# INTAKE OF FAT-SOLUBLE VITAMINS AMONG UNDERGRADUATE COLLEGE STUDENTS ATTENDING NORTH DAKOTA STATE UNIVERSITY

A Thesis
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

Samantha Erin Fuhrmann

In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Health, Nutrition and Exercise Sciences
Option: Exercise and Nutrition Science

December 2014

Fargo, North Dakota

# North Dakota State University
## Graduate School

INTAKE OF FAT-SOLUBLE VITAMINS AMONG UNDERGRADUATE COLLEGE STUDENTS ATTENDING NORTH DAKOTA STATE UNIVERSITY

**By**

SAMANTHA ERIN FUHRMANN

The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

**MASTER OF SCIENCE**

SUPERVISORY COMMITTEE:

Ardith Brunt
Chair

Megan Orr

Elizabeth Hilliard

Sherri Stastny

Approved:

December 21, 2014
Date

Margaret Fitzgerald
Department Chair

**ABSTRACT**

Fat-soluble vitamins are essential micronutrients that are critical in normal physiological processes. Deficiencies can pose increased risk of chronic diseases. This may be particularly important among college students, since the majority of this population is in peak phases of development. The purpose of this study was to determine intake of fat-soluble vitamins in 352 (212 males, 140 females) students. Students completed dietary analyses of their 72-hour food record, which were analyzed to determine if student intake met Dietary Reference Intake (DRI) recommendations. Additional analyses determined relationships between intake and gender, age, and frequency of attending a dining center. Few students met DRI for fat-soluble vitamins A (21%), D (3%), and E (7%). Moreover, <1% of students met the DRI for all 3 vitamins. Frequency of attending a dining center did not improve fat-soluble vitamin intake. In summary, few students are meeting DRI guidelines of fat-soluble vitamins.

**ACKNOWLEDGEMENTS**

I would never have been able to finish my thesis without the help of my committee members and the support from my friends and family.

First, would like to express my deepest gratitude to my advisor, Dr. Ardith Brunt for her guidance, patience, motivation, and knowledge. Her guidance has helped me throughout my time of research and writing of this thesis. I would like to thank Elizabeth Hilliard for her encouragement, recommendations, and support of nutritional knowledge and writing skills. I would like to thank the rest of my committee Dr. Sherri Stastny and Dr. Megan Orr for their insight and expertise.

I would like to thank Michelle Caldarone, for being an excellent friend and partner in this project. She was always willing to give suggestions and provide support. I thank Thomas Ames, for his encouragement, friendship, and assistance. I thank Ronda Klubben for her comfort during tough times, and Alicia Woodard for her time friendship over the past two years.

Lastly but not least, I would like to thank my parents, Kimberly and Frank Fuhrmann, who have been my biggest fans and support system since the day I was born.

## TABLE OF CONTENTS

ABSTRACT ..... iii

ACKNOWLEDGEMENTS ..... iv

LIST OF TABLES ..... vi

LIST OF FIGURES ..... vii

INTRODUCTION ..... 1

REVIEW OF LITERATURE ..... 6

METHODS ..... 24

BODY MASS INDEX, ACTIVITY, GENDER AND FAT-SOLUBLE VITAMINS AMONG COLLEGE STUDENTS ..... 27

FREQUENCY OF DINING AT RESIDENCE HALLS AND INTAKE OF FAT-SOLUBLE VITAMINS AMONG COLLEGE STUDENTS ..... 46

SUMMARY AND CONCLUSIONS ..... 65

REFERENCES ..... 69

APPENDIX. IRB LETTER OF APPROVAL ..... 75

## LIST OF TABLES

Table Page

1. DRIs and Food Sources for Fat-Soluble Vitamins ........8

2. Demographics, Age, Gender, Body Mass Index, Activity Status, Intake of Calories and Fat Soluble Vitamins of Study Participants........34

3. Number and Percent of Participants Who Met and Did Not Meet Recommended Intake of Calories, Percent Calories from Fat and Fat Soluble Vitamins........36

4. Demographic, Mean Weekly Dining Frequency, and Consumption of Calories and Fat-Soluble Vitamins among College Students........52

5. Relationship of Dining in Residence Halls and Gender, Age, Caloric, Percent of Calories from Fat and Fat-Soluble Vitamins among College Students........54

6. Number and Percent of Participants Who Met Recommended Intake of Calories, Percent Calories from Fat and Fat Soluble Vitamins in Relation to Dining Categories........55

## LIST OF FIGURES

Figures Page

1. Percentage of Students Who Met Vitamin D Recommendation at Various Weight Classifications ....................37

2. Percentage of Students Who Met Vitamin A Recommendation at Various Levels of Physical Activity ....................38

3. Percentage of Students Who Met Vitamin E Recommendation at Various Levels of Physical Activity ....................38

4. DRI of Vitamin A being Met According to Dining Frequency ( p = 0.93) ....................56

5. The Percentage of DRI for Vitamin A with Dining Frequency. (p = 0.36) ....................57

6. The Percentage of DRI for Vitamin D with Dining Frequency (p = 0.01) ....................57

7. The Percentage of DRI for Vitamin E with Dining Frequency. ....................58

# INTRODUCTION

Dietary habits are developed at a young age and have a lasting impact on overall health throughout a lifetime (Litonjua, 2012). Therefore, it is imperative that children and young adults establish healthy eating habits at a younger age (Litonjua, 2012) to decrease the risk of chronic disease later in life.

## Background of the Problem

As a student transitions from home to college, these environmental changes affect their living situations, social encounters, and dietary intake. Freedman (2010) examined the change in food choices among freshman students during these transitions. Freedman (2010) found that students who lived at home often had meals provided for them by their parent(s). However, once the students moved away from their parental home, they gained more independence and responsibility to choose the foods and quantities of foods they were going to consume (Freedman, 2010; Ouellette, Yang, Wang et al., 2012).

When students leave home to attend college, they typically live in residence halls and are required to participate in a meal plan provided by the university (Freedman, 2010). Meal plans offered by the university include numerous food options to satisfy all students. However, despite several healthier options being offered, students still choose to consume foods higher in sugars and fats (Ansari, Stock, & Mikolajczyk, 2012). Students have shown little knowledge of the impact these food choices will have on their current health and overall health later in life.

## Statement of the Problem

Few studies have assessed dietary intake of college students (Freedman, 2010; Ouellette et al., 2012); there have been almost no studies that have assessed actual intake of individual nutrients, specifically fat-soluble vitamin (A, D, E, and K) consumption among college students.

A majority of studies use food frequency questionnaires (Hendricks, Herbold, & Fung, 2004; McLean-Meyinsse, Harris, Taylor, & Gager, 2013; Musingo & Wang, 2009; Perera & Madhujith, 2012) because they are convenient, while other studies have utilized multiple 24-hour recall records (Hampl & Betts, 1995; Mitzmeser, Giraud, & Driskell, 2000). However, none of the above studies highlight specific nutrients in relation to the current Dietary Reference Intake (DRI).

**Purpose of the Study**

The purpose of this study is to investigate a sample of average college students' dietary intake of fat-soluble vitamins to determine whether students are meeting DRI recommendations based on gender and age.

**Significance of the Problem**

Fat-soluble vitamins are essential to the body and may be key to preventing several chronic diseases including multiple sclerosis (Torkildsen, Loken-Amsrud, Wergeland, Myhr, & Holmoy, 2013), osteoporosis (Ahmadieh & Arabi, 2011), some cancers, and autoimmune diseases (Litonjua, 2012). Consuming recommended amounts of fat-soluble vitamins consistently has been shown to decrease the likelihood of chronic diseases and promote a longer, healthier life (Winkleby & Cubbin, 2004). While many studies have included dietary intake of children and adults, there are few studies that assessed college-aged students (Nelson, Story, Larson, Neumark-Sztainer, & Lytle, 2008).

**Research Questions**

1. Among the students enrolled in an introductory wellness course at North Dakota State University (NDSU), how does their dietary intake of fat-soluble vitamins compare to the current DRI standard?

2. Are there significant predictors such as age, gender, level of physical activity, or BMI that influence the dietary intake of fat-soluble vitamins among students attending NDSU?
3. What is the relationship between participating in a NDSU meal plan and meeting the DRI for fat-soluble vitamins A, D, and E?

**Hypothesis**

It is hypothesized that the majority of students attending NDSU do not consume 75% of the current DRI for fat-soluble vitamins A, D, and E in relation to age and gender, leaving them at a higher risk for deficiency and a higher risk for developing chronic diseases later in life. It is assumed that this analysis can be generalized for the entire population of NDSU because Health, Nutrition, and Exercise Sciences (HNES) 100 and HNES 111 are required general education courses. However, results will not be generalizable for other populations because 86.85% of students attending NDSU are White (North Dakota State University-Ethnicity Data, 2014).

**Research Design**

During the spring semester of 2014, students enrolled in Concepts of Fitness & Wellness (HNES 100) and Wellness (HNES 111) at NDSU completed a 72-hour dietary food record to meet one of the learning objectives for the course. As a required class assignment, students entered their dietary information into NutritionCalc software (version 2010, McGraw-Hill Global Education Holding, LLC) to estimate the nutrient intake, specifically vitamins, minerals, and calories. Students submitted a nutrient report generated by NutritionCalc to the course instructor for grading. Data from the nutrient reports were used to assess the adequacy of fat-soluble vitamins A, D, and E intake compared to the DRI. DRI amounts were based on the Institute of Medicine's current recommendations and on individual participant's age and gender (Institute of Medicine, 2011).

## Assumptions, Limitations and Delimitations

NutritionCalc (Mcgraw-Hill Higher Education, 2011) is assumed to be a reliable and valid tool to estimate micro- and macronutrient content of foods. Students are assumed to accurately report their 72-hour food record and to accurately enter portions consumed.

One limitation of this study was the population selected. As of Fall 2013, 86.85% of all undergraduate students at NDSU were White, (North Dakota State University-Ethnicity Data, 2014). Only students enrolled in Concepts of Fitness & Wellness (HNES 100) and Wellness (HNES 111) were included in this study. Therefore it may not be generalized to the entire population of the United States or for all colleges. However, this study may be a good estimate for Midwestern colleges. This class fulfilled the general education requirement for all majors providing diversity among several majors. To avoid varied output of data, all students used NutritionCalc software.

## Definition of Terms

- Dietary Reference Intake (DRI) – reference values that estimate micro- and macronutrient recommendations for healthy people (Institute of Medicine, 2011).
- Energy Dense – foods that are high in calories and have little to no nutritional value (Healthy People, 2020).
- Fat-soluble vitamins – vitamins A, D, E, and K that are absorbed and transported with dietary fats (Institute Of Medicine, 2011).
- Nutrient Dense – food that provides substantial amounts of vitamins, minerals, and other biological food components and is relatively low in calories (American Institute for Cancer Research, 2014).
- Recommended Dietary Allowance (RDA) – identifies the intake level of micronutrients

that meets requirements of 97-98% of the specified nutrient for the population based on age and gender (Institute of Medicine, 2011).

**Summary**

There is a positive correlation between the prevention of some chronic diseases and adequate intake of fat-soluble vitamins; however, there is insufficient evidence to determine whether college students are obtaining recommended amounts. This study collected dietary intake data for 72-hours from a large sample of college students to estimate whether they are meeting recommended intakes of fat-soluble vitamins A, D, and E. No supplements were included in this 72-hour food record. Consuming recommended levels of fat-soluble vitamins A, D, and E could help decrease the incidence of chronic disease and support an overall healthier population. If results of this study show inadequate fat-soluble vitamin consumption, health promotion staff for college students could utilize this data to encourage foods that are good sources of fat-soluble vitamins A, D, and E for prevention of chronic diseases.

# REVIEW OF LITERATURE

## Introduction to General Nutrition

Maintaining a healthy diet and participating in physical activity promotes optimal health by decreasing the risk for several chronic diseases, including obesity, cardiovascular disorders, diabetes, and cancer (Centers for Disease and Control and Prevention, 2013). In1993, in order to prevent nutrient deficiencies and promote optimal health, the Food and Nutrition Board developed the Dietary Reference Intake (DRI) to provide Americans with specific recommendations for nutrient quantities needed by the body. The DRIs outline minimum recommendations needed to avoid deficiencies and promote health (Institute of Medicine, 2011). The creation of the DRIs was an expansion to the Recommended Dietary Allowances, published in 1941 and Recommended Nutrient Intakes created in Canada (CDC, 2010). The DRIs encompass several subsets of recommendations including, Estimated Average Requirements (EAR), Recommended Dietary Allowance (RDA), Adequate Intake (AI), and Tolerable Upper Intake Level (UL) with each subset of recommendations established based on the adequacy of research available on nutrient intake levels and health (United States Department of Agriculture, 2011). The DRI recommendations apply to healthy individuals, with recommended intake levels varying based on age and gender; however, meeting the recommended intakes may not be adequate for individuals who are malnourished (Institute of Medicine, 2011). Many of the nutrient recommendations for young adults 19-30 years of age are slightly higher to ensure that young adults are able to achieve optional bone density, as well as help provide enough nutrients for the rest of the body to function optimally, without deficiencies.

## Energy

Estimated energy requirements (EER) for an individual is easily calculated based on the gender, age, height, weight, and physical activity of that individual. Energy needs are individualized and if a person does not meet his or her recommendations regularly, they may experience negative side effects such as weight loss or gain, loss of vigor, and nutrient deficiencies. Another factor to consider are individuals who have lower estimated energy recommendations, such as women. In order to reduce the likelihood of weight gain, they may have to consume a diet that has a higher nutrient density to ensure they are consuming adequate micronutrients.

## Vitamins

Vitamins are a group of organic compounds that are needed for normal growth and development. Vitamins are needed in very small amounts compared to macronutrients which are needed in larger quantities.. Vitamins vary in source, chemical structure, function, and required dosage, to perform unique, physiological roles that are vital for health. Vitamins are classified into two categories, fat-soluble (A, D, E, and K) and water-soluble (B-complex vitamins and vitamin C).

## Water-Soluble Vitamins

Water-soluble vitamins, B-complex vitamins and vitamin C, are micronutrients that are found in a variety of plant sources. These vitamins are not stored in the body long-term; thus, they must be replenished daily. They are excreted from the body via urine. These molecules function as coenzymes for a variety of biochemical activities and assist the body in utilizing energy from foods. Although required for metabolism and energy utilization, B vitamins are also widely known to support vision, skin health, the immune response, wound healing, nerve function, and red blood cell formation. These vitamins can be found in dairy sources, green leafy vegetables, grains, legumes, fruits, and vegetables (CDC, 2010).

**Fat-Soluble Vitamins**

In contrast to water-soluble vitamins, fat-soluble vitamins (A, D, E, and K) are stored in the body for longer periods of time and may become toxic when consumed in very large amounts, usually in the form of supplements. Fat-soluble vitamins function as antioxidants supporting the immune system and are associated with reducing the risk for multiple sclerosis, autoimmune disease, cancer, and osteoporosis. Fat-soluble vitamins are found in lipid-containing sources, such as protein foods, dairy products, fruits, vegetables, and fortified foods. DRIs for fat-soluble vitamins are shown in Table 1 and are described further in depth below.

Table 1.
*DRIs and Food Sources for Fat-Soluble Vitamins*

| Life Stage | Vitamin A (mcg) | Vitamin D (mcg) | Vitamin E (mcg) | Vitamin K (mcg) |
|---|---|---|---|---|
| Males | | | | |
| 14-18y[1] | 900 | 15 | 15 | 75 |
| 19-30y[1] | 900 | 15 | 15 | 120 |
| Females | | | | |
| 14-18y[1] | 700 | 15 | 15 | 75 |
| 19-30y[1] | 700 | 15 | 15 | 90 |
| Food Sources[2] | Fish oils, liver, egg yolks, yellow and dark-green leafy vegetables, sweet potatoes apricots, cantaloupe, peaches, margarine | Fish oils, salmon, tuna, sardines, fortified milk, other fortified foods | Nuts, almonds, sunflower seeds, leafy vegetables oils, margarines, wheat germ, milk fat, egg yolks | Soybean oil, vegetable oils, green leafy vegetables, wheat bran |

[1] Institute of Medicine, Vitamins (2011)
[2] United States Department of Agriculture – Vitamin and Minerals (2014).

### Vitamin A

Vitamin A, also known as retinol, is a fat-soluble vitamin with diverse physiological functions that include growth, development (specifically bone development and function), reproduction (Torkildsen et al., 2013), tooth development, cell division, and regulation of the immune system (Institute of Medicine, 2011). Vitamin A can also be consumed in the precursor form, beta-carotene (pro-vitamin A). Beta-carotene also acts as an antioxidant. For college students, consuming adequate amounts of vitamin A is important for preventing allergies and asthma, helping with immune function, promoting reproduction (spermatogenesis) and maintaining healthy bones and teeth (Institute of Medicine, 2011; Litonjua, 2012; Torkildsen et al., 2013). Furthermore, college students who are not consuming enough vitamin A may be at greater risk for blindness and night blindness, autoimmune disease, asthma, allergies, infertility, and other chronic diseases later in life (El-Qudah, Al-Widyan, Alboqai, Suleiman, & Quasem,., 2008; Institute of Medicine, 2011; Litonjua, 2012; Torkildsen et al., 2013).

As seen in Table 1, the current DRI for vitamin A, published in 2001, recommended 900 mcg/day for males and 700 mcg/day for females who are 19-30 years old (Institute of Medicine, 2011). In the National Health and Nutrition Examination Survey (NHANES) 2005-2006 analysis, males had higher vitamin A concentrations than females; moreover, dietary intake of vitamin A for males increased with age (CDC, 2010).

As seen in Table 1, vitamin A can be found in animal sources such as fish oils, liver, and egg yolks. Beta-carotene is found in yellow and dark-green leafy vegetables, apricots, cantaloupe, and peaches (CDC, 2010; El-Qudah, Al-Widyan, Alboqai, Suleiman, & Quasem, 2008). Berner, Keast, Bailey, and Dwyer (2014) utilized NHANES 2003-2006 to determine which foods provided the most vitamin A for youths aged 2 to 18 years. Vitamin A was consumed mainly through dairy products (milk, cheese, and yogurt), beverages, and desserts that contained milk, ready-to-eat cereals, carrots, bars and toaster pastries, pizza turnovers, cookies, breads, cakes, cornbread, pancakes, tortillas, margarine, and butter (Berner et al., 2014).

**Vitamin E**

Vitamin E, also known as tocopherol, is the most abundant antioxidant and plays a role in the immune system and metabolic processes (Institute of Medicine, 2011; Torkildsen et al., 2013). As an antioxidant, vitamin E protects lipid membranes and low-density lipoprotein from oxidative damage and enhances general cell function. Recent research has also suggested that vitamin E may help in the prevention of osteoporosis (Ahmadieh & Arabi, 2011), boost the immune system, and reduce the risk for cardiovascular disease (Litonjua, 2012). Like vitamin A, individuals who do not consume adequate vitamin E may be at a higher risk for multiple sclerosis, asthma, allergies, infertility, blindness, and other chronic diseases later in life (El-Qudah et al., 2008; Institutes of Medicine, 2011; Litonjua, 2012; Torkildsen et al., 2013). It is important for college students to consume recommended amounts of vitamin E to ensure support of the immune system.  This is especially true during stressful times when students are more likely to have a depressed immune response (Gu, Tang, & Yang, 2012).

The current DRI for vitamin E, published in 2000, recommended 15 mcg/day for both men and women 19-30 years of age (Institute of Medicine, 2011). Reaching the UL of vitamin E is rare; however, excessive intake has been linked to decreased blood clotting ability (CDC, 2010). Analysis of NHANES (2001-2002; 1988-1994) (Gao, Wilde, Lichterstein, Bermundex, & Tucker, 2006) and the Continuing Survey of Food Intakes by Individuals (1994-1996) (Interagency Board for Nutrition Monitoring and Related Research, 1995), uncovered that a majority of Americans do not meet the RDA for vitamin E. Furthermore, the NHANES 2001-

2002 dietary intake data showed that 93% of the U.S. population were not meeting the DRI for vitamin E (Gao et al., 2006). Although NHANES dietary reports are epidemiological in nature, this may be a significant nutrient problem in the college age population.

As seen in Table 1, vitamin E can be found in nuts, (almonds, hazelnuts, and Brazil nuts), sunflower seeds, vegetable oils, margarines, and some fatty fish (Torkildsen et al., 2013). Although the ideal form of vitamin E, alpha tocopherol, is the most potent, the biologically less active form, gamma-tocopherol, is found most frequently in the American diet (Litonjua, 2011). These food sources include spaghetti, pizza sauces, baked goods, salad dressings, and fried potatoes (CDC, 2010). Therefore, assuming college students commonly consume these gamma-tocopherol food sources, the vitamin E content of their diet may be minimal.

**Vitamin D**

Vitamin D, also known as calciferol, is considered a hormone as well as a vitamin (Holick, 2007; Holick, 2008; Holick, O' Keefe, & Lavie, 2011). Vitamin D is found in two forms: vitamin $D_2$ (ergocalciferol) and $D_3$ (cholecalciferol). Vitamin D is essential for the absorption of calcium, which aids in preventing osteoporosis by increasing bone strength (Holick et al., 2011). Vitamin D has also been linked to preventing some cancers (Camargo & Manson, 2013), heart disease, depression, both types of diabetes, autoimmunity, allergies, multiple sclerosis, rheumatoid arthritis in women, and high blood pressure (Holick et al., 2011; Institutes of Medicine, 2011). Vitamin D has also been shown reduce viral infections such as influenza (Cannell, Vieth, Umhau et al., 2006). It is important that college students consume adequate amounts of Vitamin D to ensure calcium absorption for the promotion of bone development and increased bone mineral density (especially for females). Preventing osteoporosis is especially important in college-aged women who are in their peak years for building bone density. Vitamin D also aids in maintaining immunity and the reduction of depression and diabetes.

The current DRI for vitamin D, published in 2011, recommended 15 mcg/day (600 International Units) for individuals 19-30 years old (Institute of Medicine, 2011). Vitamin D toxicity, although rare, may occur if a person consumes more than 250 mcg/day for several months and may result in kidney or tissue damage (Institute of Medicine, 2011). However, it is estimated that over half of Americans in the United States are deficient in vitamin D (Holick, 2007).

Vitamin D is available from either fortified foods or supplements, or can be synthesized by the human body from exposure to sunlight (ultraviolet B rays) (El-Qudah et al., 2008; Holick et al., 2011). Synthesis rates of vitamin D vary depending on where a person lives, time of the year, and skin type. The more melanin a person has, the darker their skin, which reduces the ability to absorb ultraviolet B rays. This may lead to an inability to synthesize vitamin D from the sun (Holick et al., 2011). Unlike consuming vitamin D from fortified foods and supplements, ultraviolet light is able to destroy the body's excess vitamin D; therefore, the body cannot reach toxic levels from the sun (Holick et al., 2011; Torkildsen et al., 2013). Some individuals, such as those with sensitive skin, babies, and those with a history of skin cancer, may be advised to limit their sun exposure to prevent skin cancer (Holick et al., 2011). Without these conditions, others are able tolerate longer periods of exposure (Holick et al., 2011). The average person can synthesize 375 mcg to 500 mcg of vitamin D in 30 to 45 minutes of sun exposure during the summer months; however, those who live in the extreme northern or southern hemispheres may not synthesize adequate amounts during the winter months. Therefore, vitamin D supplements may be advised (Holick et al., 2011).

As seen in Table 1, food sources of vitamin D include fatty fish such as salmon, tuna, sardines, fish oils, (Cannell et al., 2006; Institute of Medicine, 2011; Torkildsen et al., 2013), fortified milk, and other fortified food sources (El-Qudah et al., 2008). Fortified foods provide a majority of vitamin D in the American diet. For example, individuals would have to consume six 8-ounce glasses of milk (dairy and nondairy) per day to meet their daily vitamin D recommendation of 15 mcg/day (CDC, 2014). Among the college population, Berner et al., (2014) found that students consume vitamin D primarily from fortified milk products, milk beverages, ready-to-eat cereals, fruit juices, eggs, shellfish, frankfurters, sausages, lunchmeats, and mixtures containing meats.

**Vitamin K**

Vitamin K, also known as phylloquinone ($K_1$) or menaquinone ($K_2$), is mostly known for its role in blood coagulation and bone formation (Ahmadieh & Arabi, 2011; Torkildsen et al., 2013). Unlike the other fat-soluble vitamins, vitamin K has no known function in the human immune system and has not been shown to decrease the risk for chronic diseases (Torkildsen et al., 2013). Published in 2001, the current DRI for vitamin K is 90 mcg/day for women and 120 mcg/day for men ages 19-30 (Institute of Medicine, 2011).

Food sources of vitamin K include avocados, liver, and green leafy vegetables (e.g. spinach, kale, broccoli, and other cooked greens) (United States Department of Agriculture, 2014)). For example, one cup of cooked spinach provides approximately the DRI for vitamin K. Among college students, no studies reported commonly consumed foods that were high in vitamin K. A possible reason is that vitamin K is a difficult vitamin to analyze in the diet; therefore, there is it may be difficult to assess whether intake is adequate. Vitamin K was not included in this study because vitamin K is not one of the nutrients assessed by NutritionCalc.

Even though vitamin K is difficult to analyze, this vitamin is still important as it promotes wound healing through blood clotting and promotes bone density (Torkildsen et al., 2013).

## Development of Dietary Habits

The amount of micro- and macronutrients an individual consumes throughout their life is based on the foods they eat and the habits to which they have grown accustomed. Lifelong dietary habits are formed late in adolescence and continue through early and later adulthood (United States Department Health and Human Services, 2000). If chronic low nutrient intakes that result in deficiencies are identified early and are able to be corrected, chronic diseases could be prevented (von Bothmer & Fridlund, 2005).

## Emerging Adulthood

As young adults transition into adulthood, their journey is marked by several developmental experiences that include graduating high school, leaving the parental home, moving to college, and becoming somewhat financially independent (Wyn, 2004). According to Arnette (2000) a young American adult experiences uncertainty, excitement, new possibilities, confusion, new freedom, and fear from gaining new independence. In the past few decades, more young adults have started moving out of the parental home at ages 18-19 to pursue higher education instead of getting married, starting families, and getting jobs (Arnette, 1998). This shift is also a significant change for women because instead of looking for a husband, more women are now attending college, where they now outnumber men (Arnette, 1998). The shift away from getting married, to attending a university, has steadily increased, with nearly two-thirds of all young adults pursuing post-secondary education (Arnette, 2000). Therefore during this time, these young adults are gaining independence from their parents; however, they are not yet able to support themselves financially (O’Connor, Allen, Bell, & Hauser, 1996).

During this transition phase, students undergo many lifestyle and environmental changes. They may be focusing on adjusting to their new surroundings and new social support systems versus learning new coping strategies (Wyn, 2004). As adolescents transition into adulthood and leave their parental home, many changes involve day to day activities as simple as choosing what foods to eat. This is seen when some students continue consuming the same types of foods that they did when in the parental home, whereas other students tend to choose less healthful foods that were not available in the parental home, and definitely not in unlimited quantities.

**College Environment**

Depending on the research method, results about student dining preference and dietary intake varied. As students move from the parental home to attend a college or university, many are required to live on campus and participate in meal plans. Most university meal plans provide students with unlimited food choices utilizing all you can eat buffets for breakfast, lunch, and dinner (Freedman, 2010). Buffets are the most cost-effective way to provide large numbers of students with a variety of food choices in a limited amount of time. Nevertheless not all students who have a complete meal plan eat healthfully. During the first semester at college, students who participated in a meal plan at residence halls, reported that consumption of dairy products, fruits, and vegetables decreased significantly (Freedman, 2010). Even though a wide variety of foods are available, students may not be choosing foods that meet their nutrient needs (LaCaille et al., 2011). The buffets at residence hall are available for all meals. Nevertheless, LaCaille et al. (2011) found that students still felt the need to get their “money’s worth” therefore they reported eating more than they normally would, ignoring their satiety cues. Repeatedly consuming large amounts of food may lead to increased weight.

Although some students, most often first year students, live on campus and have a meal plan, other students live off campus. These students who live off campus have to either prepare their own meals or purchase meals from other sources. This includes purchasing ingredients from a grocery store or prepared meals from a restaurant. LaCaille et al (2011) found that the majority of students who lived off campus thought they ate healthier than those who lived on campus. However, this was not the consensus of all students in this study. A small few believed living off campus contributed to less healthier eating because the students would then have to purchase and make their own meals (LaCaille et al., 2011). Sometimes it was just easier to stop at convenience stores or fast food restaurants to purchase prepared food. Freedman (2010) reported that a majority of the 54% of the students who lived off campus reported purchasing convenience foods and fast foods more often than those who lived on campus.

Studies have shown that the consumption of nutrient dense foods is affected by availability and convenience of ready-made foods in convenience stores, grocery stores, campus stores, and residence dining halls (Larson, Neumark-Sztainer, Story, Wall, Harnack, & Eisenberg, 2008). Many of the foods that students chose include prepackaged foods, frozen foods, and fast foods that have a higher caloric value and may have little nutrient content (Larson et al., 2008; Musingo & Wang, 2009). Students gravitated towards prepackaged meals due to the lack of time, and the convenience of a quick grab and go option while rushing between classes. Prepackaged items were also chosen due to the quick preparation time and little knowledge and skill needed for the preparation and cooking of meals (Freedman, 2010). When comparing meal consumption among students, those students who lived on campus were less likely to consume breakfast and lunch but more likely to consume dinner compared to those who lived off campus (Freedman, 2010).

Ouellette and colleagues (2012) assessed 30-day food records of 44 students at the University of Connecticut. They uncovered that students gravitated toward calorically dense foods that were higher in sugar and fat because they were hungry, and the foods were convenient. Many students did not pack snacks (LaCaille et al., 2011). When asked what they purchased for snacks when in a hurry, students said they looked for fast and convenient foods. These foods were most often prepackaged, high in fat, and calorie dense and were purchased from food courts, campus vending machines, or quick stops (LaCaille et al., 2011). When students postponed acquiring food because of closely scheduled classes, they were more likely to consume more food quickly to alleviate their hunger (Gruber, 2008; LaCaille et al., 2011).

To get feedback on how students viewed their dining centers, LaCaille et al. (2011) conducted focus groups among 49 participants, aged 18-22 years old attending a Midwestern university. The purpose of the focus groups was to identify how students viewed their dining center and how dining centers could be improved. Some of the students suggested decreasing the amount of unhealthy foods offered and promoting healthier options in dining centers and around campus. In addition to LaCaille et al. (2011), Gruber (2008) conducted focus groups among participants to gain a new perspective as to what students thought would be better strategies for providing nutrient dense foods around campus. The students suggested providing quicker, inexpensive foods and snacks, while simultaneously increasing the cost of calorically dense foods (Gruber, 2008). Some students expressed their concern for the lack of healthy options offered on campus (LaCaille et al., 2011), especially in the dining centers (El-Ansari, Stock, & Mikolajczyk, 2012; Hendricks et al., 2004). This was the primary reason students stated as to why they were not consuming healthier options.

**Importance of Making Healthy Food Choices**

It is unimportant whether students live on campus or off campus, what is important is that they are not only getting the appropriate amount of energy to meet their needs, but also getting the recommended amount of micronutrients to meet their needs. Many studies have assessed weight gain among college students and their dietary habits during this transitional phase (Brevard & Ricketts, 1996; Freedman, 2010; LaCaille et al., 2011; Larson et al., 2008). Freedman (2010) and Nelson and Story (2009) found that students were often choosing fast food options and consuming calorically dense foods. According to Larson et al. (2008), undergraduate students in Minnesota increased consumption of fast food during the first year attending college. This transition from adolescence to young adulthood can be an important time to address fast food intake, as this may be a predictor of weight gain.

**Body Mass Index and Physical Activity Influence**

Body mass index (BMI) is an adult ratio of weight to height that classifies a person as underweight, normal, overweight, or obese. The equation to calculate BMI, is a person's weight in kilograms divided by the square height in meters ($kg/m^2$) (World Health Organization, 2004). These values are then categorized into value ranges where 25 to 29.9 $kg/m^2$ is considered overweight, and a BMI of $\geq 30$ $kg/m^2$ is considered obese (World Health Organization, 2004).

Body Mass Index is affected by many lifestyle factors including dietary habits and activity levels. Freedman (2010) found 25% of his study participants were classified as overweight or obese (BMI $\geq$ 25). Freedman's (2010) findings were lower than the 33.7% that was reported by the American College Health Association-National College Health Association in their assessment of self-reported BMI among college students (American College Health Association, 2013). In Freedman's (2010) study, students who skipped breakfast had a higher

BMI than those who ate breakfast and lived off campus. Of the student population, 28% of students living on campus skipped breakfast almost daily. Freedman (2010) theorized that students living off campus woke up earlier, giving them adequate time to eat breakfast and arrive to school on time, while those who living on campus woke up just in time to walk to class (Freedman, 2010).

Deliens, Clarys, De Bourdeaudhuij, and Deforche (2013) assessed health behaviors of 151 first year students. Deliens et al., (2013) found that unhealthy lifestyles were the main predictor for being overweight such as being sedentary, skipping meals, and consuming high calories meals when they did eat. Gender differences showed that males had a greater increase in weight over the four years in college as evidenced by increasing BMI and waist circumference. During the first semester of college, males reported eating out more frequently, and having a higher intake of sugar-sweetened carbonated beverages and French fries than females (Deliens et al., 2013).

Hendricks et al. (2004) examined dietary intake as it related to weight and BMI in college-aged females. The participants who were more physically active reported eating foods that generally followed dietary guidelines with mean nutrient intakes meeting DRI recommendations (Hendricks et al., 2004). Hendricks et al. (2004) found that BMI of study participants was positively correlated with percent of calories from saturated fat, but not total fat intake. Individuals with a higher level of physical activity also had a negative relationship with percent calories from monounsaturated fats (Hendricks et al., 2004). Ouellette and colleagues (2012) demonstrated that 58% of students who had a BMI less than 25 $kg/m^2$ also consumed foods higher in micronutrients and participated in vigorous activity regularly (at least 30 minutes of brisk walking a day).

## Gender Specific Consumption

Energy, and micro- and macronutrient intakes vary with gender. This is congruent with differing intake recommendations for men and women based on their gender,  age, activity, and weight. Many studies indicate that women generally have better eating habits than men based on higher daily or weekly fruit and vegetable consumption (El-Ansari et al., 2012; Hendricks et al., 2004; LaCaille et al., 2011; Perera & Madhujith, 2012).

Ouellette and colleagues (2012) found that females consumed more fruits and vegetables, meeting most DRIs; however, they did not meet the DRIs for vitamin D and vitamin E. Approximately 96% of women were below the recommendation for vitamin D, and 84% were below the recommendation for vitamin E (Ouellette et al., 2012). Men, however, reported consuming more foods that were higher in fat and protein (Ouellette et al., 2012). Similar results were observed in studies by El-Ansari, Stock, and Mikolajczyk (2012) and Perera and Madhujith (2012). Overall, males consumed higher percentages of fat (19%) and protein (34%) than females, who consumed 15% and 32%, respectively (Ouellette et al., 2012).

## Interventions

In an attempt to lower the number of nutrient deficiencies among Americans, the United States Department of Agriculture created the MyPlate visual to show what the ideal meal should look like on a dinner plate (United States Department of Agriculture, 2011). The MyPlate Supertracker tool provides individualized guidance on the amounts of proteins, dairy, carbohydrates, fruits, and vegetables that should be consumed. The recommendations for fruits, vegetables, dairy products, and whole grains were set at a level believed to prevent development of chronic disease. Failing to consume the recommended amounts of these food groups could lead to micro-nutrient deficiencies and the development of chronic diseases (McLean-Meyinsse et al., 2013) such as multiple sclerosis (Torkildsen et al., 2013), osteoporosis (Ahmadieh & Arabi, 2011), cancer (CDC, 2013), and autoimmune diseases (Litonjua, 2012).

College students are an ideal population to target to improve health because they have opportunities to take wellness classes, be involved in clubs, and participate in activities that promote healthy lifestyles that could reduce the risk of developing chronic diseases as they age (Brevard & Ricketts, 1996; von Bothmer & Fridlund, 2005). Possible activities to increase student awareness include projects for lecture classes assessing dietary intake before nutrition education and after by analyzing specific micro- and macronutrients. A holistic approach could use campus wide activities with poster boards and prizes to promote involvement, or involving the dining centers by posting nutritional information. These opportunities allow students to learn about nutrition and creating a healthy diet. Increasing awareness of the DRIs the importance of meeting them could influence dietary intake by teaching students the importance of meeting micronutrient recommendations.

**Dietary Intake Assessment Methods**

There are several methods that could be used to evaluate dietary intake. Most studies have used food frequencies and surveys to determine dietary intake. Food frequency questionnaires (FFQ) are more commonly used to assess dietary intake among larger populations; moreover, they are easier to administer and evaluate. When using a FFQ, participants self-report an estimation of how often they consume foods on a list over a specified length of time as well as the portion size--small, medium, or large—in comparison to a reference portion. One downfall to using FFQs is the amounts of foods consumed is estimated, not recorded; therefore, the amount of nutrients consumed cannot be determined accurately (Nelson & Story, 2009). However FFQs can be created and adjusted by the research team to assess specific foods or food groups. For example, Musingo and Wang (2009) administered a 132-item FFQ to 212 university students in Florida. They used a FFQ that has been previously tested by a Rockett, Wold and Colditz (1995) to ensure the FFQ was valid and reliable. This was a self-administered questionnaire that was designed for children aged 9-18: It is called the Youth/Adolescent Questionnaire (YAQ).

Another example of a dietary intake assessment method is creating and using surveys. McLean-Meyinsse et al. (2013) sampled 305 college students who completed a series of questions such as knowledge about vitamins, frequency of reading labels, frequency of consuming fruits and vegetables, perception of health and weight, physical activity, and demographic characteristics. Freedman (2010) also used a survey method in which he sent 756 students a campus email inviting them to take the survey on www.Surveymonkey.com (www.surveymonkey.com, Portland, OR). The questionnaire asked for the individual's gender, living arrangements, height, weight, and dietary intake. A limiting factor to Freedman's (2010) study was that she did not obtain information on specific amounts of consumed. Therefore full dietary analysis for nutrient content was not possible.

Ouellette and colleagues (2012) examined the dietary intake of 44 students who completed the entire 30-day food record. Food records were submitted to the research team to be analyzed using Nutrition Data System for Research (NDSR) 2009,developed by the Nutrition Coordinating Center, University of Minnesota (Minneapolis, MN). The NDSR output included nutrients with defined by a DRI recommendations (Ouellette et al., 2012).

**Conclusion**

Several studies have emphasized the importance of nutritional knowledge to promote bone density (El-Qudah et al., 2008; Freedman, 2010; McLean-Meyinsse et al., 2013; Musingo &

Wang, 2009; Torkildsen et al., 2013), to support a healthy immune system (El-Qudah et al., 2008; Holick et al., 2011; Litonjua, 2012), and to prevent chronic diseases (Litonjua, 2012) such as multiple sclerosis (Torkildsen et al., 2013), and many other diseases. However, research currently shows few reports that include dietary intake of fat-soluble vitamins among college students, and to date no studies have been identified demonstrating whether college students are meeting the DRI for fat-soluble vitamins.

Most studies utilize FFQs or other survey methods to measure vitamin intake of college students; however, none have used a 72-hour food record to assess specific nutrients. Freedman (2010), Hendricks et al., (2004), and Ouellete et al., (2012) are a few studies that have examined the relationship between dietary intake of college students and living arrangements, activity, and BMI. Therefore, by analyzing a 72-hour food record, this study could provide a better understanding whether college students are meeting the DRI for fat-soluble vitamins and explore the various factors that influence fat-soluble vitamin intake. Because this study uses food records, it is able to use a nutrition database to analyze specific nutrient intake of college students.

# METHODS

The purpose of this study was to assess dietary intake of fat-soluble vitamins among undergraduate college students by comparing an average of their 72-hour dietary intake to the Dietary Reference Intakes (DRI) based on gender, age, physical activity, and BMI. This study was approved by the Institutional Review Board for the Protection of Human Participants in Research at North Dakota State University (See Appendix).

## Study Population and Design

This cross-sectional study was conducted among 352 undergraduate college students (ages 18-30 years) at a Midwestern University using a micronutrient printout from NutritionCalc during the spring of 2014. As reported in Fall of 2013, the demographics of the undergraduate student population at this university were 86.85% of White, 0.68% American Indian/Alaskan, 1.30% Asian, 2.57% African American, 0.04% Hawaiian/Pacific Islander, 1.44%Hispanic and 3.80% non-resident alien (Asian, White, Hispanic, 2 or more races and not specified) (North Dakota State University-Ethnicity Data, 2014). Participants were enrolled in either Concepts of Fitness & Wellness (HNES 100) or Wellness (HNES 111). These classes met the general wellness education requirements for all majors offered at North Dakota State University providing a large sample with a wide variety of majors. As part of the class curriculum, students were instructed to complete a 72-hour food record consisting of two usual weekdays and one usual weekend day. Students self-reported their physical activity and entered their food record into a dietary software analysis program, NutritionCalc (version 2010, McGraw-Hill Global Education Holding, LLC) which then provided the final analysis. NutritionCalc provides recommendations for energy and micronutrient needs based on an individual's physical activity, age and gender. NutritionCalc also, analyzes dietary intake to determine caloric and nutrient adequacy in relation to DRI recommendations.

The research team instructed each section of the wellness classes measuring and estimating portion sizes. The students were then shown how to correctly enter foods/beverages into the NutritionCalc software. At the end of this lecture, the researchers took approximately 10 minutes of the class period to briefly explain the research study, answer any questions, and obtain informed consents. The instructor of the course also taught a nutrition lecture to the class on general nutrition. This assignment was then due after both nutrition lectures. Participation in this study was voluntary, and students were not penalized for non-participation. All study components were part of the class assignments except for the frequency of attending the residence dining centers. Students were asked to indicate frequency of dining hall use on the back of the informed consent, reporting how many times they ate on campus per week. Students who declined to participate in this research still had to complete the food and activity record and diet analysis.

Only students who successfully completed their nutrient evaluation based on a 72-hour period over the course of two weekdays and one weekend day were included in the study. Exclusions were students who did not comply with the two weekday and one weekend day instruction, did not include 72-hours as part of their food record, or analyses that had outlying information such as a very low caloric intake (<700 calories per day) or high caloric intake (>7,000 calories per day).

**Dietary Assessment**

The NutritionCalc database includes over 27,000 foods from ESHA Food Processor (Portland, OR, Version 2014). ESHA is the developer and owner of NutritionCalc. Participants chose one of four activity levels available in NutritionCalc. The bar graph report from the nutrient analysis in NutritionCalc was used to gather data. The following data was included in the print out: age, gender, BMI, activity level, and nutrient values. NutritionCalc calculated BMI based on the participants' self-reported height and weight. Vitamin K was not on the nutrient print out; therefore, vitamin K was not assessed in this study.

**Statistical Analysis**

Descriptive tests, t-tests, Pearson's chi-square tests, regression, and ANOVA were completed using MiniTab 17 Statistical Software (State College, PA, 2011). Statistical significance was set at $p<0.05$. For categorical comparisons, a Pearson's chi-square test was performed to determine statistical significance. Regression analysis was performed using backward elimination regression analysis with all of the indicators (age, gender, activity, caloric intake, percentage of calories from fat, vitamin A, vitamin D, and vitamin E) and narrowed each down by eliminating any indicator with a p-value greater than 15%.

A summary of demographics from all participants' gender, age, level of activity, BMI, and frequency of eating at the dining hall was assessed. The summary included mean, standard deviation, and ranges for the categories listed above. Descriptive statistics and ANOVA were completed on the fat-soluble vitamins A (mcg), E (mcg) and D (mcg), which was then compared to DRIs, gender, BMI and level of physical activity.

# BODY MASS INDEX, ACTIVITY, GENDER AND FAT-SOLUBLE VITAMINS AMONG COLLEGE STUDENTS


## Abstract

**Objective**: Fat-soluble vitamins are essential for the body to function and aid in the prevention of chronic diseases. The goal of this study was to examine if demographic characteristics such as gender, body mass index (BMI), and physical activity would predict a adequate intake of the fat-soluble vitamins A, D, and E. **Participants**: Three hundred and fifty-two students (212 males and 140 females; mean age 19.3 ± 1.6) enrolled in an introductory course at a Midwestern university. **Methods**: Students completed a dietary analysis of a self-reported 72-hour food record. Pearson's chi-square tests, t-tests, and regression were used to show relationships between fat-soluble vitamin intake and demographics. **Results**: Few students met the DRI for the fat-soluble vitamins A (21%), D (3%), and E (7%). However, students who had a higher BMI were more likely to meet vitamin D DRI. Students who were more physically active had a higher vitamin A intake. Vitamin E was not shown to be significant related to the study variables. Students meeting recommended calorie intake are more likely to meet the DRI for fat-soluble vitamins than those who do not meet the recommended calorie intake.


## Introduction

Consuming a healthy diet and engaging in physical activity can help prevent several health conditions such as obesity, heart disease, diabetes, some cancers, and other chronic diseases (CDC, 2013). A diverse and balanced diet will provide micro- and macronutrients in order to maintain normal body processes and promote optimal health.

The Dietary Reference Intakes (DRI) are daily guidelines for micro- and macronutrients needed for most healthy individuals. These recommendations were created to prevent nutritional deficiencies and reduce the risk of developing chronic diseases such as diabetes (CDC, 2013), osteoporosis (Ahmadieh & Arabi, 2011), and some cancers (CDC, 2013). Before the DRIs were developed, the Food and Nutrition Board established the Recommended Dietary Allowances (RDAs) in 1941 to prevent nutrient deficiencies that might influence nutritional national defense (Harper, 2003). Then in 1993 the Food and Nutrition Board developed DRIs that would include four types of nutrient recommendation for healthy individuals: adequate intake (AI), estimated average intake (EAR), RDA and upper tolerable level (UL) (Harper, 2003). The current recommendation for fat-soluble vitamin (A, D, and E) are as follows: vitamin A 700 mcg/day for females, 900 mcg/day for males, vitamin D 15 mcg/day for both males and females, and vitamin E 15 mcg/day for males and females (Institutes of Medicine, 2011).

Fat-soluble vitamins are essential to the body and key to preventing several chronic diseases including multiple sclerosis (Torkildsen, Løken-Amsrud, Wergeland, Myhr, & Holmøy, 2013), osteoporosis (Ahmadieh & Arabi 2011), some cancers, and autoimmune diseases (Litonjua, 2012). Consuming recommended amounts of fat-soluble vitamins throughout life may decrease the likelihood of developing chronic diseases and promote a longer, healthier life (Winkleby & Cubbin, 2004).

Dietary habits develop at a young age and have a long-term impact on overall health throughout an individual's lifetime (Litonjua, 2012). Therefore, it is imperative that children and young adults practice healthy dietary habits early in order to decrease the risk of chronic disease later in life (Litonjua, 2012). Nevertheless, when an adolescent transitions from home to a college environment, environmental changes affect their living situations, social encounters, and dietary intake. Freedman (2010) examined the changes in food choices among young adults during these transition times, in which a student went from living at home with a parent or guardian to becoming a college freshman and living on their own (Freedman, 2010). Freedman (2010) found that when students lived at home, the young adult generally had meals provided for them by their parent(s).

Adulthood is marked by characteristics involving the developmental experiences: graduating high school, leaving the parental home, moving to college, finding a job, becoming financially independent, getting married, and having a family. Recent analysis of Americans, British, and Australian students has suggested that young adults are neither prolonging their youth nor experiencing a new chapter in life. Instead, they are simply adjusting to their surrounding and simply learning new coping strategies (Wyn, 2004).

The transition from adolescence to adulthood is where young adults gain independence (Branowski, Cullen, & Basen-Enquist, 1997; Ouellette et al., 2012; Šatalic,´ Baric, & Keser, 2007); however, according to Wyn (2004) these students may not be switching roles but simply adjusting to their surroundings. This transition is an important time to provide nutritional interventions to address dietary intake, because a majority of students have been found to choose quick easy methods for food such as fast food (Freedman, 2010).

During this time of newly gained independence, students are at high-risk for becoming obese due to increased consumption of fast food and prepackaged meals (Larson, Neumark-Sztainer et al., 2008). Students are “free” to eat whatever they choose once they move out of their parental home, which is why it is important to implement health promotion (LaCaille, Dauner, Krambeer, & Pederson, 2011) and disease prevention programs during this time. Uncontrolled eating leaves students more susceptible to weight gain and may decrease their motivation to learn about healthy eating. (Nelson, Story, Larson, Neumark-Sztainer, & Lytle, 2008).

Within the first year of attending a college or university, students may be required to take at least one general wellness class. Required coursework is an ideal way for all students who are living independently for the first time in their lives to have access to health promotion education. Healthy lifestyle skills may help reduce the risk of developing chronic diseases (Brevard & Ricketts, 1996; von Bothmer & Fridlund, 2005) and teach students about healthful eating practices. With these classes, students should become aware of the risks associated with not meeting DRIs, and how a healthful diet could improve their well being and specifically, how to prevent chronic diseases.

Body mass index (BMI) is an adult ratio of weight to height that classifies a person as underweight, normal, overweight or obese. This equation is a person's weight in kilograms divided by the square height in meters ($kg/m^2$) (World Health Organization, 2004). According to the World Health Organization, a BMI of $\geq 25$ to 29.9 $kg/m^2$ is considered overweight and BMI of $\geq 30$ $kg/m^2$ is considered obese. BMI values are age independent for both sexes. Once the BMI classification increases, a person is perceived at a greater risk for developing chronic diseases such as diabetes, hypertension, and other chronic diseases.

In an attempt to associate BMI with physical activity in young adults, Hendricks, Herbold, and Fung, (2004) found that individuals who were more physically active ate more nutrient dense diets. In addition, Hendricks and colleagues (2004) determined that BMI had a positive correlation with the percent of energy from saturated fat and decreased fiber intake. Ouellette and colleagues (2012) found that 58% of young adults with a BMI $< 25$ $kg/m^2$ ate foods higher in micronutrients and participated in vigorous activity regularly such as at least 30 minutes of brisk walking daily.

Many studies have assessed dietary intake of children and adults, overlooking college aged students (Nelson et al., 2008). The purpose of this study was to assess college students' dietary intake of fat-soluble vitamins and determine adequacy of their intake compared to the DRI. An additional purpose was to determine if gender, level of activity, BMI, caloric intake, percent of calories from fat and other fat-soluble vitamins influenced intake of a specific fat-soluble vitamin.

**Methods**

The university's Institutional Review Board for the Protection of Human Participants in Research approved this study. This cross-sectional study assessed fat-soluble vitamin intake among 352 traditional college students (ages 18-30 years) who were recruited during spring, 2014 from two general education wellness courses at the university. All students enrolled in these courses were eligible to participate, thus providing a wide range of majors and behaviors.

Researchers attended each course section to demonstrate the correct way to measure or estimate food portions utilizing teaspoons, tablespoons, cups, and ounces in relation to commonly known items. At the end of the demonstration, students 18 years of age or older were invited to complete the informed consent. No incentives were given for participation. As a class assignment, students were instructed to complete a 72-hour food record (three consecutive days covering two weekdays and one weekend day). Students were asked to choose days that were similar to their usual activity and food consumption patterns. Students created a student profile by entering their weight, height, age, activity level, and gender using NutritionCalc (version 2010, McGraw-Hill Global Education Holding, LLC). NutritionCalc calculated BMI using the height and weight that was entered.

Students then entered the foods they had recorded in the 72-hour food record. The NutritionCalc database includes over 27,000 foods from ESHA Food Processor (Oregon, Version 2014). ESHA is the developer and owner of NutritionCalc, which is a reliable and valid tool for data analysis. NutritionCalc considers age, BMI, and activity level to determine recommended calories, but calculates actual calories, fat (g), vitamin A (mcg), vitamin D (mcg), and vitamin E (mcg) as well as other recommendations based on DRIs. The nutrient analysis in NutritionCalc included a bar graph, from which was used to obtain amounts consumed. All students who completed the nutrient analysis were included since no student met the exclusions of <700 calories and >7,000 calories for the 72-hour average.

BMI was divided into three categories: normal (18.5-24.9 $kg/m^2$), overweight (25-29.9 $kg/m^2$) and obese (≥30 $kg/m^2$). To ensure adequate numbers for statistical analysis, two participants who were < 18.5 $kg/m^2$ were included in the normal category of BMI. Physical activity categories were also collapsed into three levels: lightly active, active, and very active. Four students reported being sedentary, so they were added to the lightly active category to provide appropriate proportions for statistical analysis.

Descriptive statistics, t-tests, Pearson's chi-square tests, regression and ANOVA were completed using MiniTab 17 Statistical Software (State College, PA, 2011). Statistical significance was set at $p<0.05$. For categorical comparisons, a chi-square was performed to determine statistical significance. Chi-square test was ran unless cell counts were below 5, 80% of the time in which Fishers Exact Test was ran by a statistical program R (version 2.15.1, Vienna, Austria, 2012). Regression analysis was performed using backward elimination regression analysis with all of the indicators (age, gender, activity, caloric intake, percentage of calories from fat, vitamin A, vitamin D, and vitamin E) and narrowed each down by eliminating any indicator with a p-value greater than 15%. The regression allows us to predict vitamin intake from given indicators. While it does not allow us to determine whether a vitamin DRI will be met simply by whether an indicator is met or not, it does provide us an opportunity to identify which indicators are significant predictors of fat-soluble vitamin intake.

**Results**

Descriptive characteristics of the participants are listed in Table 2 including the mean recommended calorie intake, actual calories consumed, fat (g), percentage of calories from fat, vitamin A (mcg), vitamin D (mcg), and vitamin E (mcg). There were 352 respondents (212 men, 140 women) with a mean age of 19.3 ± 1.6. Males were slightly older than females. Gender comparisons showed 56% of participants of males were younger than 20 years old and 92% of females were younger than 20 years old.

Most students were classified as normal weight (n=245, 69.6%), 82 (23.3%) students were overweight and with only a few students were classified as obese (n=25, 7.1%). Most students were either lightly active or active (289, 82.7%). The recommended mean calorie intake was 2829 ± 858. As expected males had a higher recommended caloric intake (3316 ± 662) than females (2092 ± 525). The actual calories consumed were significantly lower. Overall, mean actual intake was 1996 ± 778. Males consumed on average 2306 ± 794 calories whereas females consumed 1526 ± 451 calories. Although the calorie consumption was below the recommended amount, the percent of calories from fat were within recommendation (20-35%). The mean percent of calories for fat were 31.3% ± 6.8% (males 31.2% ± 7.1%; females 29.8% ± 6.0%).

Table 2.
*Demographics, Age, Gender, Body Mass Index, Activity Status, Intake of Calories and Fat-Soluble Vitamins of Study Participants.*

| Characteristic | Total n = 352 | Men n = 212 (60.3%) | Women n = 140 (39.7%) | p value |
|---|---|---|---|---|
| Age (years) | 19.3 ± 1.6 | 19.5 ± 1.9 | 18.9 ± 1.0 | 0.001 |
| BMI[1] | | | | |
| 18.5-24.9 kg/m$^2$ | 245 (69.6%) | 142 (67%) | 103 (73.5%) | 0.04 |
| 25.0-29.9 kg/m$^2$ | 82 (23.3%) | 49 (23.1%) | 33 (23.6%) | |
| ≥30 kg/m$^2$ | 25 (7.1%) | 21 (9.9%) | 4 (2.9%) | |
| Activity | | | | |
| Light Activity | 122 (34.7%) | 63 (29.7%) | 59 (42.1%) | 0.05 |
| Active | 169 (48.0%) | 108 (50.1%) | 61 (43.6%) | |
| Very Active | 61 (17.3%) | 41 (19.4%) | 20 (14.3%) | |
| Recommended Calories | 2829 ± 858 | 3316 ± 662 | 2092 ± 525 | <0.001 |
| Actual Caloric Intake | 1996 ± 778 | 2306 ± 794 | 1526 ± 451 | <0.001 |
| Fat (g)[2] | 70 ± 33.4 | 82.7 ± 35.0 | 50.4 ± 18.8 | <0.001 |
| % calories from Fat | 31.3% ± 6.8% | 32.2% ± 7.1% | 29.8% ± 6.0% | 0.001 |
| Vitamin A (mcg)[3] | 550 ± 492 | 602 ± 539 | 471 ± 400 | 0.01 |
| Vitamin D (mcg) | 4.4 ± 4.5 | 5.1 ± 5.04 | 3.24 ± 3.16 | <0.001 |
| Vitamin E (mcg) | 5.2 ± 6.2 | 5.3 ± 5.80 | 5.1 ± 6.81 | 0.76 |

[1] BMI = body mass index; calculated as kg/m$^2$
[2] g = grams
[3] mcg = micrograms

Fat-soluble vitamin intake varied among males and females; however, the DRI for vitamin A was more likely to be met. Unlike the other fat-soluble vitamins, vitamin A has gender specific recommendations, where the DRI for males is 900 mcg whereas the DRI for females is a lower dose of 700 mcg (19-30 years old). Overall, mean vitamin A intake was 550 ± 492 mcg (males 602 ± 539 mcg, females 471 ± 400 mcg). Vitamin D recommendation is 15 mcg a day for both males and females (19-30 years old). The mean consumption of vitamin D among all participants was 4.4 ± 4.5 mcg, with males having a higher consumption of 5.1 ± 5.04 mcg than females 3.24 ± 3.16 mcg. Vitamin E also has the recommendation of 15 mcg a day for both genders (19-30 years old). Students had an average vitamin E consumption of 5.2 ± 6.2 mcg.

Unlike vitamin D, the males and females were relatively similar in their vitamin E consumption (males 5.3 ± 5.80 mcg; females 5.1 ± 6.81 mcg).

Pearson's chi-square analysis of the BMI categories with gender showed that males were more likely to be obese. Of all normal and overweight students participated in this study, 58% were male, and approximately 84% of all obese students were male. This is a very large gap between the percentage of male and female students who were obese.

Because little is known about the transition from home to college life and how exercise habits are altered (Han, Dinger, Hull, Randal, Heesch, & Fields, 2014), it was useful to assess the activity record completed by students This study showed that 58% of all lightly active students were male, while almost 65% of active/very active students were male.

As seen in Table 3, of those students consuming greater than 75% of their recommended caloric intake, 53% were male, while 65% of those consuming less than 75% of their recommended caloric intake were female. The percentage of male and female students consuming close to or above the recommended intake of calories were about the same; however, a higher percentage of males were not consuming at least 25% of their estimated caloric needs. This could be due to the differences in eating habits between males and females.

As seen in Table 3 almost all students (males 96.2%, females 92.8%) met or exceeded the DRI (n= 234) for percent of calories from fat. No females (0%) had lower than 75% of their DRI for percent calories from fat intake, while only 1.9% of male percent of calories from fat was lower than 75% of DRI.

Table 3.

*Number and Percent of Participants Who Met and Did Not Meet Recommended Intake of Calories, Percent Calories from Fat and Fat Soluble-Vitamins.*

| Nutrient | Met Recommendation | | Exceeded Recommendation | | 75%-99% Recommendation | | 50%-74% Recommendation | | <50% Recommendation | |
|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F |
| Caloric Intake | 13 (6.2%) | 11 (7.8%) | 20 (9.4%) | 8 (5.7%) | 39 (18.4%) | 45 (32.1%) | 100 (47.2%) | 54 (38.6%) | 40 (18.9%) | 22 (15.7%) |
| % Calories from fat[1] | 127 (59.9%) | 107 (76.4%) | 77 36.3% | 23 (16.4%) | 4 (1.9%) | 10 (7.1%) | 3 (1.4%) | 0 (0%) | 1 (0.5%) | 0 (0%) |
| Vitamin A[2] | 41 (19.3%) | 31 (22.1%) | N/A | N/A | 30 (14.1%) | 15 (10.7%) | 41 (19.3%) | 31 (22.1%) | 100 (47.2%) | 63 (45%) |
| Vitamin E[3] | 16 (7.5%) | 9 (6.4%) | N/A | N/A | 5 (2.4%) | 3 (2.4%) | 18 (8.5%) | 10 (7.1%) | 173 (81.6%) | 118 (84.2) |
| Vitamin D[3] | 10 (4.7%) | 1 (0.7%) | N/A | N/A | 3 (1.4%) | 2 (1.4%) | 36 (17%) | 10 (7.1%) | 163 (76.9%) | 127 (90.7%) |

[1] DRI for % calories from fat is 20-35%

[2] DRI for females is 700 mcg and 900 mcg for males.

[3] DRI is 15 mcg.

Few students met the DRI for the fat-soluble vitamins A (21.3%), D (3%), and E (7%). More students met the DRIs for vitamin A (21.3%) than any other vitamin. As seen in Table 3, only 11 students (3.1%) met the DRI for vitamin D. When assessing mean individual intake of vitamin D, almost all (males, 95% and females 98%) were below 75% of their recommended intake.

Pearson's chi-square analysis showed no significant relationships when comparing gender and meeting the DRI of vitamin A, D, or E. Moreover, there were no significant relationships between age and meeting the DRI of vitamin A or D. However, when dividing by age groups into those younger than 20 and those older than 20, 5% of the younger group met the DRI for vitamin E, compared to 13% for the older group ($p = 0.01$).

As seen in Figure 1, most normal weight students consumed very little vitamin D with only 2% meeting DRI; however, those who were overweight or obese were more likely to consume vitamin D at recommended levels (7%, $p = 0.02$). Nevertheless, intakes of almost all students (96%) were well below recommended levels.

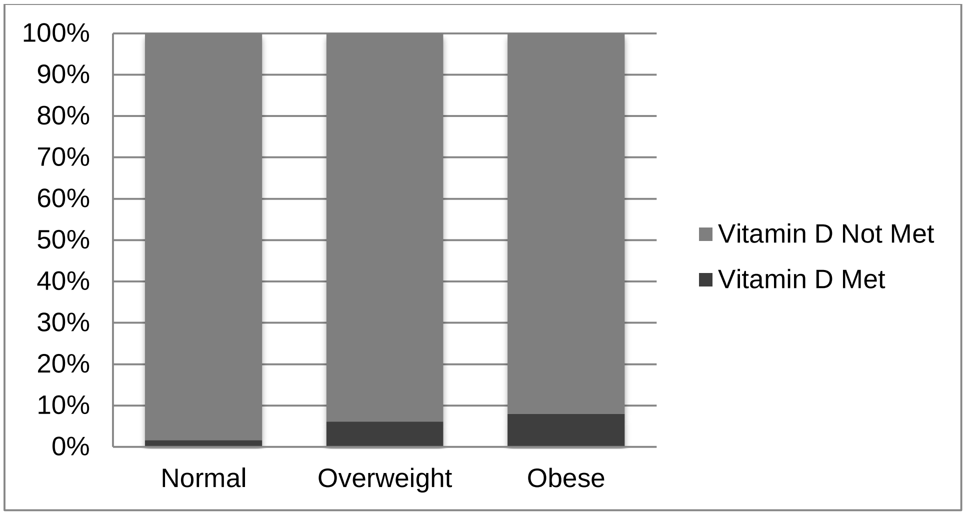


Figure 1. *Percentage of Students Who Met Vitamin D Recommendation at Various Weight Classifications*

As seen in Figure 2 and 3, chi square analysis showed that physical activity was significantly related to both vitamin A and vitamin E. Approximately 16% percent of lightly active and active met the DRI for vitamin A; however, 38% of those who were very active met the DRI for vitamin A ($p = 0.001$).

The link between vitamin E and physical activity does not appear to be as relational. A larger percent (11%) of active students met the DRI for vitamin E, whereas only 2% of lightly active and 7 % of very active met the DRI for vitamin E ($p = 0.03$).

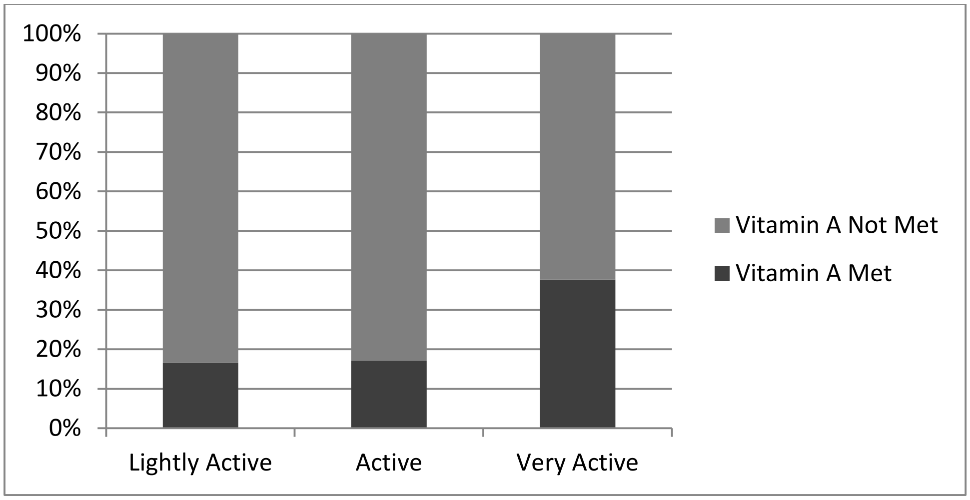


Figure 2. *Percentage of Students Who Met Vitamin A Recommendation at Various Levels of Physical Activity*

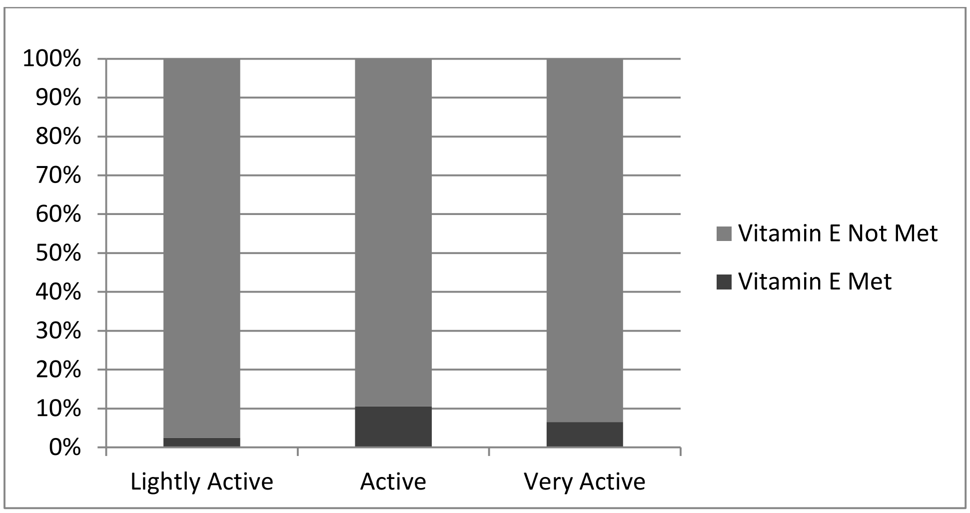


Figure 3. *Percentage of Students Who Met Vitamin E Recommendation at Various Levels of Physical Activity*

Of the students who met caloric intake recommendations, 37% met the DRI for vitamin A, while only 11% of those not meeting caloric intake met DRI for vitamin A ($p < 0.001$). This shows a direct relationship between meeting the DRI of vitamin A and consuming the recommended caloric intake. Of those students who met caloric intake recommendations, 13% met DRI for Vitamin D while only 1% of those students not meeting caloric intake met DRI for vitamin D ($p < 0.001$). Of those students who met caloric intake recommendations, 13% met DRI for vitamin E while only 6% of those students not meeting caloric intake met DRI for vitamin E ($p = 0.05$). This trend shows that students meeting recommended calorie intake were more likely to meet the DRI for fat-soluble vitamins than those who did not meet the recommended calorie intake.

Out of this sampled student population only 3 (<1%) of students, all males, met all three DRIs for the fat-soluble vitamins. Using BMI categories, two of the three were classified as overweight and the remaining one was classified as obese. Despite their high BMI classification, two were active, and one was highly active.

Regression analysis showed that Vitamin A intake was linked to gender, activity, caloric intake, and vitamin D intake. Gender, caloric intake, vitamin E intake, percent of calories from fat, and vitamin A intake significantly influenced Vitamin D intake. While there did not appear to be any significant relationship between meeting vitamin intake and percent of calories from fat, there is an influence on vitamin D as seen in the regression analysis. Finally, vitamin E intake was significantly influenced by gender, activity, caloric intake and vitamin D intake. Gender and caloric intake had an influence on all three vitamins. Activity, vitamin D and vitamin E intake also were shown to have influence on multiple vitamins. It appears that age has little influence on consuming foods that are high in fat-soluble vitamins.

**Discussion**

Using results of a 72-hour food record, this study assessed dietary intake of fat-soluble vitamins in college students. Previous studies used food frequency questionnaires (Hendricks et al., 2004; McLean-Meyinsse, Harris, Taylor, & Gager, 2013; Musingo & Wang, 2009; Perera & Madhujith, 2012). Others (Hampl & Betts, 1995; Mitzmeser, Giraud, & Driskell, 2000) used multiple 24-hour recall analysis where specific nutrients were identified as either meeting or not meeting DRI. Other studies assessed general dietary intake (Freedman, 2010; Ouellette et al., 2012). Unlike other studies, this study specifically assessed intake of the fat-soluble vitamins A, D, and E among college students using 72 hour food records.

Overall, this study found that most students did not meet the DRI for the fat-soluble vitamins A, D, and E. Moreover, most students did not meet the recommended caloric intake but most met or exceeded the recommended percentage of fat (20-35%). Particularly noteworthy is that 100 students (28.4%) consumed more than 35% of their total calories from fat. However, if students met their caloric recommendations, they would more likely meet the DRI for fat-soluble vitamins. Students with a higher BMI met the DRI for vitamin D more frequently; however, most of the students still did not meet their DRI for all fat-soluble vitamins. This is critical for the younger population because the longer an individual is below recommended level of intake, the more likely that individual will develop a chronic disease.

Physical activity showed a positive relationship among very active students and meeting the DRI for vitamin A, while active and very active students were more likely to meet the DRI for vitamin E. All vitamins have a positive relationship with the intake of the other fat soluble vitamins: students who meet one vitamin had a greater chance of having a well-rounded diet; and therefore, they had an increased likelihood of meeting the DRI for the other two fat-soluble vitamins.

One hundred students (28%) consumed more than 35% of calories from fat. This may suggest a high fat diet or that students are not aware of what they are eating. However, when assessing their fat-soluble vitamin intake, students were not getting those vitamins from the fats they consume; therefore, they may not be eating healthy fats. A large number of students consumed at least 20% of calories from fat. However, <20% met their DRI for vitamin A and only three students met the DRI for all three fat-soluble vitamins (A, D, and E).

Studies have shown that women are generally more concerned about the foods they consume compared to men. Research has shown that women generally consume more fruits, vegetables and nutrient dense foods than males (El-Ansari et al., 2012; Hendricks et al., 2004). Results from this study showed that females were more likely to meet the recommended caloric intake whereas males were about 1000 calories short when comparing recommended versus actual intake. The calorie deficit observed in males would lead one to expect a relatively lower intake of fat-soluble vitamins, since eating fewer calories may also decrease vitamin intake. However, even though male caloric intake was about 1000 calories less than the recommended, males were more likely to meet their vitamin A intake and had higher mean intake of vitamin D and E. Females, were closer to meeting their recommended calories and were closer to meeting their vitamin A intake. However, females require fewer calories; therefore, they should be consuming a more nutrient dense diet.

There are several limitations to this study. All data was self-reported, increasing the risk for over reporting or under reporting of intake; students' misreporting a higher activity level, or misreporting their body weight and height to make health practices look better than what they really are. Moreover, students may not have realized that they were not recording the information accurately. BMI also has limitations since factors, such as amount of muscle compared to fat, can create a higher BMI. When performing chi – square tests, some of the vitamin values were very low, so either information was pooled to allow for expected values greater than five or was not included as it may not be significant if no pooling was done. The amounts of individual foods consumed during the study were not examined in relationship to the calories and nutrient content, which would be useful for further studies in assessing whether students are choosing higher nutrient dense foods or not.

**Conclusion**

Over two thirds of the students did not meet 50% of the DRI recommendations for fat-soluble vitamins A, D and E with <1% meeting the DRI for all three fat-soluble vitamins. This is critical because low intake of fat-soluble vitamins can lead to increased risk of chronic diseases. Low vitamin D intake is particularly alarming because of the critical role it plays in body functions and to protecting against disease. (LaCaille et al., 2011; Perera & Madhujith, 2012).

Results of this study highlight the significant need for nutrition education as a part of college curriculums. Providing college students with information that could influence their health now and in the future may help decrease the risk of chronic disease as they age. Students need to learn knowledge and skills to choose foods that are more nutrient dense. This will help ensure they are meeting their nutrient needs. As these young adults continue to mature, making good nutritional choices will increase health and well-being. Choosing healthy foods may not be easy. If provided with the correct information, it may become easier for a person to make healthy choices for their daily lives.

**References**

Ahmadieh, H., & Arabi, A. (2011). Vitamins and bone health: beyond calcium and vitamin D. *Nutrition Reviews*, *69*(10), 584-598. Doi:10.1111/j.1753-4887.2011.00372.x

Branowski, T., Cullen, K.W., & Basen-Enquist, T. (1997) Transitions out of high school: time of increased cancer risk? *Preventive Medicine*, *25*, 694-703.

Brevard, P. B., & Ricketts, C. D. (1996). Residence of college students affects dietary intake, physical activity and serum lipid levels. *Journal of the American Dietetic Association, 96*(1), 35-38.

Centers for Disease Control and Prevention (CDC). (2013). Prevention status reports. Retrieved from http://www.cdc.gov/stltpublichealth/psr/npao/index.html.

El-Ansari, W. W., Stock, C. C., & Mikolajczyk, R. T. (2012). Relationships between food consumption and living arrangements among university students in four European countries - a cross-sectional study. *Nutrition Journal*, *11*(28), (24 A.

Freedman, M. R. (2010). Gender, residence and ethnicity affect freshman BMI and dietary habits. *American Journal of Health Behavior, 34*(5), 513-524.

Hampl, J. S., & Betts, N. M. (1995). Comparisons of dietary intake and sources of fat in low- and high-fat diets 18- to 24-year-olds. *Journal of the American Dietetic Association. 95*(8), 893-897.

Harper, A.E. (2003). Contributions of women scientists in the U.S. to the development of Recommended Dietary Allowances. *Journal of Nutrition*, *133*(11): 3698–702.

Hendricks, K. M., Herbold, N. N., & Fung, T. T. (2004). Diet and other lifestyle behaviors in young college women. *Nutrition Research, 24*(12), 981-991. Doi:10.1016/j.nutres.2004.09.004.

LaCaille, L. J., Dauner, K. N., Krambeer, R. J., & Pedersen, J. (2011). Psychosocial and environmental determinants of eating behaviors, physical activity, and weight change among college students: a qualitative analysis. *Journal of American College Health, 59*(6), 531-538. doi:10.1080/07448481.2010.523855

Larson, N. I., Neumark-Sztainer, D. R., Story, M. T., Wall, M. M., Harnack, L. J., & Eisenberg, M. E. (2008) Fast food intake: longitudinal trends during the transition to young adulthood and correlates of intake. *Journal of Adolescent Health, 43*(1), 79-86.

Litonjua, A. A. (2012). Fat-soluble vitamins and atopic disease: what is the evidence?. *Proceedings of the Nutrition Society*, *71*(1), 67-74. Doi:10.1017/S002966511100334X.

McLean-Meyinsse, P. E., Harris, E. G., Taylor, S. S., & Gager, J. V. (2013). Examining college students' daily consumption of fresh fruits and vegetables. *Journal of Food Distribution Research*, *44*(1), 10-16.

Mitzmeser, S. H., Giraud, D. W., & Driskell, J. A. (2000). Dietary and plasma levels of carotenoids, vitamin E, and vitamin C in a group of young and middle-aged nonsupplemented women and men. *Nutrition Research, 20*(11), 1537-1546.

Musingo, M. N., & Wang, L. H. (2009). Analysis of eating habits according to socio-demographic characteristics of college students. *Pakistan Journal of Nutrition*, *8*(10), 1575-1580.

Nelson, M. C., Story, N., Larson, N. I., Neumark-Sztainer, D., & Lytle, L. A. (2008). Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. *Obesity, 16*(10), 2205-2211.

Ouellette, C. D., Yang, M. M., Wang, Y. Y., Yu, C. C., Fernandez, M. L., ….. Chun, O. K. (2012). Assessment of nutrient adequacy with supplement use in a sample of healthy college students. *Journal of the American College of Nutrition*, *31*(5), 301-310.

Perera, T. T., & Madhujith, T. T. (2012). The pattern of consumption of fruits and vegetables by undergraduate students: a case study. *Tropical Agricultural Research*, *23*(3), 261-271.

Torkildsen, Ø. Ø., Løken-Amsrud, K. I., Wergeland, S. S., Myhr, K. M., & Holmøy, T. T. (2013). Fat-soluble vitamins as disease modulators in multiple sclerosis. *Acta Neurologica Scandinavica*, *127*(s196), 16-23. doi:10.1111/ane.12045.

Winkleby, M. C., & Cubbin, C. (2004). Changing patterns in health behaviors and risk factors related to chronic diseases, 1900-2000. *American Journal of Health Promotion, 19*, 19-27.

World Health Organization. (2004). Body Mass Index. http://apps.who.int/bmi.html

## FREQUENCY OF DINING AT RESIDENCE HALLS AND INTAKE OF FAT-SOLUBLE VITAMINS AMONG COLLEGE STUDENTS


### Abstract

**Objective**: Dietary habits are formed at a young age, which then influence an individual's dietary choices once they have left the parental home. Vitamins are essential nutrients the body needs to function and aid in the prevention of chronic diseases, specifically fat-soluble vitamins (A, D and E). The goal of this study was to examine if demographic characteristics such as gender, age, and frequency of eating in the campus dining halls predicted a higher intake of the fat-soluble vitamins A, D, and E. **Participants**: Three hundred and fifty two students (212 males and 140 females; mean age 19.3 ± 1.6) enrolled in an introductory course at a Midwestern university. **Methods**: Students completed a dietary analysis of a personal 72-hour food record and reported dining frequency per week. Chi square, t-tests, and regression were completed to show relationships between fat-soluble vitamin intake and demographics. **Results**: Living situations affect the amount of fat-soluble vitamins that a student consumes. Students who never ate on campus and those who ate on campus ≥11 times week had a higher percentage of meeting the Dietary Reference Intake (DRI) for fat-soluble vitamins. Those students who ate off campus had a higher percentage of students meeting vitamin E intake where as those who ate on campus had a higher percentage of meeting the DRI for vitamin A. Only 10 males met the DRI and 1 female met the DRI for Vitamin D.


### Introduction

Eating a healthy and balanced diet may help prevent several chronic health conditions such as obesity, heart disease, diabetes, and some cancers (CDC, 2013). A balanced diet provides adequate micro- and macronutrients helps to maintain normal body processes and promote optimal health. Dietary habits are developed at a young age and have a lasting impact on health throughout life (Litonjua, 2012). Therefore, it is imperative that children and young adults learn healthy dietary habits earlier in life (Litonjua, 2012) to decrease the risk of chronic diseases.

When students transition to college, they are subject to several lifestyles changes. The student is transitioning from being a dependent to becoming an independent adult. One major change is the availability of foods that may not have been available in the parental home. Freedman (2010) found that when students lived at home, their parent or guardian provided a majority of their meals. However, once students moved away from home, they become responsible for choosing the foods they are going to eat (Ouellette, Yang, Wang et al., 2012). Their dietary habits are learned behaviors that are first influenced in childhood by parental role modeling. Changing dietary habits may either be beneficial where students are consuming high nutrient dense foods, or these habits maybe detrimental where students are consuming foods that are high in sugar and fat with little to no nutritional value (Deliens, Clarys, De Bourdeaudhuij, & Deforche, 2013).

Consumption of higher nutrient foods has been affected by the availability and convenience of ready-made foods (Larson, Neumark-Sztainer, Story, Wall, Harnack, & Eisenberg, 2008; Musingo & Wang, 2009). Convenience or ready-made foods include prepackaged foods, frozen foods and/or fast foods. Ready-made foods are widely available at convenience stores, grocery stores, campus stores, campus cafeterias, and other quick stop businesses. These items require little to no preparation, and are easy to pick up on the students' way to or from school. Musingo and Wang (2009) held focus groups in which they asked the students why they chose ready-made foods, and they said due to time constraints (going to or from school, or between classes, little to no cooking time), lack of cooking skills and little motivation to make their own meals (Musingo & Wang, 2009). LaCaille, Dauner, Krambeer, and Pedersen (2011) found that students were lacking the knowledge to know which foods were healthier versus those that were not. This was especially true when choosing foods in the campus cafeteria (Hendricks, Herbold, & Fung, 2004)

Most often, students living in residence halls opt to participate in meal plans provided by the university (Freedman, 2010), whereas other universities require a meal plan if a student is living in the residence halls. Students are provided with options for nutrient dense foods; however, students have been shown to select foods higher in sugars and fats (Ansari, Stock, & Mikolajczyk, 2012).

College cafeterias may offer “block meals” where students may only come a certain number of times a week or an unlimited meal plan, where students can come to the cafeteria anytime, and as many times throughout the day/week as they choose. Some students expressed the feeling that they needed to get their “money’s worth” when eating at the dining halls, so they consumed more food than they usually would (LaCaille et al., 2011).

College dining halls and cafeterias provide students with unlimited food choices through buffets (Freedman, 2010) and all-you-care-to-eat dining options. Buffets are a cost effective way to provide a large number of students with multiple food choices in a timely fashion. Cafeteria operators try to provide both “healthier” options and meals that are not as healthy in order to satisfy all students (LaCaille et al., 2011). LaCaille and colleagues (2011) found that students thought foods higher in calories and fat tasted better. Also Ouellette et al. (2012) found that students gravitated towards less nutrient dense foods that were higher in sugars and fats.

LaCaille and colleagues (2011) conducted student focus groups to discuss what they thought would improve the college cafeterias. Some of the suggestions included: decreasing the amount of unhealthy foods available in the dining centers and promoting healthier options (healthier options were not specified). One suggestion found by Gruber (2008) was to include inexpensive, quick, convenient foods around campus such as fruits and vegetables, while simultaneously increasing the cost of unhealthy foods.

Living situations have shown an impact eating behavior as well. Students could not agree if living on campus or off campus promoted healthier eating (LaCaille et al., 2011). The perception of consuming a healthier diet eating off campus versus on campus is controversial due to the student's abilities to grocery shop and prepare foods. However, students in the study by Freedman (2010) stated they would shop at convenience stores more often and justified skipping meals and picking up fast food items on the way home. Most often these foods are higher fat, non-nutrient dense foods.

Few studies have examined specific nutrient intake, specifically fat-soluble vitamins. However, some have assessed overall dietary intake (Freedman, 2010; Ouellette et al., 2012), other studies have assessed intake of individual nutrients, specifically fat-soluble vitamin (A, D, E and K) consumption among college students. Previous studies used food frequency questionnaires (Hendricks et al., 2004; McLean-Meyinsse, Harris, Taylor, & Gager, 2013; Musingo & Wang, 2009; Perera & Madhujith, 2012) and multiple 24-hour food recall records (Hampl & Betts, 1995; Mitzmeser, Giraud, & Driskell, 2000) to determine dietary intake; however specific nutrients were not identified as either meeting or not meeting DRI. Specifically, three-day food records were not used in any research that has been reviewed.

Fat-soluble vitamins are essential to the body and pertinent in preventing several chronic diseases including multiple sclerosis (Torkildsen, Loken-Amsrud, Wergeland, Myhr, & Holmoy, 2013) osteoporosis (Ahmadieh & Arabi 2011), some cancers, and autoimmune diseases

(Litonjua, 2012). Consuming recommended amounts of fat-soluble vitamins throughout a lifetime can decrease the likelihood of chronic diseases and promote a longer, healthier life (Winkleby & Cubbin, 2004). A majority of studies have evaluated children and adult's dietary intake but overlooked college aged students (Nelson et al., 2008).

The purpose of this study is to investigate the dietary intake of fat-soluble vitamins to examine whether a sample of college students are meeting dietary reference intakes (DRI) for gender and age and if participating in a university meal plan has a positive influence on fat-soluble vitamin intake.

**Methods**

The university's Institutional Review Board Protection of Human Participants in Research has approved this study. This cross-sectional study assessed 352 traditional college students (ages 18-30 years) who were recruited from a general education wellness course in spring, 2014 at a Midwestern university. Researchers attended each class section to demonstrate the correct way to measure or estimate food portions utilizing teaspoons, tablespoons, cups, and ounces in relation to common household items. Participants 18 years of age or older were then asked to complete the informed consent. No incentives were given for participation.

Students completed a 72-hour food record (three consecutive days, two weekdays and one weekend day) for a class assignment. Students were asked to choose days that were similar to their usual diet. Each student entered his or her age, height, weight, level of physical activity and meals into NutritionCalc (version 2010, McGraw-Hill Global Education Holding, LLC). The NutritionCalc database includes over 27,000 foods from ESHA Food Processor (Oregon, Version 2014). ESHA developed and owns the rights to NutritionCalc, stating it is a reliable and valid tool for data analysis. NutritionCalc takes age, body size and physical activity into consideration to determine individual recommended calories, but calculates actual calories, fat (g), vitamin A (mcg), vitamin D (mcg), and vitamin E (mcg) as well as DRIs for other vitamin and minerals. The bar graph report generated NutritionCalc was used for all data analyzed.

Frequency of dining on campus was categorized into three groups, those who never ate on campus, those who ate on campus 1-10 times a week and ≥ 11 times a week. Categories were divided to suggest the different meal plans that were available at the university. Zero times indicated they never ate on campus, 1-10 times indicated a block meal plan where students could eat at least 2 meals a day on campus 5 time a week Monday through Friday, and those who ate on campus ≥ 11 times assumed an unlimited meal plan.

MiniTab 17 Statistical Software (State College, PA, 2011) was used to analyze descriptive tests, t-tests, chi-squared and linear regression tests were also ran. Chi-squared test was ran unless cell counts were below 5, 80% of the time in which Fishers Exact Test was ran by a statistical program R (version 2.15.1, Vienna, Austria, 2012). Statistical significance was set at $p<0.05$. For categorical comparisons, a chi-squared was performed to determine statistical significance. Regression analysis was performed using dining as the only variable. The regression predicted vitamin intake from dining frequency. Meeting caloric intake was defined as meeting >95% of caloric intake. While it does not allow one to determine whether the DRI for a vitamin will be met simply by the number of times a student accesses the dining center, it does provide us an opportunity to identify how important frequency of dining center use is to each fat-soluble vitamin.

**Results**

Characteristics and nutrient intake of the participants are shown in Table 4. There were 352 respondents (212 men, 140 women) with a mean age of 19.3 ± 1.6. Males were slightly older than females. Overall, mean students that ate in the dining centers were 9 ± 8.7 a week; there were no differences between males and females eating at dining halls.

Table 4.
*Demographic, Mean Weekly Dining Frequency, and Consumption of Calories and Fat-Soluble Vitamins among College Students.*

| Characteristic | Total N = 352 | Men N = 212 (60.3%) | Women N = 140 (39.7%) | t-Test | p-value |
|---|---|---|---|---|---|
| Age (years) | 19.3 ± 1.6 | 19.5 ± 1.9 | 18.9 ± 1.0 | 10.3 | 0.001 |
| Frequency of Dining at Residence Halls | 9 ± 8.7 | 9.0 ± 8.1 | 9.0 ± 9.1 | 0.004 | 0.95 |
| Recommended Calories | 2829 ± 858 | 3316 ± 662 | 2092 ± 525 | 335.9 | <0.001 |
| Actual Calories | 1996 ± 778 | 2306 ± 794 | 1526 ± 451 | 111.3 | <0.001 |
| Fat (g)[1] | 70 ± 33.4 | 82.7 ± 35 | 50.4 ± 18.8 | 97.4 | <0.001 |
| % calories from Fat | 31.3 ± 6.8 | 32.2 ± 7.1 | 29.8 ± 6.0 | 10.2 | 0.001 |
| Vitamin A (mcg)[2] | 550 ± 492 | 602 ± 539 | 471 ± 400 | 6.1 | 0.01 |
| Vitamin D (mcg) | 4.4 ± 4.5 | 5.1 ± 5.0 | 3.2 ± 3.2 | 15.2 | <0.001 |
| Vitamin E (mcg) | 5.2 ± 6.2 | 5.3 ± 5.8 | 5.1 ± 6.8 | 0.1 | 0.76 |

[1] g = grams
[2] mcg = micrograms

The mean recommended calorie intakes were 2829 ± 858. Males had a higher recommended caloric intake (3316 ± 662 vs 2092 ± 525, p<0.001). The mean actual intake was 1996 ± 778 for both male and females, which was about 1000 calories less than the recommended mean intake. Males consumed on average 2306 ± 794 calories compared to 1526 ± 451 for females. Percent of calories from fat were equal to recommendations for 20-35% of calories from fat. The mean of percent calories from fat for both genders were 31.3% ± 6.8%, with males consuming a larger percentage than females consumed.

Fat-soluble vitamin intake varied between genders. Overall, 21.3% of the students met the DRI for vitamin A with mean intake of vitamin A was 550 ± 492 mcg. Unlike the other fat-soluble vitamins, vitamin A has gender specific recommendations: the DRI for males is 900 mcg whereas the DRI for females is 700 mcg. Male intake was 602 ± 539 mcg with female intake being 471 ± 400 mcg.

The DRI for vitamin D is 15 mcg a day; however, the overall mean consumption among all participants was not even one-third of recommendation at 4.4 ± 4.5 mcg. Only 3% of all students met the DRI for vitamin D. Males consumed 5.1 ± 5.0 mcg whereas females consumed.3.2 ± 3.2 mcg.

Like vitamin D, vitamin E also has the recommendation of 15 mcg a day; however, students consumed vitamin E at a mean of 5.2 ± 6.2 mcg with 7% of all students meeting the DRI. Males and females were relatively close in their vitamin E consumption (males 5.3 ± 5.8 mcg; females 5.1 ± 6.8 mcg).

Table 5 shows the three frequencies of eating at the dining halls in relationship to gender, age, and nutrient intake values. Approximately one-third (34.7%) of the students (n=122; males 36.3%; females 23.1%) reported never eating on campus. This compares to 22.4% (n=79; males 21.7%; females 23.6%) of the students who ate on campus up to 10 times a week, and 43% (n=151; males 41.9%; females 44.3%) of the students ate on campus ≥ 11 times per week. Age differences were of significance: 85% of those who were older (≥19 years) did not eat at the dining halls.

Caloric intake did not vary significantly between those who ate at the dining hall and those who did not; moreover, caloric intake was not linear. Those who ate at the dining hall 1-10 times a week consumed the fewest calories (1879 ± 708); whereas, those who ate at the dining hall ≥ 11 times a week, had a slightly higher caloric intake (2083 ± 866). For those who did not eat at the dining hall, calorie intake was 1963 ± 697. As with caloric intake, no significant relationship was seen in the percent of calories from fat. The percent of calories from fat means for 0 times, 1-10 times and ≥ 11 times were 31.2% ± 7.0%, 32.4% ± 7.0%, and 30.6% ± 6.4%, respectively. It is important to note that these percentages were similar and the recommendation is > 35% of calories from fat.

Table 5.
*Relationship of Dining in Residence Halls and Gender, Age, Caloric, Percent of Calories from Fat and Fat-Soluble Vitamins among College Students.*

| Frequency of Dining in Residence Halls | 0 (n=122) | 1-10 (n=79) | ≥ 11 (n=151) | p value |
|---|---|---|---|---|
| Gender | | | | 0.72 |
| Male | 77 (63.1%) | 46 (58.2%) | 89 (58.9%) | |
| Female | 45 (36.9%) | 33 (41.5%) | 62 (41.1%) | |
| Age | | | | <0.001 |
| 18 | 18 (14.8%) | 28 (35.4%) | 60 (39.7%) | |
| 19+ | 104(85.2%) | 51 (64.6%) | 91 (60.3%) | |
| Caloric Intake | 1963 ± 697 | 1879 ± 708 | 2083 ± 866 | 0.14 |
| % Calories from fat (20-35%) | 31.2 ± 7.0 | 32.4 ± 7.0 | 30.6 ± 6.4 | 0.19 |
| Vitamin A (F= 700 mcg, M = 900 mcg) | 553 ± 430 | 479 ± 488 | 585 ± 538 | 0.30 |
| Vitamin D (15 mcg) | 4.8 ± 4.4 | 3.4 ± 4.1 | 4.5 ± 4.7 | 0.11 |
| Vitamin E (15 mcg) | 6.5 ± 8.2 | 3.9 ± 7.8 | 4.9 ± 5.1 | 0.01 |

Mean intake for vitamin A and D was not significantly related to the frequency of eating at the dining halls. Mean intake of both vitamin A and D was the lowest in the students who ate at the dining hall 1-10 times per week. Mean intake of vitamin E was significantly related to frequency of eating meals at the dining hall. Although at only 43% of the DRI, those who did not eat at the dining hall had the highest mean intake (6.5 ± 8.2 mcg); whereas those who at the dining hall 1-10 times had intake of 3.4 ± 4.1 mcg (23% of the DRI).

As seen in Table 6, of those students who did not eat on campus, few met intake for calories or fat-soluble vitamin recommendations. Only 5 males (6.5%) and 1 female (2.2%) met their caloric intake recommendation (p = 0.48); however, 83 students (males 61.0%; females 80%) met the recommendation of 20-35% of calories from fat (p = 0.12). Among that same category, 23 students (37.3%) met their vitamin A intake (p = 0.22). Only 3 males (3.9%) met the recommended intake of vitamin D; however, no female met the DRI for vitamin D (p = 0.73). Nine males (11.7%) and four females (8.9%) met the DRI for vitamin E (p = 0.14).

Table 6.
*Number and Percent of Participants Who Met Recommended Intake of Calories, Percent Calories from Fat and Fat Soluble Vitamins In Relation To Dining Categories.*

| Nutrient | 0 times (n=122) | | 1-10 times (n=79) | | ≥ 11 times (151) | |
|---|---|---|---|---|---|---|
| | M (n=77) | F (n=45) | M (n=46) | F (n=33) | M (n=89) | F (n=62) |
| Caloric Intake | 5 (6.5%)[1] | 1 (2.2%) | 3 (6.5%) | 2 (6.0%) | 5 (5.6%) | 8 (12.9%) |
| % Calories from fat (20-35%) | 47 (61.0%) | 36 (80%) | 22 (47.8%) | 23 (69.7%) | 58 (65.2%) | 48 (77.4%) |
| Vitamin A (F= 700 mcg, M = 900 mcg) | 15 (19.5%) | 8 (17.8%) | 5 (1.1%) | 7 (21.2%) | 21 (23.6%) | 16 (25.8%) |
| Vitamin D (15 mcg) | 3 (3.9%) | 0 (0.0%) | 1 (2.3%) | 1 (3.0%) | 6 (6.7%) | 0 (0.0%) |
| Vitamin E (15 mcg) | 9 (11.7%) | 4 (8.9%) | 2 (4.3%) | 1 (3.0%) | 5 (5.6%) | 4 (6.5%) |

[1]Percent represents percent of gender meeting DRI

As seen in Table 6, few students who ate on campus at least 1-10 times a week met intake for calories or fat-soluble vitamin recommendations. Only 3 males (6.5%) and 2 females (6%) met caloric intake recommendations. Eating at the dining hall 1-10 times per week did not improve fat-soluble vitamin intake with only 12 students meeting the DRI for vitamin A, 2 students for vitamin D and 3 students for vitamin E. Even with such poor fat-soluble vitamin intake, 47.8% of the males (22) and 69.7% of the females (23) were within the 20-35% of calories from fat.

Few students who ate on campus ≥11 times a week met recommended intake for calories or fat-soluble vitamins. Students who reported eating on campus ≥11 times per week 13 students (8.6%) met recommended caloric intake. Eating at the dining hall ≥11 times per week did not improve fat-soluble vitamin intake with 37 (25%) of the students meeting the DRI for vitamin A, 6 students (4%) for vitamin D, and 9 students (6%) for vitamin E. Nevertheless, even with low fat-soluble vitamin intake, 65.2% of the males (58) and 77.7% of the females (48) were within the 20-35% of calories from fat.

Dining on campus is thought to have a positive effect on the intake of fat-soluble vitamins consumed; however, this does not seem to be the case. As seen in Figure 4, those who ate ≥ 11 times a week on campus, 24% of the student group met DRI for vitamin A. Of those who never ate on campus, 18% met DRI for vitamin A. Those who ate on campus at least 1-10 times a week had decreased in DRI consumption 15% of students meeting their DRI recommendations (p = 0.22).

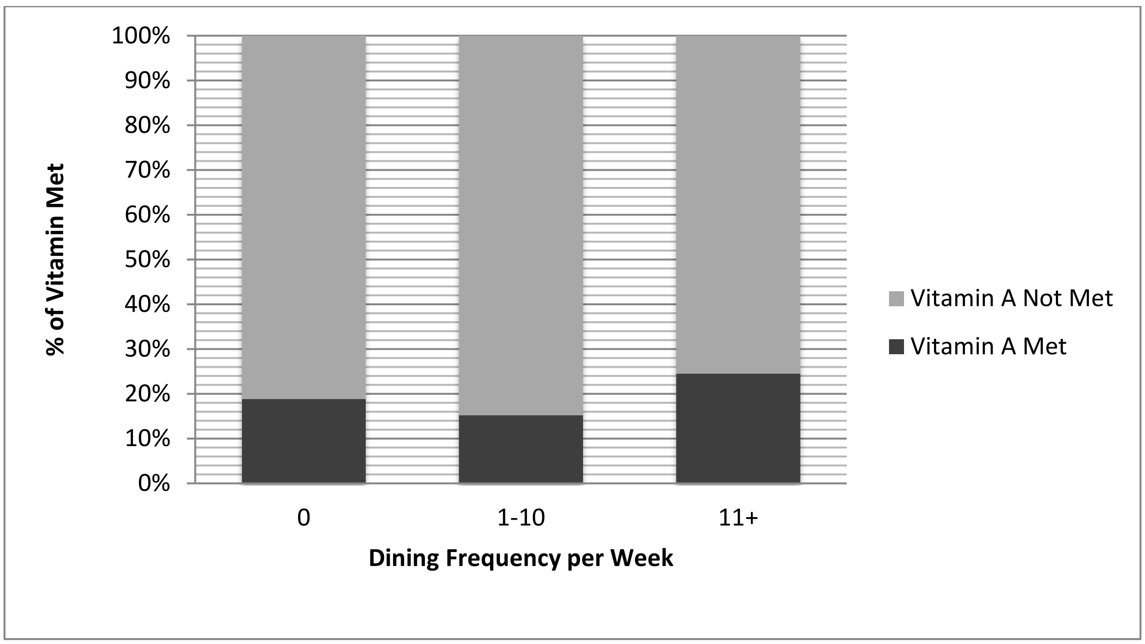


Figure 4. *DRI of Vitamin A being Met According to Dining Frequency*

**Regression Analysis**

Regression analysis (seen in Figure 5) showed that dining and vitamin A intake had a positive linear relationship (p=0.17). Vitamin D (seen in Figure 6) had a slightly positive relation (p=0.60) with dining as an indicator and vitamin E (seen in Figure 7 had a slightly negative relation in relation to dining (p=0.05)).

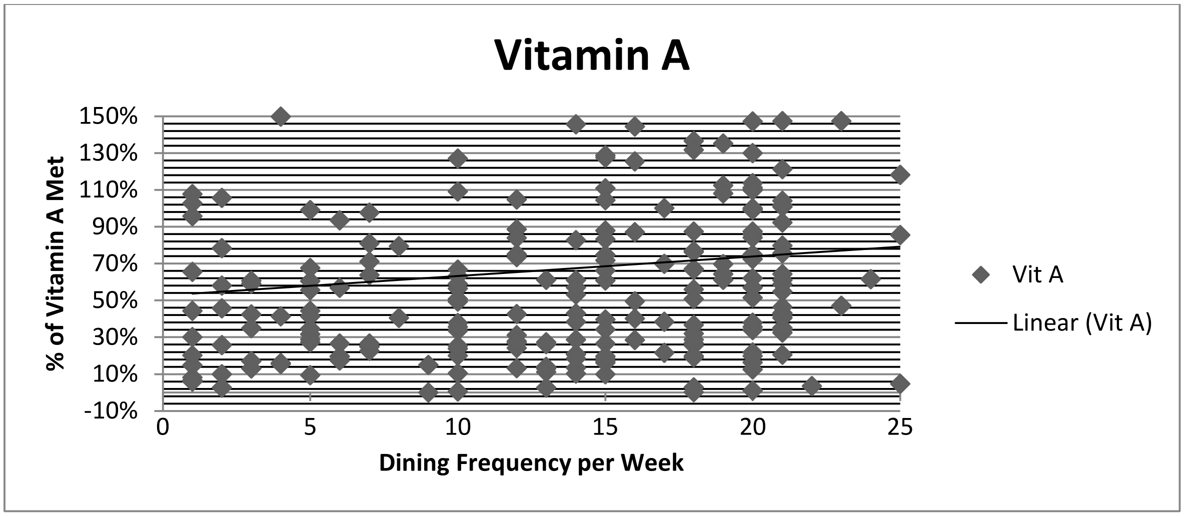


Figure 5. *The Percentage of DRI for Vitamin A with Dining Frequency (p = 0.93)*

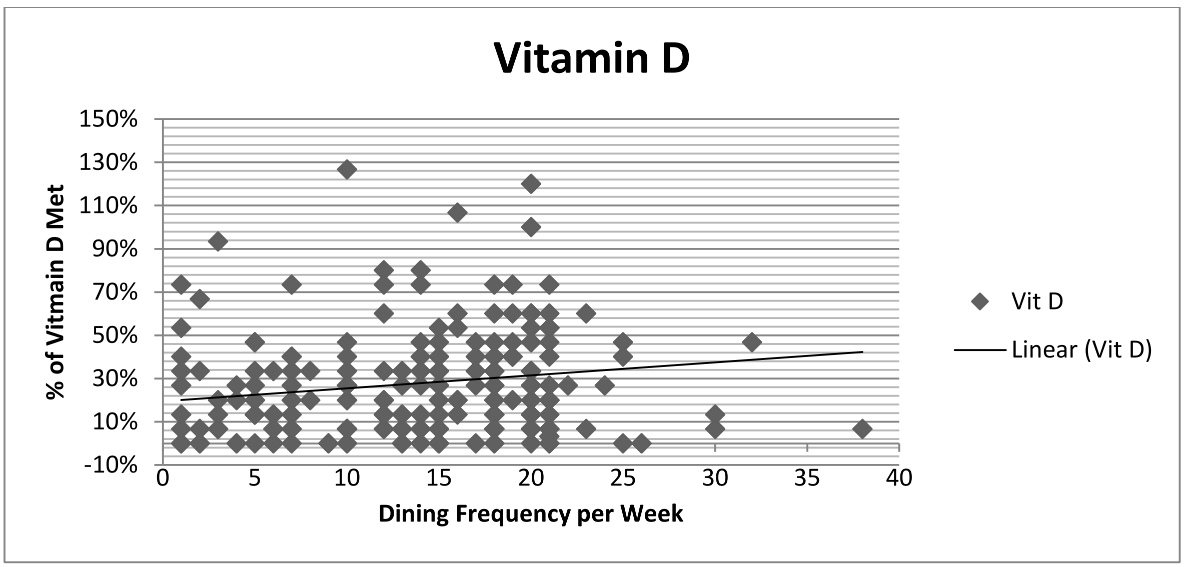


Figure 6. *The Percentage of DRI for Vitamin D with Dining Frequency (p = 0.36)*

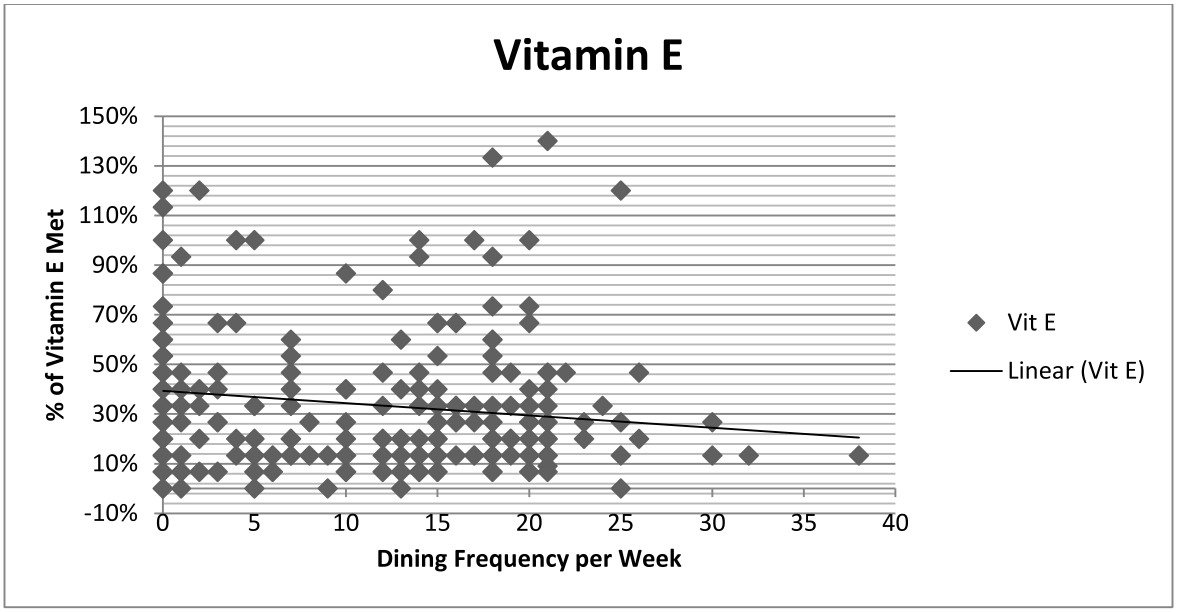


Figure 7. *The Percentage of DRI for Vitamin E with Dining Frequency (p = 0.01)*

**Discussion**

Based on the results from this study, it can be concluded that students are not meeting the recommended caloric intake regardless of where students consumed meals—dining halls or elsewhere. It appears that students are consuming foods, which provide a large portion of their calories from fat; however, the intake of fat-soluble vitamins is low. This indicates that students are eating unhealthy fats that are lacking in fat-soluble vitamins. Living situations such as living on campus and living off campus have been shown to have an effect on students and their dietary habits in meeting individual needs of fat-soluble vitamins (Freedman, 2010); however this study does not show this to be true.

College cafeterias offer various meal plans in which a student can choose to participate or not. Campus cafeterias provide students with buffets that are generally unlimited for the time they are in the dining hall. Ouellette and colleagues (2012) concluded that students gravitated to the higher fat foods, which this study supported with 100 (28%) students consuming more than 35% of calories from fat.

Living situations also have a strong influence on eating behavior. Research suggests that students who live off campus consume less nutrient dense foods than those who live on campus (LaCaille et al., 2011). Nevertheless, this study did not show significant differences in eating dining halls or eating elsewhere. The majority of the students did not meet any of the DRIs for fat-soluble vitamins.

Vitamin D was least likely to be met among all fat-soluble vitamins examined. This could be due to students not eating fortified foods that contain vitamin D (milk, orange juice, yogurt, etc.) This is alarming because students currently attending college are at the peak of their prime years to maximize bone density. Unlike females, 10 males met vitamin D intake, three never ate on campus, one ate on campus 1-10 times a week and six ate on campus ≥ 11 times a week. Not only were all students low in vitamin D consumption, but females were significantly lower in consuming vitamin D than males. This is concerning because females are have a higher risk of developing osteoporosis. However, vitamin D intake is still very low with only 2.8% of all students meeting the DRI for vitamin D. Deficiency in vitamin D has been linked to osteopenia, osteoporosis, type 1 diabetes mellitus, insulin resistance, obesity, common cancers, cardiovascular disease, hypertension, multiple sclerosis, decreased immune function and an increase in infections (Holick, 2006).

Surprisingly, vitamin E intake was higher in those students who ate off campus. Of those students who never ate on campus, 20.6% met DRI for vitamin E; however, only 7.3% of those who dined on campus 1-10 times a week, and 12.1% for those who ate on campus ≥11 times week met the DRI. Those who ate off campus may have consumed nuts and seeds more frequently. Moreover, they may have been cooking at home and been more aware of what of how their foods were prepared leading to more accurate reporting of meal components including the cooking oils. On the other hand, those who are eating on campus may not be aware of the oils that may have been used in the preparation of the foods; therefore, they did not report cooking oils in their food record.

Unlike vitamin E, those students who ate on campus ≥11 times a week were more likely to meet vitamin A needs. Vitamin A and its precursors are found in whole foods, as opposed to oils that may be used in the preparation of foods and are less obvious to the consumer. Therefore students may be more likely to report consuming foods with vitamin A. Males who never ate on campus and males who ate on campus ≥11 times had a higher percentage of meeting their vitamin A. However, both males and females who ate at the dining hall 1-10 times a week were less likely to meet the DRI for vitamin A.

It is important to note that those students who ate on campus 1-10 times a week had a lower intake of fat-soluble vitamins than those who ate off campus or ≥11 times a week. If a student eats on campus 1-10 times a week we assume they are consuming at least two meals per day on campus Monday through Friday. These students are likely eating elsewhere on the weekends. Students who ate on campus ≥11 times a week likely had an unlimited meal plan, and therefore, had access to the dining halls on the weekend. It is unknown where students eat when not eating at the dining halls. Therefore, only assumptions can be made about what students who only eat on campus 1-10 times a week are eating when they are off campus. They may be eating few nutrient dense foods or nothing at all. Regardless of where students are eating, knowing how to meal plan would increase the variety of foods they consume.

## Conclusion

Living situation, knowledge, and culinary skill set affect a person’s food choices. Since students come to college with established eating habits, it is important to identify their nutrition knowledge and culinary skills and provide them tools to make the right dietary choices.

Future research should include a more detailed assessment of foods available at and consumed in campus dining centers. This research should include an analysis of the foods and cooking methods used in the dining halls.

Future research may also need to focus on students’ foods choice, attitudes and beliefs about food in order to understand eating patterns. In addition, it would be beneficial to assess students’ culinary skills, which could be a predictor of their confidence in preparing a larger variety of foods. With the knowledge of attitudes, beliefs, eating patterns, and culinary skills, education programs could promote healthy eating could better target students’ needs.

Moreover, since this study found inadequate intake of vitamin D, nutrition education programs on the importance of Vitamin D and its food sources aimed particularly at females could improve intake of foods that contain vitamin D, and subsequently lower osteoporosis risk.

## References

Ahmadieh, H., & Arabi, A. (2011). Vitamins and bone health: beyond calcium and vitamin D. *Nutrition Reviews*, *69*(10), 584-598. Doi:10.1111/j.1753-4887.2011.00372.x.

American College Health Association (2013). American College Health Association – National College Health Assessment II: Reference Group Executive Summary Spring, 2013. Hanover, MD, American College Health Association. Accessed December 7, 2014. Retrieved from http://www.acha-ncha.org/docs/ACHA-NCHA-II_ReferenceGroup_ExecutiveSUmmary_Spring2013.pdf

Centers for Disease Control and Prevention (CDC). (2010). Nutrition. Retrieved from http://www.cdc.gov/nutrition/

Centers for Disease Control and Prevention (CDC). (2013). Prevention status reports. Retrieved from http://www.cdc.gov/stltpublichealth/psr/npao/index.html

Centers for Disease Control and Prevention (CDC). (2014). Vitamin D. Accessed on December 9, 2014. Retrieved from http://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional.

Deliens, T., Clarys, P., De Bourdeaudhuij, I., & Deforche, B. (2013). Weight, socio-demographic, and health behaviour related correlates of academic performance in first year university students. *Nutrition Journal, 12*(1), 162.

Freedman, M. R. (2010). Gender, residence and ethnicity affect freshman BMI and dietary habits. *American Journal of Health Behavior*, *34*(5), 513-524.

Gruber, K. J. (2008). Social support for exercise and dietary habits among college students. *Adolescence, 43,* 557-575.

Hampl, J. S., & Betts, N. M. (1995). Comparisons of dietary intake and sources of fat in low- and high-fat diets 18- to 24-year-olds. *Journal of the American Dietetic Association, 95*(8), 893-897.

Healthy People 2020. (2014) Low-energy dense foods and weight management: cutting calories while controlling calories. Accessed December 9, 2014. Retrieved from http://www.healthypeople.gov.

Hendricks, K. M., Herbold, N. N., & Fung, T. T. (2004). Diet and other lifestyle behaviors in young college women. *Nutrition Research, 24*(12), 981-991. Doi:10.1016/j.nutres.2004.09.004.

Holick, M. F. (2008). High prevalence of vitamin D inadequacy and implication for health. *Mayo Clinical Procedures*, *81*, 353-373.

Holick, M.F. (2007). Vitamin D deficiency. *New England Journal of Medicine*, *357*, 266-281.

Holick, M. F., O' Keefe, J. H., & Lavie, C. J. (2011). Vitamin D supplementation for cardiovascular disease prevention. *Journal of the American Medical Association, 306*(14):1546-1548. Doi:10.1001/jama.2011.1465.

LaCaille, L. J., Dauner, K., Krambeer, R. J., & Pedersen, J. (2011). Psychosocial and environmental determinants of eating behaviors, physical activity, and weight change among college students: A qualitative analysis. *Journal of American College Health*, *59*(6), 531-538. doi:10.1080/07448481.2010.523855.

Larson, N. I., Neumark-Sztainer, D. R., Story, M. T., Wall, M. M., Harnack, L. J., & Eisenberg, M. E. (2008) Fast food intake: longitudinal trends during the transition to young adulthood and correlates of intake. *Journal of Adolescent Health*, *43*(1), 79-86.

Litonjua, A. A. (2012). Fat-soluble vitamins and atopic disease: what is the evidence?. *Proceedings of the Nutrition Society, 71*(1), 67-74. Doi:10.1017/S002966511100334X

McLean-Meyinsse, P. E., Harris, E. G., Taylor, S. S., & Gager, J. V. (2013). Examining college students' daily consumption of fresh fruits and vegetables. *Journal of Food Distribution Research*, *44*(1), 10-16.

Mitmesser, S. H., Giraud, D. W., & Driskell, J. A. (2000). Dietary and plasma levels of carotenoids, vitamin E, and vitamin C in a group of young and middle-aged nonsupplemented women and men. *Nutrition Research, 20*(11), 1537-1546.

Musingo, M. N., & Wang, L. H. (2009). Analysis of eating habits according to socio-demographic characteristics of college students. *Pakistan Journal of Nutrition*, *8*(10), 1575-1580.

Ouellette, C. D., Yang, M. M., Wang, Y. Y., Yu, C. C., Fernandez, M. L., …. Chun, O. K. (2012). Assessment of nutrient adequacy with supplement use in a sample of healthy college students. *Journal of the American College of Nutrition*, *31*(5), 301-310.

Perera, T. T., & Madhujith, T. T. (2012). The pattern of consumption of fruits and vegetables by undergraduate students: a case study. *Tropical Agricultural Research*, *23*(3), 261-271.

Torkildsen, Ø. Ø., Løken-Amsrud, K. I., Wergeland, S. S., Myhr, K. M., & Holmøy, T. T. (2013). Fat-soluble vitamins as disease modulators in multiple sclerosis. *Acta Neurologica Scandinavica*, *127*(s196), 16-23. doi:10.1111/ane.12045.

Winkleby, M. C., & Cubbin, C. (2004). Changing patterns in health behaviors and risk factors related to chronic diseases, 1900-2000. *American Journal of Health Promotion, 19,* 19-27.

## SUMMARY AND CONCLUSIONS

Utilizing the results from a 72-hour food record, this study assessed dietary intake of fat-soluble vitamins in 352 Midwestern university students. Many research studies used food frequency questionnaires (Hendricks et al., 2004; McLean-Meyinsse, Harris, Taylor & Gager, 2013; Musingo & Wang, 2009; Perera & Madhujith, 2012) and (Hampl & Betts, 1995; Mitzmeser, Giraud & Driskell, 2000) multiple 24-hour recalls to assess dietary intake. This study assessed dietary nutrient intake, frequency of eating at residence halls, physical activity, BMI, gender, and their effects on the students' dietary intake. A study by Freedman (2010) discovered that living arrangements did have an effect on overall dietary intake, this study continued on Freedman's (2010) research to further examine if frequency of eating at residence dining halls had an affected on fat-soluble vitamin intake.

The results from this study discovered that students were not meeting the DRI for fat-soluble vitamins A, D, and E. Only 3 (<1%) students met all fat-soluble vitamins (A, D, and E) and 349 (99.1%) students did not meet the DRI for all three fat-soluble vitamins. Furthermore, a majority of students are not meeting their recommended caloric intake; however, most students met and/or exceeded their recommendation of percentage of calories from fat (20-35%). One hundred students (28.4%) consumed more than 35% of their total calories from fat.

When evaluating eating in residence halls, students who ate on campus 1-10 times a week had a lower intake of fat-soluble vitamins than those who ate off campus or ≥11 times a week. It was assumed that students who ate on campus ≥11 times a week had unlimited access to the dining centers, whereas students who only ate on campus 1-10 times were assumed to have a block plan, having at least two meals a day Monday thru Friday provided. Of those students who never ate on campus, 20.6% of them met the DRI for vitamin E, which is a larger percentage than those who ate meals on campus ≥11 times a week. This shows that students who ate off campus may have a better perception concerning how their meals are prepared, including the cooking oils, whereas those who dine on campus may not.

Only 10 males and 1 female, met the DRI for vitamin D. Dining on campus had a positive correlation between students who met their vitamin D intake; 6 males who dined on campus ≥11 times week meet their DRI where as those who did not dine on campus 3 males met their DRI for vitamin D. All students were low in vitamin D consumption; however females were significantly lower than males. This is concerning for college age females are at their prime stage for building strong bones decreasing their risk of developing osteoporosis. Overall, vitamin D intake is alarmingly low with only 2.8% of all students meeting the DRI for vitamin D. Deficiency in vitamin D has been linked to osteopenia, osteoporosis, type 1 diabetes mellitus, insulin resistance, obesity, common cancers, cardiovascular disease, hypertension, multiple sclerosis, decreased immune function and an increase in infections (Holick, 2006).

The combination of physical activity and dining on campus ≥11 times a week had a positive relationship with vitamin A consumption. Males who ate on campus ≥11 times a week and males who never ate on campus were more likely to meet the DRI for vitamin A. However, both males and females who ate on campus 1-10 times per week showed a slight decrease in participants meeting their DRI for vitamin A. Among the physical activity categories, very active students were more likely to meet their DRI for vitamin A whereas active and very active students were more likely to the meet their DRI for vitamin E. Eating meals off campus demonstrated a positive correlation with vitamin E intake.

Overall, since <1% of students met the fat-soluble vitamin recommend intake, nutrition interventions among college students should be advised. As vitamin deficiencies increase, so will chronic disease. These findings are alarming because some chronic diseases could be prevented.

If students were to acquire the knowledge of what nutrient dense foods can do for them and what these foods are, they would then have the opportunity to modify their diets to incorporate more fat-soluble vitamins into their diet.

**Limitations**

There are several limitations for this study. All data were self-reported which may have resulted in over reporting or under reporting of foods. The students may have a lack of knowledge as to what ingredients are used when preparing foods in the dining centers; therefore, they were not documenting oils or other ingredient used in recipes.

Students may have misreported their activity level, making themselves seem more or less physically active than what they really were. Misreporting of anthropometrics such as height and weight may have occurred skewing their BMI calculation. Moreover, BMI may not have been the best representation for all students. Some students may have a higher percentage of muscle because they were an athlete or physically fit, which increases weight because muscle weighs more than fat. Since BMI is a weight to height ratio, a larger percent of muscle may cause a higher BMI classification. Finally, this study was conducted in a Midwestern college, where a majority of students were White.

**Conclusion**

Living arrangements, activity status, knowledge, and cooking skills all affect a person's health. Since students come to college with established eating habits, it is important to provide them with correct information to ensure they have the tools to make the right dietary choices.

Fat-soluble vitamin consumption among college students is low, which could result in an increase of chronic diseases in the future. Vitamin A and E consumption is low; however, vitamin D is significantly low. Since the intake of vitamin D is so low, nutrition education aimed at all students, particularly females, could help improve overall intake of vitamin D containing foods. Without knowledge of vitamin D containing foods and the critical change in dietary intake, young adults, have an increased risk for vitamin D diseases related diseases.

Future studies could assess dietary food records examining the actual food items students are consuming versus just the nutrient numbers provided by the database. Another study should assess the diets of college students and their fat-soluble vitamin intake; provide interventions then collect a post intervention dietary food record to assess if the students changed their diets based on the new knowledge.

## REFERENCES

Ahmadieh, H., & Arabi, A. (2011). Vitamins and bone health: beyond calcium and vitamin D. *Nutrition Reviews*, *69*(10), 584-598. Doi:10.1111/j.1753-4887.2011.00372.x

American Institute for Cancer Research. (2014). Definition. Accessed December 8, 2014. Retrieved from http://www.aicr.org/.

Ansari, W. W., Stock, C. C., & Mikolajczyk, R. T. (2012). Relationships between food consumption and living arrangements among university students in four European countries [female] a cross-sectional study. *Nutrition Journal*, *11*(28), (24 A.

Arnette, J. J. (2000). Emerging: a theory of development from late teens through twenties. *American Psychologist, 55*(5), 469-480.

Arnette, J. J. (1998). Learning to stand along: the contemporary American transition to adulthood in cultural and historical context. *Human Development, 41,* 295-315.

Branowski, T., Cullen, K.W., & Basen-Enquist, T. (1997) Transitions out of high school: time of increased cancer risk? *Preventive Medicine*, 25, 694-703.

Brevard, P. B., & Ricketts, C. D. (1996). Residence of college students affects dietary intake, physical activity and serum lipid levels. *Journal of the American Dietetic Association, 96*(1), 35-38.

Berner, L. A., Keast, D. R., Bailey, R. L., & Dwyer, J. T (2014). Fortified foods are major contributors to nutrient intakes in diets of U.S. children and adolescents. *Journal of the Academy of Nutrition and Dietetics, 114*(70), 1009-1022e8.

Camargo, C. A., & Manson, J. E., (2013). Vitamin D supplementation and risk of infectious diseases: no easy answers. *The American Journal of Clinical Nutrition. 99*(1), 3-4.

Cannell, J. J. Vieth, R., Umhau, J. C., Holick, M. F., Grant, W. B., ….. Giovannuccie, E. (2006). Epidemic influenza and vitamin D. *Epidemiology & Infection, 134*, 1129-40. Doi: 10.1017/S0950268806007175.

Centers for Disease Control and Prevention (CDC). (2010). Nutrition. Retrieved from http://www.cdc.gov/nutrition/

Centers for Disease Control and Prevention (CDC). (2013). Prevention status reports. Retrieved from http://www.cdc.gov/stltpublichealth/psr/npao/index.html.

Centers for Disease Control and Prevention (CDC). (2014). Vitamin D. Accessed on December 9, 2014. Retrieved from http://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional.

Deliens, T., Clarys, P., De Bourdeaudhuij, I., & Deforche, B. (2013). Weight, socio-demographic, and health behaviour related correlates of academic performance in first year university students. *Nutrition Journal, 12*(1), 162.

El-Ansari, W. W., Stock, C. C., & Mikolajczyk, R. T. (2012). Relationships between food consumption and living arrangements among university students in four European countries - a cross-sectional study. *Nutrition Journal*, *11*(28), (24 A.

El-Qudah, J. M., Al-Widyan, O. O., Alboqai, O. K., Suleiman, A. A., & Quasem, J. M. (2008). Fat soluble vitamins (A, E and K) intake among a sample of Jordanian university students. *World Applied Sciences Journal*, *5*(2), 252-257.

Freedman, M. R. (2010). Gender, residence and ethnicity affect freshman BMI and dietary habits. *American Journal of Health Behavior*, *34*(5), 513-524.

Gao, X., Wilde, P. E., Lichtenstein, A. H., Bermudex, O. I., & Tucker K. L. (2006). The maximal amount of tocopherol intake in U.S. adults (NHANES 2001-2002). *Journal of Nutrition*, 136, 1021-1026.

Gruber, K. J. (2008). Social support for exercise and dietary habits among college students. *Adolescence*, *43*, 557-575.

Gu, H, Tang, C., Yang, Y. (2012). Psychological stress, immune response and atherosclerosis. *Atherosclerosis*, *223*(1), 69-77.

Hampl, J. S & Betts, N. M. (1995). Comparisons of dietary intake and sources of fat in low- and high-fat diets 18- to 24-year-olds. *Journal of the American Dietetic Association, 95*(8), 893-897.

Harper, A.E. (2003). Contributions of women scientists in the U.S. to the development of Recommended Dietary Allowances. *Journal of Nutrition*, *133*(11): 3698–3702.

Hendricks, K. M., Herbold, N. N., & Fung, T. T. (2004). Diet and other lifestyle behaviors in young college women. *Nutrition Research, 24*(12), 981-991. Doi:10.1016/j.nutres.2004.09.004.

Holick, M. F. (2008). High prevalence of vitamin D inadequacy and implication for health. *Mayo Clinical Procedures, 81*, 353-373.

Holick, M.F. (2007). Vitamin D deficiency. *New England Journal of Medicine*, 357, 266-281.

Holick, M. F., O' Keefe, J. H., & Lavie, C. J. (2011). Vitamin D supplementation for cardiovascular disease prevention. *Journal of the American Medical Association, 306*(14):1546-1548. Doi:10.1001/jama.2011.1465.

Institute of Medicine. (2011). Table: DRI value summary. Retrieved December 13, 2013, from http://www.iom.edu/.

Interagency Board for Nutrition Monitoring and Related Research. (1995). Third report on nutrition monitoring in the United States. Washington, DC: U.S. Government Printing office.

LaCaille, L. J., Dauner, K., Krambeer, R. J., & Pedersen, J. (2011). Psychosocial and environmental determinants of eating behaviors, physical activity, and weight change among college students: a qualitative analysis. *Journal of American College Health, 59*(6), 531-538. doi:10.1080/07448481.2010.523855

Larson, N. I., Neumark-Sztainer, D. R., Story, M. T., Wall, M. M., Harnack, L. J., & Eisenberg, M. E. (2008) Fast food intake: longitudinal trends during the transition to young adulthood and correlates of intake. *Journal of Adolescent Health, 43*(1), 79-86.

Litonjua, A. A. (2012). Fat-soluble vitamins and atopic disease: what is the evidence?. *Proceedings of the Nutrition Society*, *71*(1), 67-74. Doi:10.1017/S002966511100334X

McGraw-Hill (2012). NutritionCalc Plus Online [computer software]. Oregon.

McLean-Meyinsse, P. E., Harris, E. G., Taylor, S. S., & Gager, J. V. (2013). Examining college students' daily consumption of fresh fruits and vegetables. *Journal of Food Distribution Research*, *44*(1), 10-16.

Mitmesser, S. H., Giraud, D. W., & Driskell, J. A. (2000). Dietary and plasma levels of carotenoids, vitamin E, and vitamin C in a group of young and middle-aged nonsupplemented women and men. *Nutrition Research, 20*(11), 1537-1546.

Musingo, M. N., & Wang, L. H. (2009). Analysis of eating habits according to socio-demographic characteristics of college students. *Pakistan Journal of Nutrition*, *8*(10), 1575-1580.

Nelson, M. C., & Story, M. (2009). Food environments in university dorms 20,000 calories per dorm room and counting. *American Journal of Preventive Medicine, 36*(6), 523-526.

Nelson, M. C., Story, N., Larson, N. I., Neumark-Sztainer, D., & Lytle, L. A. (2008). Emerging adulthood and college-aged youth: an overlooked age for weight-related behavior change. *Obesity*, *16*(10), 2205-2211.

North Dakota State University-Ethnicity Data (2014). Retrieved from http://www.ndsu.edu/fileadmin/oira/Ethnicity/Ethnicity2014.pdf.

O'Connor, T. G., Allen, J. P., Bell, K. L., & Hauser, S. T. (1996). Adolescent-parent relationships and leaving the home in young adulthood. *New Direction in Childhood Development, 71*, 39-52.

Ouellette, C. D., Yang, M. M., Wang, Y. Y., Yu, C. C., Fernandez, M. L., ….. & Chun, O. K. (2012). Assessment of nutrient adequacy with supplement use in a sample of healthy college students. *Journal of the American College of Nutrition*, *31*(5), 301-310.

Park, M. J., Mulye, T. P., Adams, S. H., Brindis, C. D., & Irwin C. E Jr. (2006). The health status of young adults in the United States. *Journal of Adolescence Health, 39*, 305-317.

Perera, T. T., & Madhujith, T. T. (2012). The pattern of consumption of fruits and vegetables by undergraduate students: A case study. *Tropical Agricultural Research*, *23*(3), 261-271.

Rockett, H., Wolf, A. M., & Colditz, G. (1995). Development and reproducibility of a food frequency questionnaire to assess diets of older children and adolescents. *Journal of American Dietetic Association, 96,* 336-340.

Šatalic´, Z. Z., Baric´, I. C., & Keser, I. I. (2007). Diet quality in Croatian university students: energy, macronutrient and micronutrient intakes according to gender. *International Journal of Food Sciences and Nutrition, 58*(5), 398-410. doi:10.1080/09637480701252393

Torkildsen, Ø. Ø., Løken-Amsrud, K. I., Wergeland, S. S., Myhr, K. M., & Holmøy, T. T. (2013). Fat-soluble vitamins as disease modulators in multiple sclerosis. *Acta Neurologica Scandinavica*, *127*(s196), 16-23. doi:10.1111/ane.12045.

United States Department Health and Human Services. (2000). Healthy people 2010: understanding and improving health. Washington, DC: US Government Printing Office. DHHS Publication No. 017-001-00543-6.

United States Department of Agriculture. (2011). MyPlate. Accessed December 5, 2014. Retrieved from http://www.choosemyplate.gov/about.html.

United States Department of Agriculture. (2014). Vitamin and Minerals. Accessed December 5, 2014. Retrieved from http://fnic.nal.usda.gov/food-composition/vitamins-and-minerals.

von Bothmer, M. K., & Fridlund, B. (2005). Gender differences in health habits and in motivation for a healthy lifestyle among Swedish university students. *Nursing Health Science*, *7*(2), 107-118.

Winkleby, M. C., & Cubbin, C. (2004) Changing patterns in health behaviors and risk factors related to chronic diseases, 1900-2000. *American Journal of Health Promotion*, *19*, 19-27.

World Health Organization. (2004). Body Mass Index. Retrieved from http://apps.who.int/bmi.html.

Wyn, J. (2004). Becoming adult in the 2000s – new transitions and new careers. *Family Matters*, *68*, 6-12.

# APPENDIX. IRB LETTER OF APPROVAL

NDSU NORTH DAKOTA STATE UNIVERSITY

February 18, 2014

FederalWide Assurance FWA00002439

Dr. Ardith Brunt
Department of Health, Nutrition & Exercise Sciences
EML 351E

IRB Approval of Protocol **#HE14166, "Nutritional intake of college students"**
Co-investigator(s) and research team: **Elizabeth Hilliard, Sarah Hilgers-Greterman, Samantha Fuhrmann, Michelle Caldarone**

**Approval period: 2/18/14 to 2/17/15**

**Continuing Review Report Due: 1/1/15**

Research site(s): **NDSU**

Funding agency: **n/a**

Review Type: Expedited category # 5
IRB approval is based on original submission, with revised: consent form (received 2/13/14).

**Additional approval is required:**

- prior to implementation of any proposed changes to the protocol (*Protocol Amendment Request Form*).
- for continuation of the project beyond the approval period (*Continuing Review/Completion Report Form*). A reminder is typically sent two months prior to the expiration date; timely submission of the report is your responsibility. To avoid a lapse in approval, suspension of recruitment, and/or data collection, a report must be received, and the protocol reviewed and approved prior to the expiration date.

**A report is required for:**

- any research-related injuries, adverse events, or other unanticipated problems involving risks to participants or others within 72 hours of known occurrence (*Report of Unanticipated Problem or Serious Adverse Event Form*).
- any significant new findings that may affect risks to participants.
- closure of the project (*Continuing Review/Completion Report Form*).

**Research records are subject to random or directed audits at any time to verify compliance with IRB regulations and NDSU policies.**

Thank you for cooperating with NDSU IRB procedures, and best wishes for a successful study.

Sincerely,
Kristy Shirley

Kristy Shirley, CIP
Research Compliance Administrator

INSTITUTIONAL REVIEW BOARD
NDSU Dept 4000 | PO Box 6050 | Fargo ND 58108-6050 | 701.231.8995 | Fax 701.231.8098 | ndsu.edu/irb

Shipping address: Research 1, 1735 NDSU Research Park Drive, Fargo, ND 58102

NDSU is an EO/AA university.