouped among other personnel in the survey.

5.7 Details of the Statistical Analyses and Indicators of VAT

As noted earlier and as addressed in the limitations, the small sample size ($n=22$) was taken into consideration when running statistical analyses. Considering the population size, we conducted statistical analyses to investigate predictive variables of VAT. After checking the

distribution for normality and possible outliers, we concluded that all measures of all individuals should be included so as to not further shrink our sample size.

Our most interesting finding is that HDL-C is the most statistically significant predictive variable of VAT. While we cannot relate these variables by cause and effect, we can describe their relationship. When running an *observed power analysis* for the relationship we are looking at, we can say: given our current sample size, there is only a certain percentage (of power) of finding a statistically significant relationship, if the real relationship is as strong (as powerful) as the one in our sample.

When examining the predictive power of HDL-C on VAT, the slope estimate is -0.086 lbs/mg/dL. Every 1 mg/dL is associated with a decrease of VAT at about 0.09 lbs. This result was statistically significant ($p=0.0001$). If the real slope/relationship were -0.086 lbs/mg/dL, there is a 99% chance of obtaining a sample that would yield a statistically significant result.

Exploratory Stepwise. In running a stepwise exploratory analysis to investigate potentially significant predictors of VAT, it appeared that HDL-C was the most significant predictor of VAT when waist is locked out of the model and age and sex are always in. For the Akaike information criterion (AIC) estimator, running both a forward and backward selection with waist included in the model, HDL-C and waist collectively explain 80% of the variability in VAT after correcting for age and sex ($RSquare=0.8003$). Both HDL-C and waist appear to be statistically significant predictors of VAT ($p=0.01517$ for HDL-C, $p=0.00444$ for waist). With waist excluded from the model, a forward and backward running AIC procedure presents body mass ($p=0.03211$), TG ($p=0.01685$), and HDL-C ($p=0.00109$) as statistically significant predictors of VAT, explaining about 83% of the variability of VAT after correcting for age and sex ($RSquare=0.8287$). HDL-C is the most significant predictor of VAT unless waist is included in the model. With waist included in the model, HDL-C loses some significance, but is still statistically significant.

Best Subsets. In running a best subsets procedure, both with and without waist in the model, similar results were obtained as in the regular stepwise procedure. When waist is locked out of the model but age and sex is in, body mass, TG, and HDL-C are all predictors of VAT when

they are mutually in the model. HDL-C remains the most significant predictor of VAT ($p=0.0011$). When examining the leverage (added variable) plots (see *Figures 7-9*), a positive relationship between VAT and body mass and TG, and a negative relationship between VAT and HDL-C is shown.

When focusing on the portion of VAT that is not explained by waist, the model includes waist, and HDL-C and waist are most predictive of VAT. Waist ($p=0.0044$) also becomes more significant than HDL-C ($p=0.0152$) as a predictive variable of VAT. In this model, the added variable plots demonstrate that waist is more predictive of VAT than body mass and TG. While HDL-C is still a significant predictor (without and with waist considered), the magnitude of the HDL-C effect is smaller when waist is part of the model (parameter estimate -0.0487 compared to -0.0598).

We interpret this as when waist is considered in the model, despite the possible surrogacy/correlation to VAT, it is the most significant predictor of VAT. So if we are interested in finding out the best predictor of VAT aside from the possible surrogate measure (waist), HDL-C is most significant. HDL-C is significant in both models ($p=0.0011$ in model without waist, $p=0.0152$ in model with waist) and there is no utility in comparing the difference in p-values across models as they are in different contexts.

A standard beta value is useful to assess variable importance since the variables are on different scales. The assessment for both models (with and without waist) show that a 1 SD change in HDL-C has the largest overall effect, so it is most statistically significant, as well as practically significant. This is understood visually in the added variable plots, as it has the steepest looking slope. When waist is in the model, waist and HDL-C are significant, but TG and body weight are not. Waist ($p=0.0044$) becomes a more significant predictor variable for VAT than is HDL-C ($p=0.0152$). Waist is not only the most statistically significant, it also has a stronger effect, shown by std. beta= 0.6073 (compared to HDL-C std. beta= -0.4253). HDL-C is the variable that seems to be most strongly associated with VAT when waist is both considered and excluded from the model.

So what does all of this mean? It brings forth an interest in investigating what is currently known about the relationship, physiologically, between HDL-C and VAT. A review of current literature reveals that not much is known about VAT overall, and while some relationships have been observed between HDL-C and VAT, there have not been ample studies that have specifically examined the mechanism that relates the two. It is largely accepted that HDL-C is protective against most of the major chronic and cardiovascular diseases by the way in which it carries out excess cholesterol in the body that may otherwise build up in atherosclerotic vessels. It has similarly been understood that the amount of VAT deposition is correlated with a greater risk for developing such diseases, as VAT is not protective but rather predictive of poor health status. Although our study is merely observational, and we cannot account for dietary or lifestyle interventions that we implemented to bring about a rise or fall in HDL-C and VAT levels, it is suggestive that with such a strength in predictive power that was found with HDL-C on VAT, an important mechanism that could provide information on an effective dietary and lifestyle intervention urges further investigation relating these two variables.

In their study of peri- and postmenopausal women, Nicklas et al. (2003) examined the relationship between VAT and WC in an effort to establish a VAT cut point. The researchers used the linear regression equation of their population WC-to-VAT relationship to determine the corresponding “high-risk” (89 cm) and “very high-risk” (96 cm) WCs (Nicklas et al., 2003). They also looked at whether women with WC greater than 89 cm were at a heightened risk of having adverse CHD RFs. Nicklas et al. (2003) found that a WC of 89-95 cm was associated with low HDL-C and high LDL-C/HDL-C ratio. In our research, we viewed the WC variable as a surrogate measure for VAT given that both variables represent abdominal obesity and therefore may present issues of masking and/or collinearity. With the findings that women with higher VAT amounts were more likely to have low HDL-C, the same inverse relationship for women with a higher WC was observed. Nicklas et al. (2003) conclude that in middle-aged and older women (mean age 59 ± 6 years), a VAT area of greater than or equal to 106 cm^2 is associated with elevated risk for having low HDL-C concentrations in addition to hypertriglyceridemia, high LDL-C/HDL-C ratio, impaired glucose tolerance, and hyperinsulinemia compared with women with a

VAT less than or equal to 105 cm². Women with a VAT of greater than or equal to 163 cm² in their study is predictive of greater risk for those cardiometabolic RFs, relative to lower VAT levels (Nicklas et al., 2003). Although their study assessed risk and not raw values, the relationships may be translatable to our study.

Nicklas et al. (2003) state that anthropometric or other surrogate measures of VAT should be used as a screening tool because assessment of VAT is costly and involves radiation exposure. With DXA those limitations are largely addressed. Nicklas et al. (2003) recommend using WC as a screening tool for assessment of disease risk given that it has been shown to be the best predictor of VAT in other studies. With that, they found a modest correlation between WC and VAT but a large degree of variation in WCs for a given VAT level (Nicklas et al., 2003). The WC cut point that corresponded to “high-risk” and “very high-risk” VAT cut points in their sample were predictive of an increased risk for low HDL-C, although relative risk was not as high as those for the VAT cut points (Nicklas et al., 2003). Although WC may be a valuable screening tool, VAT measurement should be prioritized in data collection regarding actual disease risk, an important assessment we were eager to gather from the DXA scan. Their sample of postmenopausal women who may be more predisposed to selective visceral fat storage and shifting hormone patterns differs from our study sample (Nicklas et al., 2003). In their limitations, the researchers acknowledge that, like BMI cut points, a “critical level” of VAT does not establish causality for an elevated disease risk even though associations with risk or incidence of disease may be observed (Nicklas et al., 2003).

In the study by Skårn et al. (2016), the researchers found that the only significant predictor of VAT in men without a family history of diabetes (FHD) was baseline HDL-C. In their 18-year follow-up of 94 males, baseline BMI had no association with future amount of VAT among men without FHD and only HDL-C remained a significant negative predictor of VAT, which supports our findings of HDL-C being the most significant (inversely related) predictor of VAT (Skårn et al., 2016). HDL-C is considered protective against CV and metabolic diseases in longitudinal and cross-sectional studies, and has displayed long-term stability according to the researchers, especially among men with FHD. However, Skårn et al. (2016) note that other cross-

sectional analyses have shown “diverging results” regarding whether HDL-C is associated with the amount of VAT or SAT since they have neither been considered separately, nor in the context of FHD. With their findings that HDL-C may be a better predictor of future VAT, like our own findings, they also suggest that while *quality* of HDL-C may be an important consideration as opposed to *quantity* of HDL-C, *quantity* at young age does impact the future amount of unfavorable abdominal adipose tissue inversely (Skårn et al., 2016).

It has been suggested that there may be a greater risk associated with VAT than SAT as related to cardiovascular and metabolic risk (De Larochellière et al., 2014). Whether VAT or SAT has a greater risk especially in type 2 diabetics is still controversial. In their study of patients with type 2 diabetes, Sam et al. (2008) did observe that a higher VAT independent of BMI was associated with smaller HDL particles. When later adding BMI and SAT into their model, they found that neither were independently related to lipoprotein parameters.

CONCLUSION AND COMMENTARY

6.1 Contribution of Work to the Field

The premise of this project was to intervene and provide a lasting impression on a group of National Guard soldiers through nutrition education who were at possible risk of not meeting fitness standards. Although the intervention component fell through with unexpectedly high attrition, the collection of data at baseline and the insight of our researchers regarding the trials of this pilot program provide a valuable contribution to the existing and growing body of literature. Metabolic syndrome, visceral fat deposition and preferential loss, dietary intake and exercise effects on body composition, lifestyle interventions targeting cardiometabolic risk factors, and specific interventions geared toward military personnel are areas of research that may gain important insight from our findings.

What we contribute specifically by presenting our novel project is a pilot program that was devised to impart personalized nutrition for at-risk individuals, and a model designed to allow undergraduate and graduate Nutrition students to gain hands on experience in a research setting under professional and faculty supervision. Providing students opportunity to participate in research projects is essential to the Nutrition Program at Cal Poly, and serves as an important example of the teacher-pupil paradigm shift in which students and faculty work alongside one another, equally learning and contributing.

What we contribute specifically by presenting our findings is that there exists an interesting relationship between HDL-C and VAT deposition. The growing interest in VAT and the energy invested in understanding its metabolic capacities has played a major role in influencing the direction of this project. With the ability to estimate VAT via DXA body composition assessment, we directed our research questions toward elemental components that affect and/or are related to VAT, given its adverse impact on health.

6.2 Anecdotal Follow-Up

The follow-up and data collection that was conclusive of the study for two returning soldiers revealed significant improvement, in both qualitative (attitude) and quantitative (body composition) measures. Although anecdotal, and with the inability to reach statistical significance with a sample size of two, the feedback we received while debriefing with our two returning participants was positive and hopeful in the consideration of future studies and in the adjustments to be made within our own program. Both returning soldiers had been dedicated and responsive throughout the entirety of the study. With every effort on our side as researchers to interact with our study population, these participants were communicative and expressed interest from baseline. To an extent, they were the saving grace that our study may have been significantly more successful overall had we maintained or received better communication with all of our participants. These two participants may have simply been an exception to the rule, hence the anecdotal preface.

Considering any human study should be prepared for attrition with voluntary participation, and further considering our sample was comprised of participants elected by their concerned leadership personnel, perhaps the recruitment process for a study that encourages such a drastic (for some) lifestyle change must be more sensitive to the individual participant's current lifestyle. In retrospect, while it felt like we had established rapport and communicated our objectives to improve each participant's health and wellbeing, not only to ameliorate any concern with inability to re-enlist but also collectively to enhance their quality of life, we may have fallen short in certain individual scrutiny. Being National Guard soldiers, these individuals lead mostly civilian lifestyles and may compose a significant proportion of the Army population facing re-enlistment issues. It would be a grand assumption to generalize all National Guard soldiers by default present poorer physical activity, body composition, or cardiometabolic health than other Army conglomerates, but it may also be an appropriate consideration given that their military commitments are not as regulated or consistent as other branches demand. The National Guard requires a monthly weekend "drill" and a two-week training period each year. Typically, attendance for drills takes place at the armory nearest the soldier's hometown. If called to action, soldiers may remain in-

state but may also be deployed in support of combat operations, to aid in major emergencies, or other deployments in the US or overseas, according to the National Guard website. Aside from the monthly paid drill and Annual Training, soldiers remain in their local community and have a lot more flexibility than Active Duty Army. The National Guard differs from the Army Reserve in that Reserve Soldiers do not have a state mission and cannot be called to respond to floods and hurricanes, for example, according to the National Guard website. Otherwise, both Guard Soldiers and Army Reserve Soldiers train one weekend per month and two weeks every summer, and equally may contribute to the reported lower physical activity performance. The civilian lifestyle of our sample population could reflect attitudes not self-motivated to change. Certainly it would be safe to presume that no soldier would be complacent about being discharged as a result of failing to meet physical activity requirements, but it might also be a less galvanized commitment to our Sports Nutrition Program, hence the high attrition, than if our participants had personally volunteered to take part in the intervention based on their own motivation to change.

All that aside, it may be appropriate to share the qualitative feedback in addition to some quantitative measures. While the quantitative changes observed may not validate the effectiveness of our study, they are interesting to attest to the adherence of participants. Additionally, the qualitative data collected may be regarded as we devise future studies and note necessary changes in design to better address the high attrition that arose from this pilot program.

6.2.1 Qualitative Assessment

One of our participants (Subject A) who expressed great interest in the project and was very appreciative of all of our efforts found that their job was extremely demanding and proved to be a great obstacle in their ability to make dietary changes and incorporate additional exercise outside of the physical work demands. It was challenging to make healthy choices being that 12-hour work days did not cater easily to meal preparation as much as this participant expressed would be ideal. Subject A also communicated that although they did intend to incorporate additional exercise, the exhaustion and time away from home with such long shifts limited the

participant's family time. It was challenging to add intentional activity in the balance between work and home life for this participant. Although Subject A is lean in body type and composition and works a labor-intensive job, it was interesting to correlate the quantitative findings with their qualitative responses, which will be presented below. Regarding Subject A's initial involvement in this program, they remarked that motivation originated from knowing they needed to change. The commitment to stick with it stemmed from wanting to evaluate whether the behavior change was working positively, and served to reinforce self-efficacy. While motivation is still an obstacle, it is no longer a barrier for them. Despite working full time and attending classes full time, on top of supporting a family, this participant is still determined to put forth the effort and has even taught others what was learned from our program. It is extremely fulfilling, personally, to see someone so dedicated despite their personal commitments. It is also extremely rewarding to observe the power of education, and how that knowledge perpetuates.

For our second participant (Subject B), the commitment to this project was also expressed initially and sustained throughout the duration of the study. This participant's occupation did cater more suitably to adopting changes and they expressed a high degree of nutrition knowledge and previous/current engagement in physical activity outside of their occupation. Subject B did relay certain obstacles that hindered a similar commitment to change for Subject A, related to family life, relocation, etc. There is no doubt that any commitment to lifestyle change related to nutrition and exercise is challenging. Acknowledging the additional demands of balancing work and home life, it is understandable that prioritizing health change is not always feasible, even if it is of concern or expressed interest. There is an extensive mental component that affects behavior change; readiness to change, attitudes, and motivation are all elemental constructs to the actual change. Regarding Subject B's involvement in the project, they presented a background in nutrition and as such, this project provided a unique opportunity to not only impact their personal health, but to influence the health of all soldiers involved. Participant B acknowledged that their healthy habits established prior to the program were easy to maintain, but the behavioral changes related to nutrition and lifestyle were a constant challenge and difficult to overcome. This participant set out to shift their mindset with the intention to create new

(“good”) habits as opposed to ruminating on the “bad” habits that were circulating as continuous barriers. Subject B was motivated every day to work hard to change, even on the days that intention was unsuccessful. Again, it is so rewarding to see such a positive regard toward motivation in the face of obstacles. Lifestyle change is not easy, but it is extremely important and it is fulfilling to receive feedback that reiterates such drive.

6.2.2 Quantitative Outcomes

In regard to quantitative results, more improvement in body composition was observed in Subject B than in Subject A. Subject A remained mostly stable in body composition measurements from baseline to culmination, with a negligible increase in body fat and reduction in LBM. Subject B presented notable improvement in body composition, with a 3% reduction in BF and 8 lb increase in LBM.

As far as biochemical measure changes from baseline to follow-up, we observed some noteworthy changes in both participants in opposite directions. Subject A demonstrated a slight increase in Total Cholesterol, LDL-C, and FBG, and a more significant jump in TG, Iron, and Insulin. Subject A's HDL also dropped but remained above 40 mg/dL. Subject B presented a more positive blood panel change with decreases in Total Cholesterol, TG (significant), and LDL-C with a decrease in Iron and drop in HDL-C by 1 g/dL. Because the participants' blood was drawn the day we had the debriefing and follow-up anthropometric measures collected, we were unable to discuss these biochemical findings. Once received, they were sent to each participant individually.

6.3 Limitations and Strengths

There were several limitations mentioned throughout this paper that were unveiled in retrospect as short-comings in design. Beginning with our sample, the lack of randomization of our group as well as the small sample size ($n=22$) already hinder the ability to present strong statistical significance of observed effects. A *k-mean* power analysis indicates that at least 400 participants would be required in order to conclude significant correlation between variables. The sample group should also be randomly selected and it would be extremely valuable if we could

compare an experimental to control group, but we would rather approach this project with an intention-to-treat design in which all participants receive the treatment and can benefit from the personalized nutrition and education.

Our second limitation was the lack of data collected at baseline, specifically qualitative data including demographics, socioeconomic status, occupation, living environment, social environment, diet history, health and family history, etc. With the sensitivity to personal information designated when studying a military population, we were limited in the types of questions that could be asked. While we may have been able to get additional questions approved by the IRB, the collection of qualitative and demographic data was not initially submitted for review. When the consideration to collect such data was discussed after the fact, the retrograde initiation to submit additional questionnaires for review without the concrete ability to re-establish contact with our participants prevented us from pursuing such data collection. In future studies, submitting a questionnaire such as the one used in ANSUR II through the IRB would be implemented to identify additional trends between dietary intake, body composition, and biochemical assessment and demographic factors of Army/National Guard participants.

The lack of contact information to ensure successfully maintained communication and follow-up was a debilitating oversight in our baseline interaction. We understood that adherence to diet orders is expected to fluctuate and vary based on willingness to change and motivation according to the transtheoretical model, but the lack of communication and inability to foster rhetoric once our baseline period of three weeks was over ultimately resulted in the failure of the intended intervention design leading this to be a cross-sectional study only.

Another limitation was our outlier participant who only completed a 24-hr Dietary Recall at baseline as opposed to a 3-day Food Record, and our outlier participant whose age was almost 2 SD above the mean. However, when these two participants' data were assessed independently, neither one presented statistically significant leverage in relation to the response variable, VAT. An additional outlier was identified with suspected significant leverage, but was additionally ruled out as an outlier. All participant data was included in all assessment and analyses. With the

limitation of our small sample size, the ability to check for effect leverage and assurance that lack of significance translated to our ability to keep all 22 participants' data in analyses actually turned out to be a strength of our population. No individual participant, despite our sample size being so limited, demonstrated abnormal enough data to promote exclusion.

An important limitation was lack of repeated measures, specifically waist and hip circumference, as well as standardization of landmarks and consistent (same) Sports Nutrition Team member conducting the measurements. The waist circumference landmark of midway between iliac crest and lowest ribs was recalled in retrospect, but maintaining a written protocol which would ensure all members conducting measurements—if one consistent member was not doing so—were informed of the proper landmark and methodology would have strengthened and further validated our data. Because our research was specific to measures of obesity, repeated measures particularly for waist and hip circumference should have been conducted, with an average of 3 measures recorded. It should also have been limited to one investigator collecting all measurements so as to ensure consistency and limit error to one individual as opposed to multiple. It would also have strengthened our data collection to perform repeated measures of heart rate and blood pressure and to have taken an average of 2-3 measures.

Another limitation was disuse of a standardized NKA tool—we developed our own which lacks quantifiability and does not allow us to compare it to other studies. The degree of improvement in nutrition knowledge of our participants was measured by an increase in score from before to after their nutrition lesson.

As was revealed in the literature review, there is certainly a lack of studies currently investigating the effects of diet on visceral adipose tissue in human models. While several animal (rat) models currently exist, and some have even appointed the research to examine human adipose tissue within the rat model, the application to human studies is still lacking. This limitation in the existing literature therefore limits our ability to establish a significant amount of comparable studies from which we can validate the success of our own.

We were also restricted in gathering current literature related to the dietary intake of military and specifically of National Guard populations. With our approach to provide personalized meal plans, the novelty and ability to take the time and develop dietary recommendations individually is rarely in the literature. Most studies approach their dietary intervention with one control and one experimental diet applied to all members of the treatment group. This does ensure consistency and reduces extraneous variables of the individual design, but we are beginning to understand the importance, and venture to say the superiority, in intentionally adopting the individualized approach to diet in order to affect body composition and health positively. While certainly a strength of our study, the individualized approach was also limiting in that it is challenging to find comparable study designs.

A strength of this study was that our design did include measurable outcomes that could be monitored and evaluated, had communication been successfully maintained through follow-up. To complement the education component, our assessment of participant retention of information was designed for implementation when they were on-site as well as remotely. When the participants were present for their 3-week training at Camp SLO, we were able to provide a nutrition education presentation and instructional cooking lessons. We measured their knowledge retention by providing an NKA before and after the education presentation. As part of the cooking lessons, we educated the participants on the purpose of each ingredient and food item as part of a balanced meal. Once the participants departed, our goal was to follow-up with their knowledge retention in several ways: with our scheduled 24-hour Dietary Recalls remote by phone (as indicated in the original study design to take place in mid-July and August) we intended to measure their knowledge of personalized nutrition and their ability to create balanced meals and consume healthy snacks throughout the day by analyzing their intake and comparing it to their recommended values. We provided three personalized meal plans in order to suggest a variety of macronutrient food choices and substitutions. We were also available for contact as specific questions may arise when participants requested more options, had nutrition inquiries or concerns, or questions related to physical activity and diet changes. Our intention with the planned 24-hr Dietary Recalls was to utilize the encounter not only to assess their adoption of

dietary recommendations, but also to check in with them personally. With significant changes presented to some participants, we wanted to ensure that the recommendations were not too challenging or unfeasible. We wanted to ensure that our recommendations were meeting their needs and we were interested in how it affected their energy, mood, and any changes they had observed in fitness, body composition or body image. While our objectives were established with measurable outcomes, the inability to maintain communication and follow-up proved to be critical obstacles in monitoring the progress and status of our participants. With only two of 22 participants ultimately returning to conclude the study, our assessment of change in target variables would not reach significance despite our measurable outcomes.

6.4 Future Work

Even though our study was not carried out to its full potential as an intervention, we conclude this project with important findings and means to pursue future research. Acknowledging our strengths and limitations, several components of our methodology will be corrected in an effort to represent the importance of this initial study design. A nutrition education-based intervention with measurable outcomes including body composition, biochemical measures, and dietary intake is an appropriate and applicable design to address the issue of overweight and obese complexities aligning with cardiometabolic risk factors. The individualized dietary plans for each participant are not only devised to address their inability to meet basic requirements, but also resonates with the growing support for individualized nutrition practice. By assessing the unique needs of one individual to the next, we are able to prioritize the optimum nutrition on a very specific level. General dietary guidelines and recommendations are still observed, but a consideration of the individual's personal preferences, needs, restraints, and environmental factors sets the likelihood of their behavior modification on a more compelling route to success. Particularly with our study sample of National Guard soldiers, their fairly civilian lifestyle imbues the possibility of lower activity requirements compared to active military soldiers; their lifestyle more closely resembles that of the general population, with varying levels of activity and sedentary behavior.

With the expressed concern of the National Guard soldiers not meeting their physical assessment parameters, the shift to focus on health via nutrition education is pertinent. National Guard soldiers need to be prepared for service at any moment and so their ongoing and upkeep health and wellbeing is vital for their success and for the subsequent protection of our country. Currently, more programs are being established with the prioritization of nutrition. It will require continued studies to provide supporting evidence for the effectiveness of these programs and interventions. In due time, it is possible that the growing support for nutrition education and programming will be overwhelming. The contributions of our work to the field include the interesting findings relating HDL-C and VAT. Current research on VAT is limited and thus our baseline data, although merely cross-sectional is valuable. It guides future studies to investigate further what the specific mechanism HDL-C incurs on VAT deposition or vice versa. The contribution of our work to the field is significant and future work is encouraged to regard our findings, all strengths and limitations included.

BIBLIOGRAPHY

- Adams Jr, H. P., Del Zoppo, G., Alberts, M. J., Bhatt, D. L., Brass, L., Furlan, A., ... & Lyden, P. D. (2007). Guidelines for the early management of adults with ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council, Clinical Cardiology Council, Cardiovascular Radiology and Intervention Council, and the Atherosclerotic Peripheral Vascular Disease and Quality of Care Outcomes in Research Interdisciplinary Working Groups: the American Academy of Neurology affirms the value of this guideline as an educational tool for neurologists. *Circulation*, 115(20), e478-e534.
- Alberti, K. G. M. M., Eckel, R. H., Grundy, S. M., Zimmet, P. Z., Cleeman, J. I., Donato, K. A., ... & Smith Jr, S. C. (2009). Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. *Circulation*, 120(16), 1640-1645.
- Aljasir, B. A., Al-Mugti, H. S., Alosaimi, M. N., & Al-Mugati, A. S. (2017). Evaluation of the National Guard Health Promotion Program for Chronic Diseases and Comorbid Conditions Among Military Personnel in Jeddah City, Saudi Arabia, 2016. *Military medicine*, 182(11-12), e1973-e1980.
- American Diabetes Association. (Rev., 2016). Diagnosing diabetes and learning about prediabetes. Retrieved from <http://www.diabetes.org/diabetes-basics/diagnosis/>
- Assmann, G., & Gotto Jr, A. M. (2004). HDL cholesterol and protective factors in atherosclerosis. *Circulation*, 109(23_suppl_1), III-8.
- Barlas, F. M., Higgins, W. B., Pflieger, J. C., & Diecker, K. (2013). *2011 Health related behaviors survey of active duty military personnel*. ICF International Inc. Fairfax, VA.
- Bartlett, C. G., & Stankorb, S. (2017). Physical performance and attrition among US Air Force trainees participating in the basic military training fueling initiative. *Military medicine*, 182(1-2), e1603-e1609.
- Bray, R. M. (Ed.). (2009). *Department of Defense survey of health related behaviors among active duty military personnel: A component of the Defense Lifestyle Assessment Program*. Diane Publishing.
- Carlson, A. R., Smith, M. A., & McCarthy, M. S. (2013). Diet, physical activity, and bone density in soldiers before and after deployment. *US Army Medical Department Journal*.
- Cawley, J., & Maclean, J. C. (2012). Unfit for service: the implications of rising obesity for US military recruitment. *Health Economics*, 21(11), 1348-1366.
- Cederberg, H., Mikkola, I., Jokelainen, J., Laakso, M., Härkönen, P., Ikäheimo, T., ... & Keinänen-Kiukaanniemi, S. (2011). Exercise during military training improves cardiovascular risk factors in young men. *Atherosclerosis*, 216(2), 489-495.
- Ceppa, F., Merens, A., Burnat, P., Mayaudon, H., & Bauduceau, B. (2008). Military community: a privileged site for clinical research: Epidemiological Study of Metabolic Syndrome Risk Factors in the Military Environment. *Military medicine*, 173(10), 960-967.

- Chaston, T. B., & Dixon, J. B. (2008). Factors associated with percent change in visceral versus subcutaneous abdominal fat during weight loss: findings from a systematic review. *International journal of obesity*, 32(4), 619.
- Combest, T. M., Howard, R. S., & Andrews, A. M. (2017). Comparison of circumference body composition measurements and eight-point bioelectrical impedance analysis to dual energy x-ray absorptiometry to measure body fat percentage. *Military medicine*, 182(7), e1908-e1912.
- Crombie, A. P., Funderburk, L. K., Smith, T. J., McGraw, S. M., Walker, L. A., Champagne, C. M., ... & Young, A. J. (2013). Effects of modified foodservice practices in military dining facilities on ad libitum nutritional intake of US army soldiers. *Journal of the Academy of Nutrition and Dietetics*, 113(7), 920-927.
- De Larochellière, E., Côté, J., Gilbert, G., Bibeau, K., Ross, M. K., Dion-Roy, V., ... & Larose, É. (2014). Visceral/epicardial adiposity in nonobese and apparently healthy young adults: association with the cardiometabolic profile. *Atherosclerosis*, 234(1), 23-29.
- Després, J. P., Arsenault, B. J., Côté, M., Cartier, A., & Lemieux, I. (2008). Abdominal obesity: the cholesterol of the 21st century?. *The Canadian journal of cardiology*, 24(Suppl D), 7D.
- Després, J. P., & Lamarche, B. (1993). Effects of diet and physical activity on adiposity and body fat distribution: Implications for the prevention of cardiovascular disease. *Nutrition research reviews*, 6(1), 137-159.
- de Souza, R. J., Bray, G. A., Carey, V. J., Hall, K. D., LeBoff, M. S., Loria, C. M., ... & Smith, S. R. (2012). Effects of 4 weight-loss diets differing in fat, protein, and carbohydrate on fat mass, lean mass, visceral adipose tissue, and hepatic fat: results from the POUNDS LOST trial-. *The American journal of clinical nutrition*, 95(3), 614-625.
- Donath, M. Y., Ehres, J. A., Maedler, K., Schumann, D. M., Ellingsgaard, H., Eppler, E., & Reinecke, M. (2005). Mechanisms of β -cell death in type 2 diabetes. *Diabetes*, 54(suppl 2), S108-S113.
- Duyff, R. L. (2017). *Academy of Nutrition and Dietetics Complete Food and Nutrition Guide*. Houghton Mifflin Harcourt.
- Farrand, M. E. (1988). National Cholesterol Education Program guidelines: New opportunities and challenges for dietitians. *Topics in Clinical Nutrition*, 3(2), 9-20.
- Fischer, K., Pick, J. A., Moewes, D., & Nöthlings, U. (2015). Qualitative aspects of diet affecting visceral and subcutaneous abdominal adipose tissue: a systematic review of observational and controlled intervention studies. *Nutrition reviews*, 73(4), 191-215.
- Flegal, K. M., Carroll, M. D., Kit, B. K., & Ogden, C. L. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999-2010. *Jama*, 307(5), 491-497.
- Ford, E. S., Maynard, L. M., & Li, C. (2014). Trends in mean waist circumference and abdominal obesity among US adults, 1999-2012. *Jama*, 312(11), 1151-1153.
- Gagnon, M., & Stephens, M. B. (2015). Obesity and national defense: will America be too heavy to fight?. *Military medicine*, 180(4), 464-467.

- Gallagher, D., Heshka, S., Kelley, D. E., Thornton, J., Boxt, L., Pi-Sunyer, F. X., ... & Clark, J. M. (2014). MRI Ancillary Study Group of Look AHEAD Research Group. Changes in adipose tissue depots and metabolic markers following a 1-year diet and exercise intervention in overweight and obese patients with type 2 diabetes. *Diabetes Care*, 37(12), 3325-3332.
- Gordon, C. C., Blackwell, C. L., Bradtmiller, B., Parham, J. L., Barrientos, P., Paquette, S. P., ... & Mucher, M. (2014). *2012 Anthropometric survey of US Army personnel: Methods and summary statistics* (No. NATICK/TR-15/007). Army Natick Soldier Research Development and Engineering Center MA.
- Hallgreen, C. E., & Hall, K. D. (2008). Allometric relationship between changes of visceral fat and total fat mass. *International Journal of Obesity*, 32(5), 845.
- Harrow, J. J., Cordovés, R. I., & Hulette, R. B. (2006). Attitudes toward intentional weight loss and dietary behavior among US Army Reserve soldiers during annual training. *Military medicine*, 171(7), 678-683.
- Heinrich, K. M., Jitnarin, N., Suminski, R. R., Berkel, L., Hunter, C. M., Alvarez, L., ... & Poston, W. S. (2008). Obesity classification in military personnel: a comparison of body fat, waist circumference, and body mass index measurements. *Military medicine*, 173(1), 67-73.
- Herzog, C. M., Chao, S. Y., Eilerman, P. A., Luce, B. K., & Carnahan, D. H. (2015). Metabolic syndrome in the Military Health System based on electronic health data, 2009–2012. *Military medicine*, 180(1), 83-90.
- Hill, J. C., & Millan, I. S. (2014). Validation of musculoskeletal ultrasound to assess and quantify muscle glycogen content. A novel approach. *The Physician and sportsmedicine*, 42(3), 45-52.
- Hruby, A., & Hu, F. B. (2015). The epidemiology of obesity: a big picture. *Pharmacoeconomics*, 33(7), 673-689.
- Kahn, B. B., & Flier, J. S. (2000). Obesity and insulin resistance. *The Journal of clinical investigation*, 106(4), 473-481.
- Kaul, S., Rothney, M. P., Peters, D. M., Wacker, W. K., Davis, C. E., Shapiro, M. D., & Ergun, D. L. (2012). Dual-energy X-ray absorptiometry for quantification of visceral fat. *Obesity*, 20(6), 1313-1318.
- Lapidus, L., Bengtsson, C., Larsson, B. O., Pennert, K., Rybo, E., & Sjöström, L. (1984). Distribution of adipose tissue and risk of cardiovascular disease and death: a 12 year follow up of participants in the population study of women in Gothenburg, Sweden. *Br Med J (Clin Res Ed)*, 289(6454), 1257-1261.
- Larsson, B., Svärdsudd, K., Welin, L., Wilhelmsen, L., Björntorp, P., & Tibblin, G. (1984). Abdominal adipose tissue distribution, obesity, and risk of cardiovascular disease and death: 13 year follow up of participants in the study of men born in 1913. *Br Med J (Clin Res Ed)*, 288(6428), 1401-1404.
- Lee, J. J., Pedley, A., Hoffmann, U., Massaro, J. M., & Fox, C. S. (2016). Association of changes in abdominal fat quantity and quality with incident cardiovascular disease risk factors. *Journal of the American College of Cardiology*, 68(14), 1509-1521.
- Li, C., Ford, E. S., McGuire, L. C., & Mokdad, A. H. (2007). Increasing trends in waist circumference and abdominal obesity among US adults. *Obesity*, 15(1), 216-216.

- Ma, W. Y., Yang, C. Y., Shih, S. R., Hsieh, H. J., Hung, C. S., Chiu, F. C., Lin, M. S., Liu, P. H., Hua, C. H., Hsein, Y. C., Chuang, L. M., Lin, J. W., Wei, J. N., ... Li, H. Y. (2013). Measurement of Waist Circumference: midabdominal or iliac crest?. *Diabetes care*, 36(6), 1660-6.
- Marriott, B. M. (Ed.). (1994). *Food Components to Enhance Performance: An evaluation of potential performance-enhancing food components for operational rations*. National Academies Press.
- Matsushita, Y., Nakagawa, T., Yamamoto, S., Takahashi, Y., Yokoyama, T., Mizoue, T., & Noda, M. (2013). Effect of longitudinal changes in visceral fat area on incidence of metabolic risk factors: the Hitachi health study. *Obesity*, 21(10), 2126-2129.
- Molenaar, E. A., Massaro, J. M., Jacques, P. F., Pou, K. M., Ellison, R. C., Hoffmann, U., ... & Fox, C. S. (2009). Association of lifestyle factors with abdominal subcutaneous and visceral adiposity: the Framingham Heart Study. *Diabetes care*, 32(3), 505-510.
- Millan, I. S., Hill, J., & Wischmeyer, P. (2015). Measurement of skeletal muscle glycogen status in critically ill patients: a new approach in critical care monitoring. *Critical Care*, 19(1), P400.
- Murphy, J. C., McDaniel, J. L., Mora, K., Villareal, D. T., Fontana, L., & Weiss, E. P. (2011). Preferential reductions in intermuscular and visceral adipose tissue with exercise-induced weight loss compared with calorie restriction. *Journal of applied physiology*, 112(1), 79-85.
- National Cholesterol Education Program. (2001). ATP III guidelines at-a-glance quick desk reference. Bethesda, Md.: National Institutes of Health, National Heart, Lung, and Blood Institute, no. 01-3305. Retrieved from <https://www.nhlbi.nih.gov/files/docs/guidelines/atglance.pdf>
- National Heart, Lung, and Blood Institute. (2015). What is metabolic syndrome?. Retrieved from <http://www.nhlbi.nih.gov/health/health-topics/topics/ms#>
- National Research Council. (1983). Food and Nutrition Board (1989) Recommended Dietary Allowances. *National Academy of Science Press, Washington, DC*.
- Nazare, J. A., Smith, J., Borel, A. L., Alméras, N., Tremblay, A., Bergeron, J., ... & Després, J. P. (2013). Changes in Both Global Diet Quality and Physical Activity Level Synergistically Reduce Visceral Adiposity in Men with Features of Metabolic Syndrome-3. *The Journal of nutrition*, 143(7), 1074-1083.
- Neeland, I. J., Grundy, S. M., Li, X., Adams-Huet, B., & Vega, G. L. (2016). Comparison of visceral fat mass measurement by dual-X-ray absorptiometry and magnetic resonance imaging in a multiethnic cohort: the Dallas Heart Study. *Nutrition & diabetes*, 6(7), e221.
- NHLBI Obesity Education Initiative, National Heart, Lung, Blood Institute, North American Association for the Study of Obesity, Expert Panel on the Identification, ... & Obesity in Adults (US). (2000). *The practical guide: identification, evaluation, and treatment of overweight and obesity in adults*. The Institute.
- Nicklas, B. J., Penninx, B. W., Ryan, A. S., Berman, D. M., Lynch, N. A., & Dennis, K. E. (2003). Visceral adipose tissue cutoffs associated with metabolic risk factors for coronary heart disease in women. *Diabetes care*, 26(5), 1413-1420.

- Nieman, D. C., Shanely, R. A., Zwetsloot, K. A., Meaney, M. P., & Farris, G. E. (2015). Ultrasonic assessment of exercise-induced change in skeletal muscle glycogen content. *BMC sports science, medicine and rehabilitation*, 7(1), 9.
- Roussell, M. A., & Kris-Etherton, P. (2007). Effects of lifestyle interventions on high-density lipoprotein cholesterol levels. *Journal of clinical lipidology*, 1(1), 65-73.
- Sam, S., Haffner, S., & Davidson, M. H. (2008). D' Agostino RB Sr, Feinstein S, Kondos G, Perez A, Mazzone T: Relationship of abdominal visceral and subcutaneous adipose tissue with lipoprotein particle number and size in type 2 diabetes. *Diabetes*, 57(8), 2022-2027.
- Shepherd, J. A., Fan, B., Lu, Y., Wu, X. P., Wacker, W. K., Ergun, D. L., & Levine, M. A. (2012). A multinational study to develop universal standardization of whole-body bone density and composition using GE Healthcare Lunar and Hologic DXA systems. *Journal of Bone and Mineral Research*, 27(10), 2208-2216.
- Shuster, A., Patlas, M., Pinthus, J. H., & Mourtzakis, M. (2012). The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis. *The British journal of radiology*, 85(1009), 1-10.
- Skårn, S. N., Eggesbø, H. B., Flaa, A., Kjeldsen, S. E., Rostrup, M., Brunborg, C., ... & Aksnes, T. A. (2016). Predictors of abdominal adipose tissue compartments: 18-year follow-up of young men with and without family history of diabetes. *European journal of internal medicine*, 29, 26-31.
- Tanofsky-Kraff, M., Sbrocco, T., Theim, K. R., Cohen, L. A., Mackey, E. R., Stice, E., ... & Stephens, M. B. (2013). Obesity and the US military family. *Obesity*, 21(11), 2205-2220.
- Verheggen, R. J. H. M., Maessen, M. F. H., Green, D. J., Hermus, A. R. M. M., Hopman, M. T. E., & Thijssen, D. H. T. (2016). A systematic review and meta-analysis on the effects of exercise training versus hypocaloric diet: distinct effects on body weight and visceral adipose tissue. *Obesity Reviews*, 17(8), 664-690.
- Whaley, M. H., Brubaker, P. H., Otto, R. M., & Armstrong, L. E. (2006). *ACSM's guidelines for exercise testing and prescription*. Philadelphia, Pa: Lippincott Williams & Wilkins.
- Williams, M. J., Hunter, G. R., Kekes-Szabo, T., Trueth, M. S., Snyder, S., Berland, L., & Blaudeau, T. (1996). Intra-abdominal adipose tissue cut-points related to elevated cardiovascular risk in women. *International journal of obesity and related metabolic disorders: journal of the International Association for the Study of Obesity*, 20(7), 613-617.
- World Health Organization. (2011). Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008. Geneva: World Health Organization. <http://www.who.int/iris/handle/10665/44583>

APPENDIX A

Nutrition Knowledge Assessment

Please select the best answer for each question and fill in the provided scantron.

1. All of the following are classified as macronutrients **EXCEPT** _____.
 - a. Fat
 - b. Protein
 - c. Calcium
 - d. Carbohydrate
2. Most calories in our diet should come from _____.
 - a. Proteins
 - b. Fats
 - c. Carbohydrates
3. Which of the following **cannot** add fat to the body?
 - a. Alcohol
 - b. Proteins
 - c. Carbohydrates
 - d. Calcium
4. An empty-kcalorie food is one that contains
 - a. No calories
 - b. An abundance of vitamins but little or no minerals
 - c. An abundance of minerals but little or no vitamins
 - d. Energy and little or no protein, vitamins, or minerals
5. Which of the following breads has the highest fiber content?
 - a. White
 - b. Refined
 - c. Enriched
 - d. Whole-grain
6. Which of the following is a component of all three dietary disaccharides?
 - a. Sucrose
 - b. Glucose
 - c. Fructose
 - d. Galactose
7. Glycogen is stored mainly in which of the following tissues?
 - a. Muscle and liver
 - b. Pancreas and kidneys
 - c. Stomach and intestine
 - d. Brain and red blood cells
8. Each of the following is true regarding Type 2 Diabetes **EXCEPT**:
 - a. Obesity is a major risk factor
 - b. Genetics plays a significant role as a risk factor
 - c. Type 2 Diabetes is less common than Type 1 Diabetes
 - d. Muscle cells are not sensitive to insulin

9. Which of the following is **TRUE** regarding exercise and energy (fuel) sources during exercise?
- a. Plasma free fatty acids are NOT used during anaerobic exercise
 - b. Blood glucose is NOT used during anaerobic exercise
 - c. Protein is used as a major fuel source during high intensity exercise
 - d. Muscle glycogen is used more as exercise intensity increases
10. What type of nutrient is starch?
- a. Fiber
 - b. Gluten
 - c. Simple carbohydrate
 - d. Complex carbohydrate
11. The main source of energy during a high intensity workout tends to be _____.
- a. Protein
 - b. Carbohydrate
 - c. Fat
12. Protein is needed for normal development of cells and muscle mass but excessive amounts of protein
- a. Is even better and will bring faster results
 - b. Will not significantly increase the building of body tissue
 - c. Won't add significant strength to the body
 - d. B and C
13. Fructose is the sweetest-tasting simple carbohydrate in the diet.
- a. True
 - b. False
14. What is the first organ to respond to an increase in blood glucose concentration?
- a. Brain
 - b. Liver
 - c. Muscle
 - d. Pancreas
15. When blood glucose concentration falls, what pancreatic hormone is secreted to stimulate release of stored glucose?
- a. Insulin
 - b. Glucagon
 - c. Epinephrine
 - d. Cholecystokinin
16. When you are under physical stress or performing exercise, what hormone is released quickly to stimulate an increase in blood glucose concentration?
- a. Insulin
 - b. Growth Hormone
 - c. Glucagon
 - d. Epinephrine

17. If the diet is lacking an essential amino acid, what will be the course of action?
- Body cells will synthesize it
 - Protein synthesis will be limited
 - Health will not be affected as long as other nutrients are adequate
 - Proteins will be made but they will lack that particular amino acid
18. In comparison to the composition of carbohydrates and fats, which element found in proteins makes them unique?
- Carbon
 - Oxygen
 - Nitrogen
 - Hydrogen
19. Following a high intensity workout, which of the following is the better option?
- Consume food that is almost all protein
 - Consume foods that make blood glucose go up
 - Consume foods that do not change blood glucose
 - Consume high fat foods
20. Which of the following is true regarding proteins and amino acids?
- The liver can make nonessential amino acids from essential amino acids
 - The liver can make essential amino acids from glucose
 - All amino acids have a similar side group
 - Exogenous amino acids are used more than endogenous amino acids for making proteins in the body
21. Which of the following foods contains cholesterol?
- Corn
 - Olives
 - Roasted turkey
 - Roasted peanuts
22. When nitrogen taken into the body exceeds nitrogen losses, we say the person is in
- A healthy state
 - Nitrogen equilibrium
 - Positive nitrogen balance
 - Negative nitrogen balance
23. A **low** risk of cardiovascular disease correlates with high blood levels of
- Triglycerides
 - Free fatty acids
 - High-density lipoproteins
 - Very-low-density lipoproteins
24. LDL molecules contain mostly _____ as their lipid component
- Triglycerides
 - Phospholipids
 - Cholesterol
 - None of the above

25. Your mother eats a fairly balanced diet but wants to include a good source of omega-3 fats. Which of the following is the best recommendation for her?
- a. Fish oil supplements
 - b. Low fat cheese
 - c. Skinless chicken breast

APPENDIX B

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (August 2002)

SHORT LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health-related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ

Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation

Translation from English is supported to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ

International collaboration on IPAQ is on-going and an *International Physical Activity Prevalence Study* is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective*. Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

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** 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. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ **days per week**

☐ No vigorous physical activities → **Skip to question 3**

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

☐ No moderate physical activities → **Skip to question 5**

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → **Skip to question 7**

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent 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.

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

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

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

APPENDIX C

Please do the best job possible of accurately recording everything you eat and drink. Your diet will be analyzed for three days and nutrient intakes will be averaged. This will provide a good representation of your current diet. In addition to manually recording, **please photograph your meal, snacks, and beverages** as prepared and include a standard object (such as a pen) in the photo for size-reference.

Instructions for the Food Record:

1. You will be recording everything you eat for three days. You will record **two weekdays** and **one weekend day**. **Please return to us by email on or before August 31**. You can scan or take pictures of each page and email to us.

Tips for recording accurately:

1. Record each individual food item plus any supplements you take. For example, if you ate oatmeal, fruit and coffee for breakfast, the meal would be represented as shown below:

Time of Day	Portion Size (amount)	Food Description including location/brand	Preparation Method
7:00 am Breakfast (B)	½ cup dry	Quaker Oats, old fashioned, dry	As instructed
B	2 teaspoons	Smart Balance light buttery spread with flax	
B	1 large	egg	Scrambled with spray of non-stick cooking olive oil
B	1 cup	Lactaid milk, 1%	
B	1 tablespoon	Brown sugar	
B	½ cup	Blueberries, fresh	
B	1 cup	Brewed drip coffee	As instructed
B	1 tablespoon	Land O'Lakes Nonfat half and half creamer	
B	1 tablet	Men's One-A-Day vitamin and mineral supplement	

Please **notice all details** about the oatmeal including **preparation/cooking method**, **added foods** (buttery spread, milk, brown sugar), **brand names** if applicable (Quaker, Smart Balance, Land-o-Lakes), **descriptions** of the food products ("light," "1%") and **specific amounts** ("2 teaspoons," "1/2 cup") are provided. Please be as specific as possible ("fresh," "frozen," "blanched," "fried," "steamed") so proper assessment of the *quality* of your diet can be evaluated. The specific details make the overall assessment more accurate and reflective of your actual intake.

Please do not forget to **record added condiments** (mayo, ketchup, oil, butter, creamer, etc.), **alcoholic beverages**, and **salt**. It is not necessary to add other spices and seasonings; we are more concerned with added salt, which contains the mineral sodium. Notice that preparation method details have also been included when appropriate.

2. If you don't know the exact portion, revert to the **Food Portions Guide** as a tool to estimate your portion size. Some examples are provided in the table below:

Time of Day	Portion Size (amount)	Food Description including location/brand	Preparation Method
8:00 pm Dinner (D)	1 deck of cards = 3 oz	Safeway Select Chicken breast, boneless skinless	Sautéed w/ canola oil and salt then finished in the oven
D	1 ½ quarters = ½ tablespoon	Canola oil	
D	¼ teaspoon	Salt	
D	1 fist full = 1 cup cooked	Brown rice, long-grain	As instructed

Food Record Day 1

Name: _____

Date: _____ Day: _____

Time of Day	Portion Size (amount)	Food Description including location/brand	Preparation Method

Food Record Day 2

Name: _____

Date: _____ Day: _____

Time of Day	Portion Size (amount)	Food Description including location/brand	Preparation Method

Food Record Day 3

Name: _____

Date: _____ Day: _____

Time of Day	Portion Size (amount)	Food Description including location/brand	Preparation Method

Healthy Dinner Recipes

Sports Nutrition Program | National Guard | June 13, 2016

PREP

Thaw chicken and/or salmon overnight in fridge or in bowl of warm water for ~1 hr. Do NOT thaw overnight on countertop.

1. Boil 6 cups of water (rice)
2. Preheat oven to 375° for salmon
3. Rinse sweet potato (one for each person), cut into fries
4. Coat sweet potato in minimal olive oil, place in microwaveable container, microwave for 4-5 mins
(when sweet potatoes are soft, they are done)

******Check water for boil!*** (add 2 cups rice if boiling, put timer on for 20 mins)***

5. Rinse green beans and mushrooms, chop mushrooms and onions, mince garlic
6. On separate cutting board, slice 2 chicken breasts each into 2 thin pieces. Lightly coat with olive oil, add any seasoning you wish
7. Cover a baking pan with one sheet of foil. Lightly coat 2 fillets of salmon with olive oil and any desired seasonings, place in middle of pan.

COOK

8. **Sweet Potato Fries:** Cover another baking pan with foil; spread a thin layer of olive oil and the sweet potato fries. Add any seasonings you prefer (salt and pepper are a great classic!). Put in group convection oven; put timer on for 8 mins.
9. **Salmon:** Place the baking sheet with prepped salmon in oven (should be preheated to 375°). Put timer on for 8 mins.
10. ******Check rice! Poke hole in rice with knife, check for water on bottom. No water = rice is done. If not, set another timer******

11. **Vegetables:** heat pan with olive oil, when oil is runny like water add green beans. Cover with lid until green beans are slightly soft. Add onions next; when those are slightly soft add the mushrooms. When the chicken is almost done (next), add the garlic!
12. **Chicken:** Heat pan on medium heat, add small amount of olive oil (chicken should already be coated). Place chicken in pan, cover with lid for 3-4 mins. Remove lid and flip chicken; cook for ~1-2 mins

Take-Home Recipes

Teriyaki Salmon

Ingredients: 1 Salmon Fillet (Costco- 7 wild frozen fillets: \$35) 1 tbsp teriyaki sauce (Albertsons ~\$4)	Cookware & Tools: Baking pan Foil Measuring spoons
Directions: <ol style="list-style-type: none"> 1. If frozen, thaw salmon- place fillet in fridge the night before, OR in bowl of water no longer than 1 hour before 2. Preheat oven to 375° 3. Place salmon on baking pan or foil, add 1 tbsp teriyaki sauce 4. Cook for 10-15 minutes, checking periodically 	
Tips: To tell if salmon is cooked, the layers of the fish should pull away easily and have a light-pink color	

Lemon Rosemary Chicken

Ingredients: Chicken breast (17 frozen breasts at Costco- \$17) ½ tbsp Lemon juice 1 tbsp Olive oil Black pepper Dried rosemary	Cookware & Tools: Knife Skillet & lid Spatula or tongs Measuring spoons
Directions: <ol style="list-style-type: none"> 1. If frozen, thaw chicken- place breast in fridge the night before, OR in bowl of water no longer than 1 hour before 2. Slice breast horizontally into 2 thin pieces 	

<ol style="list-style-type: none"> 3. Pour ½ tbsp lemon juice on chicken, let sit while heating 1 tbsp olive oil on skillet at medium heat 4. Place breast pieces in skillet, sprinkle with black pepper and dried rosemary. Cover with lid and cook for 3-4 mins 5. Remove lid and flip breasts, cook until the side touching the skillet is brown.
<p>Tips:</p> <p>To tell if chicken is cooked, cut into the thickest part of the breast and check for color (pink is raw), and texture (meat should be fibrous and pull apart)</p>

Brown Rice

<p>Ingredients:</p> <p>1 cup short grain brown rice (Costco 10lbs- \$6.49)</p>	<p>Cookware & Tools:</p> <p>Measuring cup</p> <p>Saucepan or pot with lid</p>
<p>Directions:</p> <ol style="list-style-type: none"> 1. Boil 3 cups water in pot or saucepan (cover pot with lid) 2. When boiling, add 1 cup rice, stir immediately 3. Once rice and water are back to boil, reduce heat to low, cover pot with lid, and let simmer for 30-40 mins 	
<p>Tips:</p> <p>Do not touch the rice once it is simmering! To check rice, use a utensil to gently poke a hole in rice to see the bottom of the pot, if there is still water, continue cooking; if the bottom of the pot is dry, the rice is done!</p>	

Green Bean Sautee

<p>Ingredients:</p> <p>½ yellow onion</p> <p>3-4 mushrooms</p> <p>2 cloves garlic</p> <p>green beans</p>	<p>Cookware & Tools:</p> <p>Knife</p> <p>Skillet with lid</p> <p>Wooden spoon or spatula</p> <p>Measuring spoons</p>
--	--

salt & pepper	
<p>Directions:</p> <ol style="list-style-type: none"> 1. Rinse all vegetables well 2. Chop onions and mushrooms; finely chop (mince) garlic 3. Heat pan, add 1 tbsp olive oil, then the green beans 4. Cover pan with lid, cook for 2-3 mins. 5. Uncover pan, add onions and mushrooms (keep pan uncovered from now on) 6. Add a dash of salt and pepper, cook 6-8 mins, stirring often 7. Add garlic, cook 1 min 	
<p>Tips:</p> <ul style="list-style-type: none"> - Garlic burns very easily, that is why you want it in the pan no longer than a minute. - For more browning, increase the heat on the pan. 	

Sweet Potato Fries

Ingredients:	Cookware & Tools:
1 medium sweet potato (Costco 10lb- \$10) Olive oil Salt & pepper	Knife Microwave safe Tupperware or 2 cereal bowls Baking pan and foil (for oven) Or Skillet (for stove-top browning) Spatula or tongs
<p>Directions:</p> <ol style="list-style-type: none"> 1. Rinse sweet potato 2. Cut into strips (like fries) 3. Put in microwave-safe container (certain tupperware, OR 2 bowls on top of each other), cook for 3-5 minutes until fries are soft <p>In the Oven:</p> <ol style="list-style-type: none"> 4. Preheat oven to 475° 5. Spread fries on baking pan with enough olive oil to cover (~2 Tbsp), salt and pepper, place in oven and cook for 8-10 minutes. <p>On a pan:</p> <ol style="list-style-type: none"> 4. Heat pan at medium heat, add 1-2 Tbsp olive oil 5. Cook fried in pan until brown, flipping often (~5 mins) 	

<p>Tips:</p> <ul style="list-style-type: none">- The thinner the fries are cut, the faster the cooking process- DO NOT put metal or aluminum foil in the microwave!- Get creative with your spices- garlic salt or cinnamon are good options!