

THE CORRELATION BETWEEN CRAVINGS AND REPORTED NUTRIENT
INTAKE IN FEMALE UNIVERSITY STUDENTS AGES 18-24

by

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ABSTRACT

Background: Cravings traditionally have been considered psychological or hormonal. Limited data exist regarding the physiological relationship between food cravings and nutrient intakes.

Objective: The purpose was to determine if a relationship exists between cravings and nutrient intakes. It was hypothesized that individuals with low self-reported macronutrient and/or micronutrient (magnesium, calcium, iron, zinc, vitamin C, B vitamins) intakes will report certain food cravings.

Design: This study utilized a cross-sectional, observational study design with convenience sampling.

Participants/setting: Recruitment occurred at Texas Christian University (TCU). Participants (n=26, age=20.7±1.3) completed a one-time visit (approximately 15 min) in which they each filled out an informed consent form and a questionnaire. Food and craving logs were recorded in participants' naturalistic environments. Of the 60 female TCU students recruited, 26 completed all requirements.

Intervention: Participants completed a 27-question survey followed by a five-day food and craving log using MyFitnessPal.

Main outcome measures: Intakes of each nutrient were averaged then calculated as percentage of the nutrient-specific RDA (%RDA). Food cravings were recorded and categorized, then compared to the average intakes and %RDA.

Statistical analyses: Data were coded and analyzed using SPSS to determine correlations between each reported nutrient intake and food cravings. Mean, standard deviation, Pearson correlation, frequencies, and variances were calculated for the data.

Results: A positive relationship was found between average carbohydrate intake and meat cravings. Negative correlations were found between carbohydrate intake and chocolate cravings and between zinc intake and fried food cravings.

Conclusions: This study demonstrates several correlations between reported macro- and micronutrient intakes and food cravings. Food cravings were also correlated to self-reported exercise frequency, regimen, and intensity; menstrual cycle flow; and alcohol intake. Limitations of this study include the small, homogenous sample and use of self-reported data.

Keywords: Craving, iron, zinc, vitamin C, B vitamins, food diary, MyFitnessPal, micronutrient, macronutrient

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CHAPTER I

INTRODUCTION

Over two billion people worldwide are chronically deficient in micronutrients.¹ The World Health Organization (WHO) has identified iron as the most underconsumed nutrient worldwide.² Interestingly, in 2011, the WHO determined that 29% (496 million) of adult non-pregnant women worldwide had anemia, with iron deficiency being the primary cause of over 50% of these cases.² The most common consequence of iron deficiency anemia, particularly during pregnancy, is pica, the craving of non-nutritive substances, including clay, dirt, and laundry starch.³ In the United States, inadequate intakes of folate, calcium, magnesium, fiber, potassium, vitamins A, D, E and C, and iron are considered major public health issues.⁴ Iron presents the greatest risk of deficiency in adolescent and premenopausal females since this population most often consumes inadequate amounts.⁴ The Dietary Guidelines of America Committee (DGAC) defines these micronutrients as shortfall nutrients since, on average, Americans consume these in amounts less than the Estimated Average Requirement (EAR) or Adequate Intake (AI) levels set by the Institute of Medicine (IOM).⁴

This study defined inadequate nutrient intake as below the recommended dietary allowance (RDA) established by the IOM. The RDA is the average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%–98%) healthy individuals.⁵ The RDA is specific to nutrient, age, and gender.⁵ A craving is a strong desire for a specific food which often cannot be resolved until an individual consumes said food. This study evaluated a potential correlation between each reported inadequate intake of macro- and/or micronutrients and reported food cravings among female university students 18-24

years old. The macronutrients are carbohydrates, protein, and fat, while the micronutrients selected for this study were magnesium, calcium, iron, zinc, vitamin C, and B vitamins. This study categorized food cravings as one of the following: chocolate, non-chocolate sweets, salty foods, fried foods, meats, dairy/dairy products, fruits, and vegetables.

This research study sought to contribute to the relatively limited research pool by examining a potential physiological correlation between food cravings and nutrient intake. Minimal scientific research exists regarding a correlation between suboptimal nutrient intakes and cravings, and many articles report cravings as psychological phenomena rather physiological. Current research on this topic mainly evaluates the relationship between pica and iron deficiency. Many of the articles on food cravings in women further assess the correlation between cravings and phase in the menstrual cycle and/or pregnancy. Few articles are independent of these factors, which is another reason this study sought to close the gap in current research.

Several naturopathic articles, which focus on drug-free alternatives to western medicine, speculate that certain nutrient deficiencies cause food cravings. Among these outdated and unsupported beliefs are correlations between the following: magnesium and chocolate⁶; fatty foods and calcium⁶; coffee or tea and iron⁶; alcohol and calcium⁶; and trace minerals (chromium, vanadium, magnesium, and zinc) and sugar⁷. These assumptions served as the basis for the present study, as scientific evidence is greatly lacking in this area.

The purpose of this study was to determine the prevalence of food cravings and their relation to adequate intakes, according to the RDA, in females 18-24 years old.

Therefore, this study will determine the presence of food cravings based on participant nutritional status. We hypothesized that females 18-24 years old with self-reported low intakes of macronutrients (carbohydrates, protein, and fat) and/or selected micronutrients (magnesium, calcium, iron, zinc, vitamin C, and B vitamins) would report food cravings as evidenced by (1) a five-day food diary, (2) a questionnaire including food frequency questions, and (3) self-reported food cravings by category.

CHAPTER II

REVIEW OF LITERATURE

Macronutrients

Food cravings are an exceedingly frequent phenomenon, especially among females. According to Merriam-Webster, carbohydrate, protein, and fat are the three macronutrients, defined as a chemical element or substance required in relatively large quantities in nutrition.⁸ Among common speculations are that specific macronutrient cravings result from physiological needs; however, another study, which focused on eating disorders, attributed cravings to the physiological need to alter neurotransmitters. Thus, there is inconclusive evidence regarding the relationship between cravings and physiological needs.⁹

Carbohydrates

Carbohydrates are the major energy source in the human diet as they contribute over half of daily caloric intake.¹⁰ There are many structural forms of carbohydrates, from simple monosaccharides to the most complex polysaccharides, but the main source of carbohydrates in the diet are starches (polysaccharides) and disaccharides.¹⁰ After being hydrolyzed into mono- and disaccharides during digestion, carbohydrates are absorbed in the small intestine and travel through the bloodstream to various cells in the body, which then convert the carbohydrates into needed energy.¹⁰ The RDA of carbohydrate for women 19 to 30 years of age is 130 g/d, which would equate to about eight and a half pieces of bread.¹⁰ Unless an individual follows a carbohydrate-restricted diet, intake will meet RDA requirements because all fruits, vegetables, grains, and dairy products contain carbohydrates.

In a study evaluating the consumption patterns of female participants who craved high-carbohydrate foods following the consumption of protein-rich meals, researchers compared the macronutrient composition of a consumed meal to that of a craved food and concluded that the carbohydrate craving resulted from a macronutrient compensation mechanism of the body; after consuming high amounts of one macronutrient, individuals crave another macronutrient.¹¹ Another study evaluated the cravings of restricted foods by Japanese female undergraduate students and found that participants most commonly craved rice.¹² This was the first study to present empirical data supporting that carbohydrate deprivation heightens cravings for a carbohydrate-rich staple food such as rice.¹² However, it is questionable whether this craving resulted from physiological need for carbohydrates or sheer likeability of the staple food.¹²

In regards to carbohydrate intake and cravings, one of the avenues for prediction is Flatt's model.¹³ Flatt developed the "glycogenostatic model," which suggests a physiologic mechanism responsible for the maintenance of stable glycogen stores.¹³ This model is characterized by a negative correlation between carbohydrate balance and subsequent daily intake, indicating that the intake of carbohydrate-rich foods may be stimulated by low glycogen levels in an effort to replenish stores.¹³ Flatt's hypothesis was tested on animals, however, and few human studies involving the relationship between dietary manipulation and glycogen stores have been performed. Those that have been conducted have produced largely negative and/or inconsistent effects on intake.¹³

Protein

Present throughout the body, protein is essential to cell structure and repair.¹⁰ Skeletal muscle, body organs, and skin and blood contain the largest percentages of

protein, with 40%, 25%, and 35%, respectively.¹⁰ Amino acids are the building blocks of proteins; they are essential components, meaning they can only be obtained from dietary sources rather than endogenous synthesis. Proteins have many functional roles throughout the body, including catalytic enzymes, hormonal messengers, structural roles, fluid balancers, and wound healing responders.¹⁰ The RDA of protein for females 19-30 years of age is 46 grams (g) protein per day or 0.8 g/kg body weight/day of protein.¹⁰ According to the National Health and Nutrition Examination Survey 2003-2004, 7.7% of adolescent females and 7.2-8.6% post-adolescent adult women reported consuming less protein than their average RDA requirement, whereas the percentage of males not meeting the requirement was very low.¹⁴

Fat

Fats, also known as lipids, serve as an energy source for the body and as constituents of cell and organelle membranes. Fats also serve as the basis of fat-soluble vitamins, some hormones, and certain transport molecules.¹⁰ Food preparation techniques that rely on fats include baking, frying, and sautéing.¹⁰ In each method, fat contributes desirable sensory qualities, such as richness in flavor and mouthfeel.¹⁰ The 2015 Dietary Guidelines recommend average daily intakes of 19 g of oil and 24-31 g of solid fats.¹⁵

Micronutrients

According to Merriam-Webster Dictionary, micronutrients are organic compounds, which are essential in minute amounts to the growth and health of an organism's physiology.¹⁶ The average adult requires between 1 and 100 milligrams (mg) of each micronutrient per day, depending on the specific vitamin or mineral.¹⁰

Calcium

Calcium, which comprises 40% of the body's mineral mass and 2% of total body weight, is the most abundant cation found in the body.¹⁰ It functions as a structural component of bones and teeth with metabolic roles in cellular muscle contraction, blood clotting, and enzyme activation.^{10,17} Food sources of calcium include dairy and dairy products, sardines, oysters, turnip and mustard greens and legumes.¹⁸ The RDA for calcium is 1000 mg/d for non-pregnant females ages 19 to 50 years old.¹⁷

Prior to absorption, calcium undergoes solubilization during digestion.¹⁰ While the small intestine absorbs approximately 50% to 60% of dietary calcium, the average adult absorbs only about 25% to 30% dietary calcium.¹⁰ Many factors affect calcium absorption. Growth, pregnancy, lactation, and increased parathyroid hormone (along with the consumption of lactose, sugars, sugar alcohols, and protein) increase calcium absorption.¹⁰ Caffeine, phytic acid, some fibers, and oxalic acid decrease absorption.¹⁰

Calcium deficiency results from inadequate intake, poor absorption, excessive losses, or a combination of these factors.¹⁰ This mineral deficiency, which affects bone and muscle, is the primary cause of rickets in children and osteoporosis in adults.¹⁹ Symptoms of rickets and osteoporosis include lethargy, arrhythmias, tetany, paresthesia, convulsions and weakened bone matrix.^{10,17} The most effective treatment for rickets is calcium supplementation.¹⁹ Research has found correlations between inadequate calcium intake and hypertension, colon cancer, type 2 diabetes mellitus, and overweight/obesity.¹⁰

Magnesium

Bones, extracellular fluids, soft tissues (namely skeletal muscle) and organs, such as the liver and kidneys, contain magnesium, which is the second most abundant

intracellular cation after potassium.^{10,20} Magnesium has functions in bone formation, nerve impulse transmission and protein synthesis as an enzyme cofactor.^{10,20} Food sources of magnesium include nuts, legumes, whole grain cereals, chocolate, coffee, green leafy vegetables, seafood, and certain spices.¹⁰ Food processing may significantly reduce a food's magnesium content by over 75%.¹⁰ The RDA for magnesium is 310 mg/d for non-pregnant women ages 19 to 30 years old.²¹ Individuals with fat malabsorption, inflammatory bowel disease, and/or pancreatic diseases often require magnesium supplements; optimal absorption of magnesium supplements occurs when taken at the same time as other mineral supplements.¹⁰

Unlike other major minerals, dietary magnesium does not require digestion before absorption.¹⁰ The small intestine serves as the absorption site for magnesium, and the colon may also play a role if a disease causes impaired small intestine function.¹⁰ The intestine absorbs approximately 30% to 40% of dietary magnesium,²² though absorption increases when magnesium intake is less than 40 mg/d.¹⁰ Several dietary factors inhibit magnesium absorption, including high quantities of unabsorbed fatty acids in the gastrointestinal tract, potassium, phosphorus, phytic acid and non-fermentable fibers.¹⁰

Magnesium deficiency primarily results from inadequate dietary intake, vomiting and diarrhea, excessive alcohol use, malabsorptive diseases, and/or chronic use of diuretics, proton pump inhibitors, and antibiotics.^{10,22,23} Estimates suggest that nearly 60% of Americans do not meet daily magnesium requirements.²³ Nonspecific symptoms of hypomagnesemia, including depression, fatigue and muscle spasms, may take years to develop. However, research has shown a correlation between low magnesium intakes and cardiovascular diseases (namely hypertension) and diabetes mellitus.²²

Iron

Iron, a trace mineral, is a component of hemoglobin, myoglobin, enzymes and blood.^{10,24} It functions in oxygen transport and storage, erythropoiesis, electron transport, amino acid metabolism, DNA purine base catabolism, and the synthesis of niacin, carnitine, procollagen, nitric oxide, and DNA.^{10,25}

Dietary iron is categorized as heme or nonheme iron based on its chemical structure; the body more easily absorbs the heme form.²⁴ Animal products, such as meat, fish and poultry, contain mostly heme iron (porphyrin ring), while iron in plant foods, nuts, tofu, and dairy products is in the nonheme form.¹⁰ Oral iron supplements provide iron in this less-absorbable, nonheme form.¹⁰ The RDA for iron is 18 mg/d for non-pregnant females ages 19 to 50 years old.²⁴

Several dietary components affect iron absorption. Sugars, acids, meat, poultry, and fish enhance nonheme iron absorption by chelating or serving as ligands with iron.¹⁰ Polyphenols (tannins), oxalic acid, phytic acid, and phosvitin inhibit nonheme iron absorption by forming a complex with iron; calcium may also interfere with the acute absorption of both heme and nonheme iron.^{10,25} Tannin sources include tea, coffee, grain products, oregano and red wine, while the only known phosvitin source is egg yolk.¹⁸ Sources of oxalic acid include spinach, chard, berries, chocolate and tea, whereas those of phytic acid include whole grains and legumes.^{10,24} An alkali gastrointestinal tract, usually the result of medications or aging, may also inhibit iron absorption.¹⁰

While a person's iron status affects absorption rates, the majority of American adults absorb only 10% to 18% of their dietary iron intake.¹⁰ Inadequate iron intake causes the majority of iron deficiency cases. Infants and young children, adolescents,

females during childbearing years and pregnant women are at increased risk of iron deficiency due to low iron content of milk, growth spurts, menstrual iron losses, and expanded blood volume, respectively.^{10,24} Because iron deficiency anemia and poverty are related, developing countries tend to have more cases of iron deficiency anemia, particularly among these identified populations.²⁵ Symptoms of iron deficiency include pallor, behavioral disturbances, impaired cognitive abilities, fatigue, and short attention span.¹⁰ Supplementation is the most effective and used treatment for iron deficiency.¹⁰

Zinc

All organs, tissues and body fluids contain zinc, categorized as both a metal and trace mineral.¹⁰ Zinc serves as a metalloenzyme component and also functions in immunity, sexual maturation, fertility and reproduction.²⁶ Physiologically, zinc acts in bone formation and skin and cell membrane integrity.¹⁰

Dietary zinc sources include oysters, beans, nuts, whole grains, fortified breakfast cereals and dairy products.²⁶ The RDA for zinc is 8 mg/d for non-pregnant females over 19 years old.²⁷ As with iron, zinc has the ability to bind with chelators or ligands, thereby inhibiting absorption. Dietary components that may inhibit zinc absorption include phytic acid, oxalic acid, folate, iron and calcium. While research has not shown that dietary components increase zinc absorption, other factors do. These enhancers include organic acids, prostaglandins, pancreatic secretions, glutathione, and an acidic environment.¹⁰

Zinc deficiency may have long-term repercussions if not treated immediately. In children, zinc deficiency may result in growth retardation, skeletal abnormalities, poor wound healing, dermatitis, and delayed sexual maturation.^{10,26} Adults experience a different set of signs and symptoms, among which are anorexia, diarrhea, lethargy,

depression, dermatitis, hypogeusia (impaired taste sensation), alopecia, and impaired immune function, protein synthesis and wound healing.¹⁰

Vitamin C

Vitamin C is a water-soluble vitamin that functions in the growth and repair of tissues.¹⁰ The urine excretes unused amounts of the water soluble vitamins, thereby increasing the importance of daily intake as deficiency develops more quickly than it does with fat soluble vitamins.¹⁰ Vitamin C also acts as an antioxidant, which can inhibit oxidative cell damage caused by free radicals.¹⁰ More pertinently, vitamin C increases absorption of both heme and nonheme iron, which is an important factor to consider when evaluating females of menstruating age for micronutrient deficiencies.²⁸

Humans are one of the few mammals that are unable to synthesize vitamin C endogenously; thus, vitamin C must be obtained from the diet.¹⁰ Individuals must consume water soluble vitamins, including vitamin C, more frequently due to the lack of a storage mechanism in the body.¹⁰ Citrus fruits (e.g., oranges and grapefruits), cantaloupe, kiwi, mango, pineapple, and a variety of berries are significant sources of vitamin C, supplying between 70 and 80 mg/serving.¹⁰ Vegetables such as broccoli, Brussels sprouts, peppers, spinach, tomatoes, and potatoes also contain appreciable amounts of vitamin C.²⁸ Fortified breakfast cereals may contribute to vitamin C intake based on the individual food's processing.²⁸

The major form of vitamin C in foods is ascorbic acid.¹⁰ The small intestine absorbs approximately 70% to 90% of dietary ascorbic acid (between the amounts of 30-180 mg), as regulated by active transport.¹⁰ If an individual consumes greater than 1 g/d, the absorption rate decreases to 50%, as vitamin C needs have already been met.¹⁰

Likewise, the absorption rate increases when vitamin C intake is insufficient to meet daily needs.¹⁰ The current RDA for women is 75 mg/d, though this amount increases during pregnancy, lactation, and smoking.¹⁰ If vitamin C intake is consistently below the RDA for a month or longer, scurvy will develop.¹⁰ This vitamin deficiency causes compromised tissue integrity due to impaired collagen synthesis and weakened connective tissue weakens.²⁸ Other signs of scurvy include joint pain, poor wound healing, petechiae, ecchymoses, and purpura.²⁸ Studies have found that depression, gingivitis, and iron-deficiency anemia often occur in conjunction with chronic vitamin C deficiency.²⁸

B Vitamins

Niacin

Niacin, also known as nicotinic acid or vitamin B3, primarily functions in macronutrient metabolism while also supporting digestive function, skin integrity, and nerve function.²⁹ Niacin is a water-soluble vitamin and therefore must be obtained from the diet, as storage is not possible.¹⁰ Because niacin is tightly bound to protein, the best sources of niacin include animal products, such as meat, poultry, eggs, and fish; enriched bread products, nuts, and legumes also contain considerable levels of niacin.³⁰ Niacin also has been found in coffee and tea as a result of the roasting process.³⁰

The stomach and small intestine absorb nearly all dietary niacin consumed.¹⁰ Tryptophan aids in niacin metabolism; thus, individuals must consume at least 60 mg/d of tryptophan in order to metabolize this water soluble vitamin.¹⁰ Since the average US diet contains around 900 mg of tryptophan intake daily, tryptophan is rarely the reason for

niacin deficiency.¹⁰ Deficient levels of niacin can lead to pellagra, a disease state characterized by digestive complications, severe dermatitis, and mental impairment.³⁰

Thiamin

Thiamin, a B vitamin, helps the body convert carbohydrates into energy, specifically for use in the muscles, heart, kidney, liver, and brain.¹⁰ Thiamin also plays a role in conduction of nerve cells and muscle contraction.²⁹ Like all B vitamins, this water-soluble micronutrient must be consumed in consistent amounts in order to meet the body's needs. Thiamin differs from other water-soluble vitamins, though, in that the body perpetually stores 30 mg of thiamin in the liver, muscles, heart, kidney, and brain for maintenance needs.¹⁰

The RDA for thiamin is 1.1 mg/d for adult women.¹⁰ The majority of dietary thiamin comes from food products enriched with B vitamins (such as enriched grain products), animal products, legumes, nuts, and seeds.¹⁰ The primary sites of niacin absorption are jejunum and ileum, where dietary thiamin is absorbed at a fairly high level due to its function in supporting critical organs in the body.¹⁰ Alcohol tends to inhibit intestinal thiamin absorption; therefore, individuals who consume excessive amounts of alcohol have a greater risk of thiamin deficiency.³¹ Additionally, those over-consuming alcohol will require increased intakes of thiamin due to decreased absorption.^{14,31}

Riboflavin

Riboflavin, also known as vitamin B2, is responsible for erythropoiesis, cellular growth, and energy cleavage from proteins, which are all crucial to body functioning.^{10,32} Riboflavin consumption on a daily basis is essential to maintain adequate levels, which thereby ensure that riboflavin can adequately perform its roles in the body.¹⁰

Riboflavin is found in a wide variety of foods, but especially those of animal origin (such as milk products, eggs, and meat - specifically organ meats); additional sources of this nutrient include green leafy vegetables, legumes, and nuts.^{10,32} The RDA for riboflavin is 1.1 mg/d for women.³²

Hydrochloric acid in the stomach partially digests riboflavin prior to absorption in the small intestine.¹⁰ About 95% of dietary riboflavin is absorbed.¹⁰ Deficiency in riboflavin is fairly uncommon in the United States, as the average American diet is high in animal products. If deficiency does occur, symptoms, such as oropharyngeal edema, anemia, and widespread inflammation, will appear.^{14,32}

Vitamin B6

Vitamin B6 aids in the production of several neurotransmitters and hormones; it also promotes brain development and function through regulation of gene expression. While plant-based foods have the highest amounts of vitamin B6, some meats and fish also contain this vitamin; these sources include steak, salmon and pork loin.¹⁰ Vitamin B6 can be lost through certain storage and preservation methods, including prolonged heating, canning, and the milling and refining of grains.¹⁰ Overall absorption of B6 is about 75%, with the liver serving as the main organ for vitamin B6 metabolism before the unabsorbed vitamin is excreted in the urine.¹⁰ Muscles are the primary site of storage, maintaining up to 80% of vitamin B6 stores.¹⁰

The RDA for both men and women aged 19-50 years is 1.3 mg/day, with pregnancy and lactation recommendations increasing to 2 mg/day.¹⁰ B6 deficiency is rare in the US but spiked in the 1950's when infant milk was overheated, causing decreased vitamin activity.¹⁰ Signs of deficiency can take up to 2.5 months to surface and can be

characterized by a seborrheic rash, fatigue, confusion, neuropathy, and seizures.¹⁰

Vitamin B6 deficiency also impairs niacin synthesis, therefore inhibiting homocysteine metabolism, which may increase risk for heart disease.¹⁰

Vitamin B12

Vitamin B12, found primarily in animal products such as meat, poultry, fish/shellfish, and eggs, helps maintain nervous, hematologic, and genetic functioning.¹⁰ Vitamin B12 is relatively stable and resistant to light, heat, and oxidation, which allows it to be fortified into cereals and soy milk.¹⁰ B12 digestion occurs in the stomach with the help of gastric intrinsic factor; the enterocytes then participate in B12 absorption.¹⁰ Only 0.1% of consumed B12 is utilized, with the majority of B12 being excreted in bile.¹⁰

Impaired B12 absorption leading to B12 deficiency can cause megaloblastic macrocytic anemia.¹⁰ B12 deficiency is most likely to occur in strict vegans and vegetarians, who consume minimal to no animal products, as well as the elderly, who produce less gastric intrinsic factor. B12 deficiency results in hematologic and neurologic symptoms.¹⁰ The RDA for adults is 2.4 micrograms (μg)/day, with higher recommendations during lactation and pregnancy.¹⁰

Comparison to Other Studies

One study analyzed the effects on weight gain of sensitivity to food cues and subsequent cravings.³³ Boswell and Kober³³ demonstrated that reactivity to picture and video cues had a strong relationship with the reactivity to visual cues of real food, though neither was significantly related to weight gain.³³ Another study examined the psychological relationship between food cravings and both brain chemistry and neural activity.³⁴ This second study found that exposure to food and stress cues lead to several

physiological reactions, including increased activation in striatal, insular, and hypothalamic regions in the brain; this increased neural activity had a positive relationship with food cravings and insulin.³⁴ Jastreboff et al³⁴ concluded that improving insulin sensitivity may greatly decrease food cravings, thereby suggesting a physiological cause of food cravings.³³

CHAPTER III

METHODS

Study Design

This study was a cross-sectional, observational study design with convenience sampling. The Texas Christian University Institutional Review Board (IRB) approved this research study. All recruitment occurred on campus at Texas Christian University (TCU). Participants completed a one-time visit, approximately 15 min, and were asked to record dietary intake and food cravings for five consecutive days using MyFitnessPal (Under Armour, Baltimore, MD).

Participants first completed an in-person screening (age and gender). During the study visit, participants had the opportunity to ask questions about the study before signing the Consent to Participate in Research Form (TCU, Fort Worth, TX). Participants then signed the Protected Health Information Authorization Form (TCU, Fort Worth, TX), stating that the Health Insurance Portability and Accountability Act (HIPAA) would be upheld throughout the study. Participants then completed an in-person questionnaire. Each participant was assigned a random participant identification code, which was used on all research-related documents and to create emails for associated MyFitnessPal accounts. Before leaving the study visit, participants were instructed to keep an electronic diary (MyFitnessPal), recording all food and beverage intakes and cravings for five consecutive days. Participants received a handout with directions for diary logging, which included how to access their MyFitnessPal accounts (either online or using the free smartphone application) and how to estimate portion sizes of consumed foods and beverages based on comparison to common objects (see **Appendix A**).

Daily intakes of calorie, carbohydrate, protein, fat, calcium, iron, and vitamin C were extracted from the five-day MyFitnessPal diaries. Participants' reported food and beverage intakes were entered into SuperTracker (USDA, Washington D.C.) to obtain the daily intakes of magnesium, zinc, vitamin B6, vitamin B12, thiamin, riboflavin, and niacin, which were unavailable in the MyFitnessPal database.

Participants

Participant Recruitment

In the fall of 2015, female students at TCU were recruited through class presentations, announcements at campus organizations, and word of mouth. During the recruitment process, participants were provided with a description of the study as well as an overview of participant responsibilities. It was clearly stated in each recruitment presentation that the eating patterns of the individuals should be unaltered, as the goal of this study was to examine existing behaviors and their physiological effects, rather than provoke a behavior change during the course of the study. Participation was voluntary for this study, and participants had the option to withdraw at any point by contacting the principal investigator. In order to prevent the encouragement of otherwise uninterested participants, there were no tangible incentives for participation in this study. Of the 60 recruited participants, 26 females completed the entire five-day food diary and were therefore included in the data analyses.

Number of Participants

Through the recruiting process, 60 female TCU students between the ages of 18 and 24 volunteered to participate in this study. These participants, in order to be

successfully recruited, must have met the inclusion criteria to increase the validity and reliability of the study results.

Inclusion Criteria

The inclusion criteria were: female gender, between the ages of 18 and 24 years, and a current TCU student. Participants must have met each of the inclusion criteria in order to enter into this study. Additionally, participants were screened to assess willingness to commit to and complete all steps of the study; this increased participation rates and minimized outliers in the data, thereby allowing for more accurate extrapolation of study conclusions to the general population of females between the ages of 18-24.

Exclusion Criteria

The following were the exclusion criteria for this study: male gender, less than 18 years of age or greater than 24 years of age, and not a current TCU student. For those who met all the inclusion criteria, an additional exclusion criterion was failure to complete all study requirements (consent and HIPAA forms, screening, questionnaire, and five-day food and craving log). Data from these participants were therefore excluded. Of the 60 recruited participants, 34 females were excluded from the study due to incomplete food and craving diaries. Thus, 26 females completed the study entirely and were included in data analyses.

IRB/Process of Informed Consent

Approval for this study was granted by the TCU IRB to promote an ethical study design and protect participant rights. The study description was outlined in the Consent to Participate in Research Form, which was clearly presented to and signed by participants in order to increase understanding of the study and its requirements. Signed HIPAA

forms were also obtained from each participant prior to beginning the study to assure participants that their confidentiality and safety would be maintained throughout the study. Any questions regarding the study were addressed by the researchers.

Protocol

Questionnaire

Participants completed a 27-question survey (see **Appendix B**) that asked about self-reported anthropometrics (2 questions), age, physical activity (3), alcohol and drug use (2), menstrual cycle (2), pregnancy status (1), dietary restrictions (7), daily food intakes (7), and food cravings (2). These questions were fill-in-the-blank (3), multiple choice (18), and yes/no (6).

Food Diary

Participants were given anonymous login information for MyFitnessPal, which matched their assigned identification codes. Participants were given instructions on using MyFitnessPal to log both cravings and intakes of food and beverage (Appendix A). Participants were provided with information on estimating serving sizes by comparing amounts to ordinary objects (Appendix A); this increased participants' ability to log appropriately, thereby yielding more accurate results.

MyFitnessPal was chosen because it is user-friendly and allows participants to scan food product barcodes, thus allowing for greater precision regarding nutrient compositions. There is also a notes section in MyFitnessPal, where participants were instructed to record food cravings. The usernames and passwords were used to access each participant's MyFitnessPal account one month after the participant began the study;

this provided adequate time for each participant to complete her five-day food and craving log before researchers accessed the information.

Total Calorie and Nutrient Recommendations

Calorie requirements were calculated for all participants as 25 kcal/kg body weight (BW). The Acceptable Macronutrient Distribution Ranges (AMDR) set by the IOM were used to calculate macronutrient requirements; AMDR is calculated from calorie recommendations. The midrange of the AMDR for each macronutrient was taken; percentages were adjusted by an equal amount in order to reach 100% total calories. For this study, the macronutrient distribution was as followed: 53.4% calories from carbohydrate, 20.8% from protein, and 25.8% from fat. The RDA was used for each selected micronutrient.

Average Nutrient Intake

Participant dietary intake was evaluated using nutrient composition data from the MyFitnessPal food diary and SuperTracker. SuperTracker was used to analyze intakes of magnesium, zinc, riboflavin, niacin, thiamin, and vitamins B6 and B12 since MyFitnessPal did not have data on these specific micronutrients.

Statistical Analyses

SPSS version 23 statistical analysis software (IBM Corporation, Armonk, NY) was used for all analyses. Each nutrient intake was averaged over the five-day period for each participant. Each of these average nutrient intake values was calculated as a percentage of that nutrient's RDA (%RDA), specific to this sample's sex and age range. Nutrient intake was assessed as an average over the five days in order to provide a more accurate indication of nutritional status and to better identify correlations to reported food

cravings. Statistical analyses for frequency and measures of variability were run for both the average five-day intake (in grams, milligrams, or micrograms, specific to each nutrient) and the %RDA. Descriptive statistics (measures of central tendency: mean, mode, standard deviation, range) were calculated for each variable using SPSS. Statistical significance was established at $p < 0.05$.

CHAPTER IV

RESULTS & DISCUSSION

Results

Participants

The study sample consisted of female TCU students between 18 and 24 years of age. Sixty participants were recruited, completed the initial questionnaire and were given the study instructions. Of these 60 initially recruited participants, 26 females completed all five days of the food and craving diary and were included in data analysis. All participants denied smoking, current or previous pregnancies, and food allergies on the questionnaire. Baseline characteristics are represented in **Table 1.1**. Results were obtained from each participant's questionnaire (Q) and food and craving diary (D).

Nutrient Intake

The %RDA of carbohydrate consumed (D) was positively correlated to meat cravings ($r=0.560$, $p=0.003$). Similarly, average carbohydrate intake (D) was positively correlated to meat cravings (Q) ($r=0.412$, $p=0.036$). Questionnaire results indicated that alcohol intake was positively correlated with the number of cravings per week ($r=0.546$, $p=0.004$). Based on questionnaire data, it was also determined that fruit intake was positively related to fruit cravings ($r=0.613$, $p=0.001$), while dairy intake was positively related to dairy cravings ($r=0.721$, $p<0.001$).

Less significantly, salty cravings (Q) were positively correlated to logged salty cravings (D), but negatively correlated with meat cravings (D) and chocolate cravings (D) ($r=0.400$, $p=0.043$; $r=-0.392$, $p=0.048$; and $r=-0.470$, $p=0.015$, respectively). Chocolate cravings (Q) were negatively correlated with salty cravings (D) ($r=-0.390$,

$p=0.049$). Questionnaire-reported cravings for fried foods, dairy foods, and vegetables positively corresponded to logged cravings for fried foods, dairy foods, and vegetables, respectively ($r=0.436$, $p=0.026$; $r=0.459$, $p=0.018$; and $r=0.474$, $p=0.014$, respectively). Following a low fat diet (Q) was negatively correlated with nut and seed consumption (Q) ($r=-0.469$, $p=0.016$). Finally, grain intake (Q) was positively correlated with calcium intake ($r=0.461$, $p=0.018$) and %RDA consumed ($r=0.461$, $p=0.018$).

Food Diary

Average intake and %RDA of the studied macro- and micronutrients are represented in **Table 1.2**, and average intake represented as a %RDA for calories and macronutrients, vitamins, and minerals are represented in **Figure 1.1**, **1.2**, and **1.3**, respectively. The average number of food cravings reported over the course of the five-day diary was 4.4 ± 3.7 cravings per participant. Cravings reported on the questionnaire compared to cravings logged in the diary are represented in **Figure 1.4**. The total number of cravings (D) positively correlated with cravings of meat (D) ($r=0.579$, $p=0.002$), sweets (D) ($r=0.596$, $p=0.001$), salty foods (D) ($r=0.583$, $p=0.002$), fried foods (D) ($r=0.561$, $p=0.003$), and fruit (D) ($r=0.542$, $p=0.004$). The number of chocolate cravings (D) was negatively correlated with average carbohydrate intake (D) ($r=-0.564$, $p=0.003$) and %RDA of carbohydrate consumed (D) ($r=-0.495$, $p=0.010$). The only micronutrient intake associated with cravings was zinc; average zinc intake (D) and %RDA of zinc (D) were negatively correlated to reported fried food cravings (D) ($r=-0.393$, $p=0.047$).

Exercise

Exercise frequency (Q) was positively correlated with intakes of calcium ($r=0.533$, $p=0.005$), magnesium ($r=0.609$, $p=0.001$), and riboflavin ($r=0.566$, $p=0.003$).

Exercise regimen (Q) was positively correlated with fruit cravings (Q) ($r=0.439$, $p=0.025$) but negatively correlated to meat intake (Q) and cravings (D) ($r=-0.628$, $p=0.00$; $r=-0.413$, $p=0.036$, respectively). Lastly, exercise intensity (Q) was positively correlated with vegetable intake (Q) ($r=0.598$, $p=0.001$) but negatively correlated with fried food intake (Q) ($r=-0.501$, $p=0.009$).

Menstruation

Participants who reported heavy menstrual flow reported fewer total cravings (D) ($r=-0.501$, $p=0.009$), lower sweets intake (Q) ($r=-0.426$, $p=0.030$), and fewer vegetable cravings both on the questionnaire ($r=-0.457$, $p=0.019$) and on the food diary ($r=-0.501$, $p=0.009$). On the other hand, heavy menstrual flow (Q) was positively correlated with average fat intake (D) ($r=0.406$, $p=0.040$).

Discussion

The aim of this study was to determine the prevalence of food cravings and their relation to adequate nutrient intake, based on each nutrient's RDA, in females between the ages of 18 and 24 years old. Many correlations were identified. The only micronutrient associated with cravings was zinc; participants who consumed higher than average zinc intakes logged more cravings for fried foods.

Data supports that the greater the %RDA for carbohydrates consumed, the greater the chance that a participant reported craving meat on the questionnaire. Conversely, consuming a higher amount of carbohydrates was correlated to a decreased incidence of chocolate cravings. Participants who reported drinking more than one alcoholic beverage per day were found to have a greater number of cravings per week.

Chocolate was also found to have a relationship with salt. A negative correlation was found between cravings for chocolate and those for salty foods, as participants who reported craving chocolate on the questionnaire were less likely to log cravings for salty foods in the diary. Additionally, participants who reported craving salty foods on the questionnaire were less likely to log meat cravings in the diary.

Finally, while exercise and menstruation were not explicitly examined in this study, several correlations were identified. A positive correlation was found between reported exercise frequency and the intakes of calcium, magnesium, and riboflavin. Participants who reported heavy menstrual flow recorded higher fat intakes, a lower intake of sweets and fewer cravings overall, specifically of vegetables.

Minimal scientific evidence exists that addresses a physiological relationship between cravings and intake. Despite this lack of empirical evidence, it has been speculated that diets low in trace minerals – namely chromium, vanadium, magnesium, and zinc – are linked to an increased number of sugar cravings.¹ In contrast to this proposed connection, however, data from the present study indicate that participants who consumed adequate amounts of zinc were more likely to crave fried foods than sugar.

While this was not exclusively a mechanistic study, it evaluated a potential physiological correlation between cravings and nutrient intake. Most correlations identified in this study involved carbohydrates, chocolate, salty foods, and alcohol. Carbohydrates, which are metabolized into glucose, serve as the primary fuel for the brain. It is possible that individual stress levels, which result partially from academic course load, may affect the brain's need for glucose and therefore require increased carbohydrate intake. Chocolate and salty foods are among the most commonly craved

foods. The inverse relationship between cravings for chocolate and those for salty foods indicate that individual taste sensations may play a role in cravings. It is possible that the higher the taste threshold for salt, the lower the taste threshold for sweet. Furthermore, it is likely that alcohol suppresses the thirst mechanism and instead triggers hunger.

There were some limitations in the current study that warrant discussion. Due to the relatively small pool of recruited participants, it is possible that the final sample size (n=26) was too small to demonstrate significance in the relationship between reported nutrient intakes and food cravings.

Additionally, all data were self-reported. While quantitative data were obtained by conducting nutrient analysis on participant food diaries, this study did not obtain concrete baseline data regarding participants' nutritional status. Likewise, the relatively short time frame (five days) for data collection prevented researchers from properly assessing nutritional status and its relation to cravings.

Finally, human error in the logging process and self-administered questionnaire increases the likelihood that foods and/or cravings could have been overlooked or improperly logged. While participants were provided written directions and the opportunity to ask researchers questions, participants were not verbally educated on portion sizes and how to properly estimate food and beverage intake.

In order to increase statistical significance, it may be advantageous to conduct research using controlled nutrient intakes in relation to more specific food cravings over a longer time period. Additionally, the nutritional status of each participant should be assessed prior to study initiation using blood serum levels or other established methods.

Though minimal correlations were found, this study allowed researchers to address gaps in current research regarding cravings. This study can serve as a model for future studies, particularly due to the ability of researchers to identify limitations and therefore allow for more thorough, quantitative research designs in the future.

Results from this study may impact dietetics, given that cravings were not found to be physiological in nature. Since cravings can contribute to disordered eating, it is useful to know that cravings are not physiological and that the mind has the ability to overpower urges for certain foods. Dietitians and other nutrition experts have the ability to utilize motivational interviewing in their practice in order to help their clients overcome cravings and disordered eating. This study supports that dietitians should continue emphasizing a balanced diet, which may help control cravings given the relationships identified in this study.

CHAPTER V

CONCLUSIONS

Conclusions

The present findings indicate a physiological relationship between self-reported nutrient intakes and food cravings. The only macronutrient linked to food cravings was carbohydrate, while the only micronutrient was zinc. The most significant positive correlation found was between %RDA of carbohydrate consumed and meat cravings, and the most significant negative correlations were between carbohydrate intake and chocolate cravings and between zinc intake and fried food cravings.

Individuals who consume larger amounts of carbohydrates may not be consuming as much protein, thus explaining the positive relationship between %RDA of carbohydrate and cravings for meat. The inverse relationship between carbohydrate intake and chocolate cravings could be explained by the relatively high carbohydrate composition of most chocolate varieties; it is likely that the greater the individual's carbohydrate intake, the lower her physiological need for the carbohydrates found in chocolate. The negative correlation between zinc intake and fried food cravings could potentially be the result of a physiological need for more fat, since dietary sources of zinc, which include red meat, beans, nuts, and fish, tend to be higher in fat.

Overall, most participants reported adequate macro- and micronutrient intakes (see Figures 1.1, 1.2, and 1.3). Participants' food diaries did support the DGAC in identifying vitamin C, calcium, and magnesium as shortfall nutrients, as participants reported consuming less than 100% RDA of each of these micronutrients. However,

participants in this study consumed more than adequate amounts of iron, which globally is the most underconsumed nutrient.

Clinical Implications

The current research pool does not demonstrate that cravings have a physiological etiology. However, registered dietitians (RDs) and other nutrition professionals can utilize this study's findings of a physiological relationship to tailor their education and counseling sessions. Since disordered eating is prevalent among this population, RDs can adopt motivational interviewing techniques to help individuals overcome cravings and consume a more healthful, balanced diet. Knowledge of craving etiology may also assist health professionals in referring patients to appropriate services.

Suggestions for Future Research

Future studies would benefit from a larger sample size and longer time frame. Selecting a few nutrients and cravings to evaluate may aid researchers in acquiring more statistically significant results regarding the physiological relationship between cravings and nutrient intakes. Future studies should better examine the relationships between zinc intake and fried food cravings and between carbohydrate intake and chocolate cravings.

Researchers also should consider obtaining physiological data regarding nutritional status and hormones involved in food cravings. A more comprehensive picture of the participants' eating habits or nutrition status could be obtained by using a standardized food frequency questionnaire. More significant results could be produced by controlling the participants' diet by providing meals and/or controlling supplementation of certain nutrients. Serum analysis before and after the study could lead to a better sense of nutrient intakes and reveal if any clinical deficiencies were present.

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APPENDIX A

HOW TO KEEP A FOOD LOG

- Record all food and drink consumed, including water, for five consecutive days, including at least one weekend day.
- Record food eaten and drank immediately after consumption, as it becomes more difficult to recall as more time passes.
- MyFitnessPal will be used to track intake. MyFitnessPal can be used online on a computer or smartphones using Apple or Android apps.
- Step-by-step instructions for creating an account (computer version):
 - Even if you have used MyFitnessPal before, please create a new account for the purpose of this research project.
 - Enter your assigned username: **ASM001**, password: **asm001**, and email address **asm001@gmail.com**.

The screenshot shows a web form titled "Your Account Information". It contains three input fields: "Username:" with the placeholder "username" and a note "4-30 characters, no space"; "Email Address:"; and "Password:" with a masked password "*****" and a note "6-255 characters, no space". Below these fields is a checkbox labeled "Receive our free newsletter with diet tips, recipes and more?". A "Continue »" button is positioned below the checkbox. Underneath the button, a small text block reads: "By clicking Continue you're indicating that you have read and agree to the Terms of Service and Privacy Policy and that you're at least 18 years of age." At the bottom of the form, there are two links: "▶ Already have an account? Click here to log in." and "▶ Forgot your username or password?"

- Enter your personal information in the “Tell Us About Yourself” section. It’s important for the entered information to be accurate. Your identity will not be revealed in any part of this investigation.
 - Choose “Maintain my weight” in the pull down menu for your

The screenshot shows a section titled "What is your goal?". It features a dropdown menu with "Maintain my current weight" selected. Below the dropdown is a "Save And Continue »" button.

current goal, whether or not you have a different goal.

- Skip the next section, and then press “Get Started Now”
- A confirmation email will be sent to your entered email. It should arrive shortly, and be sure to check your spam folder if it doesn’t.

When logging food and drinks, try to be as specific as possible both with amount eaten and form of food.

- When entering an item like a sandwich, think of it as all of the components and quantify.
 - Example: 2 slices wheat bread, 4 slices low sodium turkey breast, 2 slices tomato, 3 leaves romaine lettuce, 2 tsp. low fat mayo, etc.
- It can be difficult to gauge the exact amount of food eaten. Use these practical comparisons to help:
 - 1 cup = a fist or a tennis ball
 - 3 oz. = a deck of cards
 - 1 oz. = four dice
 - 2 Tablespoons = a golf ball
 - 1 teaspoon = a nickel or your thumb above the knuckle
- Forms of food can range from the form purchased fresh, canned, and frozen to the way it's prepared: grilled, fried, baked, etc. Be sure to specify when searching for an item in the database.
- MyFitnessPal has an extensive amount of food entries with a wide range of restaurants and brands, making your food entries simpler.

APPENDIX B

QUESTIONNAIRE

The Correlation between Cravings and Reported Nutrient Intake in Female University Students Aged 18-24

Please thoughtfully answer each question below; your identity and answers will be unknown. Do not forget to fill in your given participant ID.

Please fill in accordingly:

Participant ID: _____

Height: ___ ft ___ in

Weight: _____

Age: _____

How many hours do you exercise a week on average?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How would you characterize your exercise regime?

- a. Cardiovascular based (aerobic based)
- b. Strength Training (anaerobic based, weight lifting)
- c. Combination of cardiovascular and strength training

At what intensity do you train during an average exercise?

- a. Light to moderate
- b. Moderate to intense

How many alcoholic beverages do you have during the week on average (1 drink = 1.5-oz shot, 5-oz wine (about ½ glass), or 12-oz beer)?

- a. Do not consume alcohol
- b. 0-2
- c. 3-5
- d. 6-8
- e. 9 or more

How many cigarettes do you smoke in a week on average?

- a. Do not smoke
- b. 0-2
- c. 3-5
- d. 6-8
- e. 9 or more

How many times do you get your menstrual period in a year?

- a. 0-3
- b. 4-7
- c. 8-11
- d. 12
- e. 13 or more

How heavy is your period?

- a. Light or spotting
- b. Moderate
- c. Heavy

Are you presently pregnant, or have you ever been pregnant?

- a. Pregnant at this time
- b. Have been pregnant in the past
- c. Not pregnant presently and have never been pregnant

Do you follow a vegetarian diet?

- a. Yes
- b. No

Do you follow a vegan diet?

- a. Yes
- b. No

Do you follow a lactose-free diet?

- a. Yes
- b. No

Do you follow a gluten-free diet?

- a. Yes
- b. No

Do you have any allergies?

- a. Yes
Please specify your allergy/allergies: _____
- a. No

Do you have any other dietary restrictions or modifications that were not previously mentioned?

- a. Yes
Please specify your restrictions/modifications: _____
- b. No

How many times a year do you go on a diet where you restrict certain foods or food groups?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many servings of grains do you eat per day on average (1 serving = 1 slice bread, $\frac{1}{2}$ cup cooked rice or pasta, $\frac{3}{4}$ cup cereal)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many servings of fruit do you eat per day on average (1 serving = 1 whole fruit, $\frac{1}{2}$ cup fresh/frozen/canned fruit, $\frac{1}{4}$ cup dried fruit, $\frac{1}{2}$ cup juice)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many servings of vegetables do you eat per day on average (1 serving = 1 cup raw greens, $\frac{1}{2}$ cup raw or cooked vegetables, $\frac{1}{2}$ cup juice)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many servings of dairy do you eat per day on average (1 serving = 1 cup milk or yogurt; 1 cube or 1 slice cheese)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many servings of meats, poultry and seafood do you eat per day on average (1 serving = 3 oz or about the size of a computer mouse)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many servings of nuts, seeds or legumes do you eat per day on average (1 serving = 1/3 cup nuts, 2 Tbsp peanut butter, 2 Tbsp seeds, 1/2 cup beans or peas)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many days out of the week do you eat sweets (candy, ice cream, sugar, jelly, etc.)?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

How many times a week do you have a craving for a specific food or flavor that isn't satisfied until that food is eaten?

- a. 0-2
- b. 3-5
- c. 6-8
- d. 9 or more

What specific food, if any, do you crave often or more so than others? Mark all that apply.

- a. Chocolate
- b. Sweets (other than chocolate)
- c. Salty foods
- d. Fried foods
- e. Meat
- f. Dairy
- g. Fruits
- h. Vegetables

APPENDIX C

TABLES

Table 1.1 Self-reported characteristics of sample

	Range	Mean
Age, y	18-23	20.7 ± 1.3
Height, in	60-70	65.2 ± 2.9
Weight, lb	105-170	137.0 ± 16.8
BMI, kg/m²	18.5-30.1	22.7 ± 3.0

*Values are presented as range (min to max) and mean ± SD.

**BMI* = Body Mass Index

Table 1.2 Average intakes and %RDA of macro-and micronutrients over five days

	Intake Range	Average Intake	%RDA Intake	Average %RDA
Macronutrient				
<i>Carbohydrates, g</i>	66-321	177.5 ± 55.6	36.9-128.5	86.9 ± 27.8
<i>Protein, g</i>	39-131	70.6 ± 24.4	50.1-175.4	89.1 ± 35.2
<i>Fat, g</i>	26-210	63.3 ± 34.6	47.9-427.7	143.5 ± 72.4
Micronutrient				
<i>Vitamin C, mg</i>	2.3-115.4	20.2 ± 24.2	3.1-153.8	26.9 ± 32.2
<i>B6, mg</i>	1.0-3.3	1.7 ± 0.6	73.9-256.9	133.4 ± 49.5
<i>B12, µg</i>	0.6-211	19.3 ± 55.6	25.0-8805.8	802.8 ± 2320.2
<i>Riboflavin, mg</i>	0.6-2.8	1.6 ± 0.6	52.7-254.6	147.0 ± 51.7
<i>Thiamin, mg</i>	0.56-2.9	1.4 ± 0.5	50.9-267.3	124.3 ± 48.2
<i>Niacin, mg</i>	10.8-3	22.9 ± 6.9	77.1-264.3	163.4 ± 49.0
<i>Calcium, mg</i>	8.2-134.0	558.0 ± 327.2	8.2-134.0	55.8 ± 32.7
<i>Iron, mg</i>	6.8-100.7	35.7 ± 21.3	38.0-559.2	198.4 ± 118.3
<i>Magnesium, mg</i>	123.2-527.2	264.3 ± 108.2	39.7-170.1	85.3 ± 34.9
<i>Zinc, mg</i>	3.8-15.2	9.0 ± 2.9	47.50-190.0	112.9 ± 36.7
Total Calories	697-2171	1542.1 ± 378.7	45.5-161.9%	101.6 ± 29.6

*Values are presented as range (min to max) and mean ± SD.

*Intake range provides min to max nutrient intakes over five-day period

*Average intake was calculated as total nutrient intake/(130) (5 days x n=26)

*Recommended amounts of calories and macronutrients were calculated for each individual.

Recommended Kcals=25 kcal/kg body weight (BW).

Macronutrient recommendations calculated as: Carbohydrates=53.4% kcals, Protein=20.8% kcals,

Fat=25.8% kcals (based on midranges provided by AMDR set by IOM)

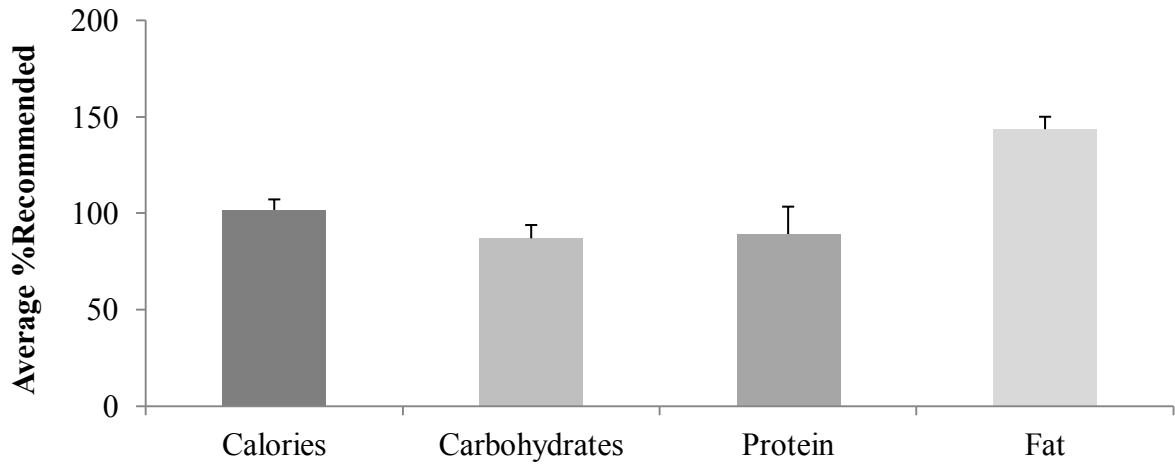
*%RDA = %RDA across the five days for all participants (n=26), from min to max

*Average %RDA = avg %RDA intake over the five-day period/RDA for each nutrient

APPENDIX D

FIGURES

Figure 1.1 Average intakes of calories and macronutrients, based on %recommended, consumed by participants over five-day study period



*Data presented as average %RDA with SE bars

*Recommended amounts of calories and macronutrients were calculated for each individual.

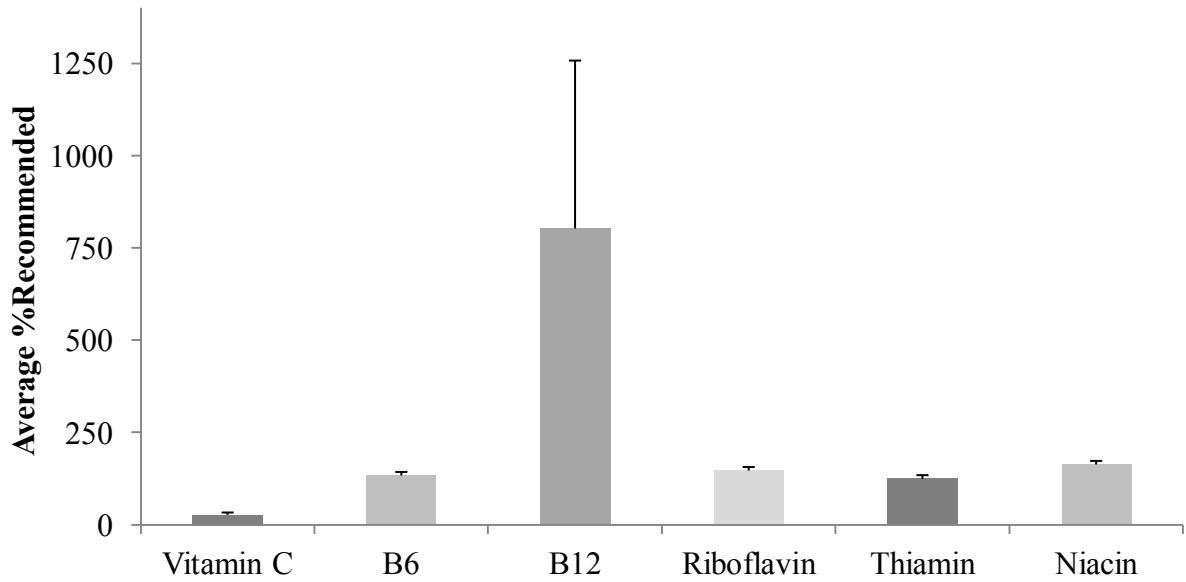
Recommended Kcals=25 kcal/kg body weight (BW).

Macronutrient recommendations calculated as: Carbohydrates=53.4% kcals,
Protein=20.8% kcals,

Fat=25.8% kcals (based on midranges provided by AMDR set by IOM)

*%Recommended calculated as (avg intake over 5 days) / (recommended amount)

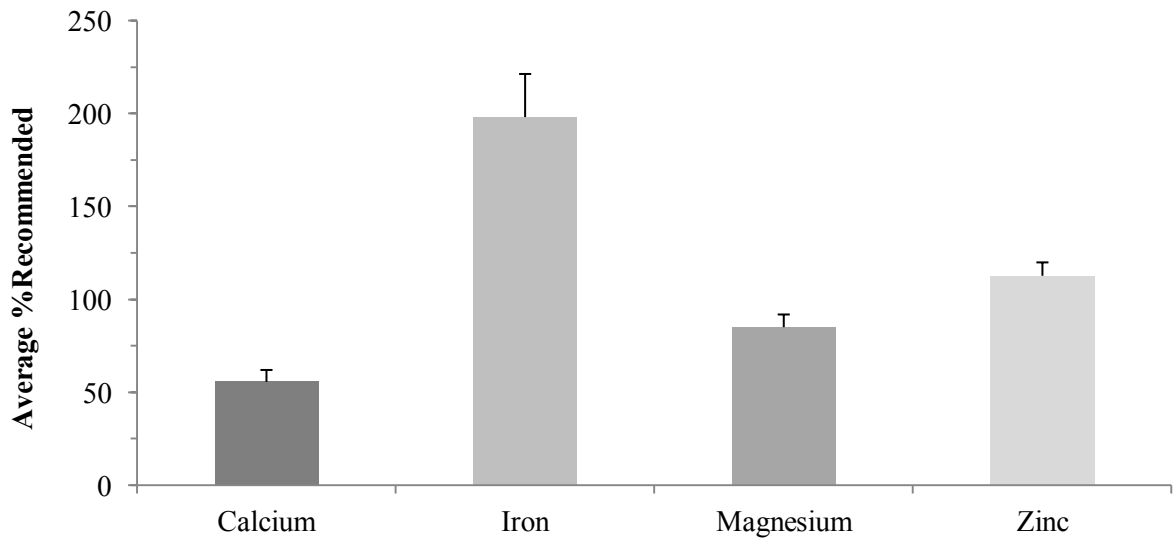
Figure 1.2 Average vitamin intakes, based on %RDA for each nutrient, consumed by participants over five-day study period



*Data presented as average %RDA with SE bars

*Avg%Recommended calculated as (avg intake for each nutrient over five days) / (nutrient-specific RDA)

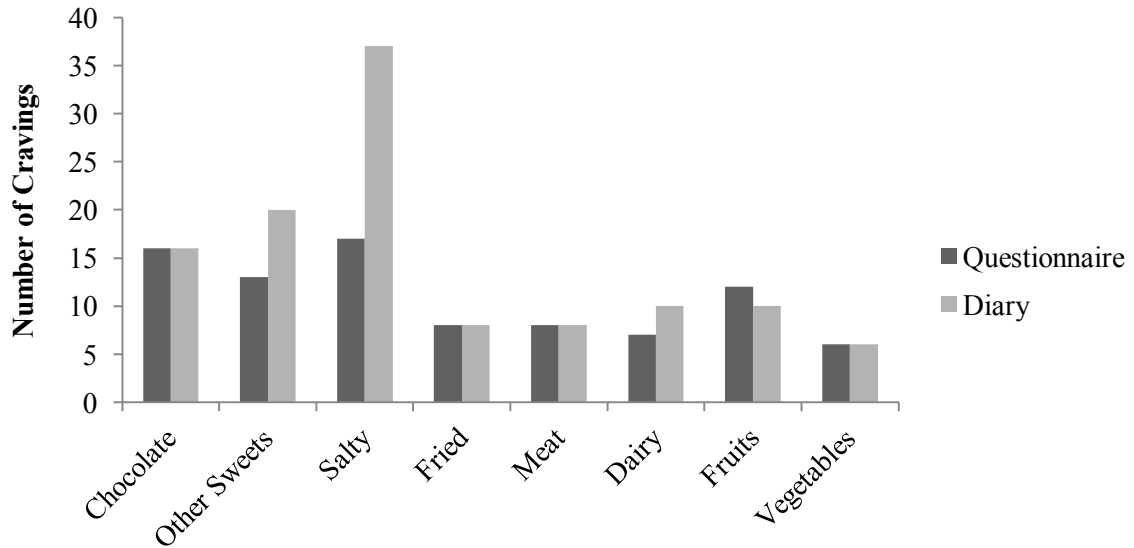
Figure 1.3 Average mineral intakes, based on %RDA for each nutrient, consumed by participants over five-day study period



*Data presented as average %RDA with SE bars

*Avg %Recommended calculated as (avg intake for each nutrient over five days) / (nutrient-specific RDA)

Figure 1.4 Presence or absence of cravings based on questionnaire responses in comparison to the number of diary-logged cravings over the five-day study period



*Questionnaire responses (black bars) indicate the number of participants who reported craving that food.

*Diary responses (gray bars) indicate the number of times that food craving was logged over the five-day period by all participants.