Research Proposal: Plant-Based Nutrition Intervention Providing the Recommended Dietary Allowance for Iron in Menstruating, Female Endurance Athletes

by

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Submitted in partial fulfillment
of the requirements for the degree of
Master of Science in Dietetics
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August 2020

Abstract

Nutrition has become an increasingly popular topic within athletics, however, there is a general lack of scientific evidence that utilizes a plant-based nutrition intervention in providing the increased nutritional needs required by athletes. The purpose of this research proposal is to recommend a study design that will analyze the impact a plant-based diet has on providing the recommended dietary allowance of iron within menstruating, female endurance athletes. A total of 40 female cross-country athletes aged 19-25 years old will participate within this study. Data collected will include anthropometrics, iron labs indicative of iron deficiency anemia, past eating patterns collected with the use of the National Health and Nutrition Examination Survey Food Frequency Questionnaire, and three unannounced 24-hour dietary recalls. The anticipated results from this study indicate that the plant-based diet intervention can provide the recommended dietary allowance of iron in menstruating female endurance athletes while maintaining iron labs indicative of iron deficiency anemia within normal range. It will be anticipated that iron labs indicative of iron deficiency anemia will improve as the study progresses, secondary to increased calories focusing on non-heme iron food sources. More research is warranted with the use of a plant-based nutrition intervention.

Keywords: iron deficiency anemia, endurance athletes, plant-based diet

Acknowledgements

I would like to express my special appreciation and thanks to Professor Dr. Dana Scheunemann, she has been a supportive mentor for me throughout this process. The advice, references and responses she has provided me throughout this journey have been invaluable as I learned the knowledge required to create a research proposal. I would like to thank Professor Dr. Megan Baumler for her guidance in constructing my graduate school semesters to ensure I graduate within a timely fashion. And Professor Lisa Stark for providing me with a memorable internship experience that provided me with not only lasting friendships, but an experience that has shaped me into the dietitian I am today.

I would like to thank my parents for their continuous support and encouragement – without their love and care, I would not be where I am today. I would like to thank my sisters and friends throughout this process, who kept me sane during the long, demanding weeks. And lastly, I would like to thank Kraig and Klark for continuously reminding me of their love and support throughout this process, and for their daily reminder to enjoy the simple things in life.

Table of Contents

List of Tables

Chapter One: Introduction of the Study

Iron is an essential mineral vital for the transportation of oxygen to cells throughout the body (Johnson-Wimbley & Graham, 2011). Johnson-Wimbley and Graham (2011) stated, when inadequate consumption of iron-rich foods, chronic blood loss, or complications in the absorption, metabolism and physiological process of iron occurs, iron deficiency anemia may develop. Signs of iron deficiency include weakness, fatigue, decreased physical performance, shortness of breath, headaches, dizziness and pica (Mayo Clinic, 2019). When iron deficiency is left untreated, "Mayo Clinic" (2019) mentioned this deficiency can lead to iron deficiency anemia, causing more serious health issues related to heart problems, growth problems, and problems with pregnancy. Iron deficiency anemia is the most common nutritional deficiency worldwide (Johnson-Wimbley & Graham, 2011).

Athletes are at a higher risk of developing iron deficiency anemia when compared to sedentary individuals as red blood cells break down more quickly during physical activity (Gaudiani, 2018). As stated by Gaudiani (2018), it is estimated that nearly half of all female athletes develop iron deficiency anemia, while an estimated 11% of male athletes develop this deficiency. Female athletes are at an increased risk of developing iron deficiency anemia due to frequent blood loss through menstruation (Gaudiani, 2018). Due to this increased risk, previous research studies have examined the effects of an oral iron supplement and animal protein in providing the recommended dietary allowance of iron within female athletes. The study conducted by Gaudiani (2018) indicated that an oral iron supplement and animal protein does assist in providing the recommended dietary allowance and does treat iron deficiency anemia. Yet, consequences specific to the use of an oral iron supplement may include constipation and potential trace mineral deficiencies (Snyder, Dvorak & Roepke, 1989). Little is known on the topic of a plant-based nutrition intervention providing the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range.

Background

Iron is a mineral that has many roles in promoting optimal health. This micronutrient is vital for supporting a healthy metabolism, growth and immunity as well as providing oxygen to the body's tissues and muscles (Zelmean, 2019). As explained by Zelman (2019), there are two forms of dietary iron. One form is found primarily in meat as heme iron, and the second form is primarily found in plant and iron-rich foods as non-heme iron. Heme iron is more bioavailable than non-heme iron, with a 15-35 percent absorption rate compared to non-heme iron that has a 1-23 percent absorption rate (Zelmean, 2019). Zelmean (2019) further explained that it is estimated approximately 14-18 percent of iron consumed is absorbed when following a diet that consists of a variety of foods including meat and seafood, and approximately 5-12 percent of iron consumed is absorbed when following a vegetarian diet that includes dairy and eggs.

Non-heme iron is generally consumed in larger quantities when compared to heme iron due to the abundant amount of non-heme iron found in a variety of plant-based foods. When non-heme iron is consumed with vitamin C rich foods, absorption rates are enhanced. The amount of vitamin C consumed is directly correlated with the amount of non-heme iron absorbed (Beck, 2014). Beck (2014) mentioned approximately 25-100 mg of vitamin C has been shown to enhance the absorption of non-heme iron, four times as great when compared to non-heme iron consumption alone. However, when paired with calcium rich foods such as tofu, cheese or milk, absorption rates of non-heme iron will be inhibited (Zelmean, 2019).

When inadequate consumption of iron occurs, the risk of developing iron deficiency anemia increases (Zelmean, 2019). As stated by Zelmean (2019), about half of all anemia diagnoses are due to iron deficiency. If iron deficiency is not reversed, serious medical conditions may occur, including death. Zelmean (2019) mentioned, it has been estimated that about 50 percent of preschooled children, menstruating females, and pregnant women in developing countries (30-40% in developed countries) may become deficient in this nutrient. If individuals are unable to consume adequate amounts of dietary iron, an oral iron supplement will be recommended, especially for individuals at high risk for developing iron deficiency anemia. However, side effects from an oral iron supplement may occur such as constipation, stomach pain, nausea and trace mineral deficiencies (Zelmean, 2019).

There is limited research regarding the ability of a plant-based nutrition intervention in providing the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. This research proposal will explore the topic of iron deficiency anemia and outline a possible study that utilizes a plant-based nutrition intervention within a high-risk population. Iron, a micronutrient, will be reviewed significantly as it relates to the function, absorption, food sources high in iron, requirements, iron deficiency anemia stages, and current research regarding iron deficiency within female athletes in the following chapters.

Problem Statement

Current research related to treating and preventing iron deficiency within menstruating, female endurance athletes focuses on the use of oral iron supplements and/or animal protein consumption. Research is lacking as it relates to a nutrition intervention following a plant-based diet to provide the recommended dietary allowance of iron while maintaining iron labs indicative of anemia within normal range, for this specified, high-risk population.

Purpose of the Study

The purpose of this 17-week randomized, controlled trial is to investigate if a plant-based diet is effective in providing the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range.

Research Question and Hypotheses

- The research questions is, does a plant-based diet provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range?
- The null hypothesis is that a plant-based diet will not provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range.
- Alternatively, it is hypothesized that a plant-based diet will provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range.
- Table 1, page 42 indicates both the independent and dependent variables within this study.

Nature of the Study

This study will be a randomized, controlled trial that will last a total of 17 weeks. The study will include subjects from the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee women’s cross-country teams during the months of July through September of 2021.

A normal distribution will be used to ensure data is normally distributed, so no wrong conclusions are made. A central tendency will be applied to collect the mean, mode and median to determine the typical value in the dataset. Data collected will include the mean age of the participants, body mass index, training habits, and duration of the diet consumed for individuals participating within the intervention group.

A chi-square test will be utilized in this study as the dependent variables are categorical. The results from this study will be compared between the intervention and control group to determine if the intervention provides the recommended dietary allowance of iron in menstruating, female endurance athletes and maintains iron labs indicative of anemia within normal range.

Definitions

Iron deficiency: A common nutrition deficiency caused by inadequate amount of iron consumption (Mayo Clinic, 2019).

Recommended Dietary Allowance (RDA) for iron: a basis for the percent daily values; RDA for females aged 19-50 is 18 mg iron per day (Stöppler, 2018).

Iron deficiency anemia: inadequate amount of healthy red blood cells present in the blood, a common type of anemia. This is diagnosed by having red blood cells that are smaller and more pale than normal, low hematocrit, hemoglobin and ferritin levels (Mayo Clinic, 2019).

Endurance athletes: An individual who participates in a sport of prolonged stamina, typically 14-21 hours of exercise per week (“Endurance”, 2020).

Plant-based diet: An eating pattern where foods consumed are primarily from plants, such as vegetables, fruits, nuts, seeds, whole grains, legumes, and oils (McManus, 2018). In this study, a plant-based diet will include a minimum of 4 cups of vegetables, 3 cups of fruit, 6 ounces of whole grains, 3 cups of dairy including soy products, 1 serving of iron-fortified foods, and 5.5 ounces of protein with more than half of the protein coming from plant-based food sources, focusing on pairing non-heme iron with enhancers.

Iron: An essential mineral with the purpose of carrying oxygen in the hemoglobin of the red blood cells throughout the body to produce energy (Kohn, J, n.d.).

Non-heme iron: Iron found in plant food sources such as whole grains, nuts, seeds, legumes, and leafy greens as well as animal flesh and fortified foods (Harvard, 2019).

Heme iron: Iron found only in meat flesh such as meat, poultry and seafood (Harvard, 2019).

Inhibitor: Substance that suppresses the activity of another substance. In this study the inhibitors are black tea and calcium rich foods including yogurt and cheese ("Inhibitor," 2020).

Enhancer: A substance that improves or increases the quality of another substance. In this study the enhancers are foods rich in vitamin C including peppers, oranges, and strawberries (Cambridge Dictionary, 2020).

Ferritin: A protein containing iron. Ferritin is the stored form of iron that is closely regulated in the body (American Association for Clinical Chemistry, 2020).

Recommended Dietary Allowance: Average daily level of intake to meet the nutrient requirements of 97%–98% healthy individuals (National Institutes of Health – Office of Dietary Supplements, 2020).

Hematocrit levels: Expressed as percentage by volume, determines percentage of red blood cells in the blood (Davis, 2019).

Serum Iron: Circulating iron bound to transferrin and serum ferritin (Sullivan, 2020).

Transferrin Saturation: Value of serum iron divided by total iron-binding capacity of available transferrin, measured as a percentage (Sullivan, 2020).

Assumptions

It will be assumed that the inclusion criteria for this study is appropriate, and it will be assumed all subjects included within the intervention group will have similar experiences. It is assumed the subjects involved within the intervention group will remain compliant with the plant-based diet, and subjects involved within the control group will remain compliant with their normal eating patterns throughout the duration of the study. It is assumed all subjects will be menstruating throughout the duration of the study as this will allow the research dietitian to understand how feasible the intervention is in providing the required iron needs to maintain normal iron labs indicative of iron deficiency anemia within this population. It will also be assumed subjects will complete the National Health and Nutrition Examination Survey (NHANES) Food Frequency Questionnaire and 24-hour dietary recalls honestly for accurate results. It is assumed the statistical tests chosen to decipher the results between the two groups will provide normality of data with minimal impact made from unknown variables. These listed assumptions are assumed as these factors do not have the ability to be controlled by the research dietitian.

Limitations

Limitations to this study include the small sample size of 40 female endurance athletes. This small sample size is associated with low statistical power, inflated false discovery rate, and inflated effect size estimation which may compromise the conclusions drawn from the study. This research proposal does not assess total blood loss via monthly menstruation, which was found by Malczewska et al. (2000) to be a principal cause of iron deficiency in female athletes whose iron intake was sufficient. The short duration of the study involving 17-weeks is also a limitation as the lifespan of red blood cells is around 120 days. To determine if a plant-based nutrition intervention can provide the recommended dietary allowance of iron while maintaining iron labs indicative of iron deficiency anemia, a study longer than three months should be conducted.

Weaver and Rajaram (1992) discussed that the estimated average requirement of iron for female athletes may be 70% higher than the recommended dietary allowance for females aged 19-50. This is due to their increased sweat production, blood loss in the urine, menstrual cycle, and GI tract, and the continuous mechanical force of foot pounding leading to a shorter life span of erythrocytes. It is estimated that 2.3 mg of iron is lost per day in female athletes (Weaver & Rajaram, 1992). This is another limitation in this study as the research question is asking if the menstruating female endurance athletes are meeting the recommended dietary allowance versus their estimated average requirement.

Delimitations

To create boundaries, a set of inclusion and exclusion criteria have been created. Inclusion delimitations include female endurance athletes aged 19-25 years old, female subjects who are menstruating, and females participating on the women's cross-country teams for either the University of Wisconsin-Madison or the University of Wisconsin-Milwaukee. Exclusion delimitations include females who are not menstruating, are pregnant, are vegan or who have dietary limitations that include the elimination of animal food sources, are using an oral iron supplement, have a history of chronic blood loss, have a history of an intestinal disorder such as celiac disease, or other diseases such as hemochromatosis that impacts iron levels. These exclusion delimitations have been created to prevent any variables that may alter results related to the absorption rates of iron.

Significance

This study has high significance as there is a lack of conclusive research studies utilizing a plant-based nutrition intervention to provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. Current nutrition interventions involve the recommendations of consuming an oral iron supplement that may come with unwanted side effects, or consuming animal protein to provide the recommended dietary allowance of iron. This research proposal will provide important information on whether a plant-based nutrition intervention within this high-risk population provides the recommended dietary allowance of iron while maintaining iron labs indicative of anemia within normal range.

Summary

There is limited research related to a plant-based diet providing the recommended dietary allowance of iron within menstruating, female endurance athletes. Therefore, this randomized, controlled trial with subjects from two college cross country teams will provide valuable information related to whether a plant-based diet provides the recommended dietary allowance for iron. The findings from this study will provide as a foundation for future studies to conduct research related on this topic. Future studies will have the ability to find evidence-based results for a plant-based nutrition intervention for menstruating, female endurance athletes in the prevention of iron deficiency anemia by strengthening the weaknesses present in this study.

Within the next chapter, iron will be reviewed and examined to understand the role this micronutrient has within the human body. Current research discussing this micronutrient will be analyzed to understand the association this deficiency has within this high-risk population. Chapter two will also indicate the gap in the research, requiring future studies to be conducted on this topic to provide a stronger, evidence-based nutrition intervention. Chapter three is the methodology for this research proposal. A randomized, control trial will be described to provide an evidence-based nutrition intervention related to a plant-based diet for menstruating, female endurance athletes. Chapter four will provide the anticipated results collected from this study, and chapter five will discuss the findings from this study and the importance of this topic as it relates to the field of dietetics.

Chapter Two: Review of Literature

Iron is an essential micronutrient important for several necessary metabolic processes within the body (University of California San Francisco Health, 2019). Athletes are at a higher risk of developing iron deficiency when compared to sedentary individuals as red blood cells break down more quickly during physical activity (Gaudiani, 2018). Gaudiani (2018) discussed how female athletes are at an even higher risk of developing this deficiency due to frequent blood loss through menstruation.

Chapter two will review important aspects in understanding iron deficiency anemia. The function of iron will be examined along with iron absorption, and food sources high in heme and non-heme iron. Risk factors and stages for developing this nutritional deficiency will be thoroughly discussed along with signs and symptoms and current practices. Existing research will review four research studies that have focused on the purpose of determining whether a plant-based nutrition intervention is effective in providing adequate iron within female athletes. A summary will conclude this chapter to compare the research articles analyzed and determine what improvements future research studies may do to create a stronger conclusion that will provide an evidence-based nutrition intervention for this specified group.

Literature Research Strategy

Original research studies were compiled using several databases including PubMed Central, Google Scholar, and EBSCOhost. Several verbiages including “iron deficiency anemia,” “female endurance athletes and iron status,” “vegetarian female endurance athletes and iron status,” “plant-based female athletes and iron status,” and “vegetarian female endurance athletes with iron deficiency” were investigated to conduct a detailed literature search. During the quest for reputable sources, abstracts were reviewed to determine if the study would be included within this literature review based on the specified inclusion criteria.

Background

Iron Function. Iron plays many important roles within the body (University of California San Francisco Health, 2019). The University of California San Francisco Health (2019) stated iron is crucial in blood production with 70% of the body's iron found in heme proteins called hemoglobin, which are located within erythrocytes and myoglobin. The University of California San Francisco Health (2019) continued to explain, hemoglobin transports oxygen throughout the body, while myoglobin carries and stores oxygen in muscle cells. Proteins required to produce DNA synthesis, cell division, neurotransmitters, and connective tissues require iron for obtaining oxygen, making iron crucial in many metabolic processes (Traverso, 2004). Traverso (2004) continued to mention that iron plays an important role in immune system maintenance. Iron assists in cell proliferation and maturation in lymphocytes specifically, which are white blood cells that protect the body from infection ("NCI Dictionary of Cancer Terms," n.d.).

Iron Absorption. Iron is highly regulated to ensure adequate storage in the body (National Center for Biotechnology Information, 2001). According to the National Center for Biotechnology Information (2001), only a small amount of iron is lost per day, in the absence of menstruation or pregnancy, to minimize the risk for deficiency and to ensure adequate iron stores. Men require approximately one milligram of iron absorption per day to maintain storage. Females require a higher amount, approximately 1.5 milligrams per day, with variations based on individual needs due to bleeding via menstruation or pregnancy. Iron is a micronutrient found in a range of foods. Depending on the type of iron form consumed, absorption rates differ slightly.

The two forms of iron include heme or non-heme iron. Heme iron is more easily absorbed while non-heme iron has several absorption inhibitors, making it less bioavailable. Heme iron is found primarily in the hemoglobin and myoglobin cells present within meats. Non-heme iron is primarily derived from plant and dairy foods. Both forms are absorbed in the lumen of stomach and duodenum (National Center for Biotechnology Information, 2001).

Heme iron is degraded by pancreatic enzymes, then absorbed by the intestinal cells to be further reduced by heme oxygenase-1, releasing the non-heme iron (Johnson-Wimbley & Graham, 2011). Unlike heme iron, which can be immediately absorbed, non-heme iron requires a reduction reaction before absorption, Johnson-Wimbley and Graham (2011) explained. Non-heme iron has two forms known as either ferric (Fe+2) or ferrous (Fe+3) iron, the difference between ferric and ferrous is their oxidation state of iron; ferric is the +3 oxidation and ferrous the +2 (Johnson-Wimbley & Graham, 2011). Once ferric iron enters the duodenum, the duodenal cytochrome b reduces ferric to the ferrous form, which is then transported into the apical membrane of the enterocyte (Zhang & Enns, 2009). Once reduced, specific foods may enhance or inhibit the absorption of non-heme iron (Johnson-Wimbley & Graham, 2011). According to Johnson-Wimbley and Graham (2011), ascorbic acid, citrate, and amino acids from meat and fish enhance the absorption of non-heme iron. Plant phytates found in legumes, rice and grains, tannins found in berries, tea and wine, calcium found in dairy products, tofu and leafy greens, polyphenols found in fruits, vegetables, dry legumes and chocolate, iron overload, and antacids (which decrease stomach acidity) inhibit the absorption of non-heme iron (Johnson-Wimbley & Graham, 2011).

Heme iron is exceedingly bioavailable and not highly impacted by various factors (Bridges, 2001). However, Bridges (2001) stated that lead, cobalt, strontium, manganese, and zinc are micronutrients that compete for the same intestinal receptors required for heme iron absorption. This may ultimately impede overall iron absorption if foods high in these micronutrients are consumed at the same time.

Transport, Metabolism, Storage and Excretion of Iron. Iron can transfer easily between cells due to the reversible binding to transferrin, a transport protein (National Center for Biotechnology Information, 2001). Per the National Center for Biotechnology Information (2001), when iron is bound to transferrin, it can then be transported and bound to a specific transferrin receptor located on the receiving cell requiring iron. Iron will then be stored as ferritin or hemosiderin, a water-insoluble product of ferritin, within the cells, or may be used to balance future iron metabolism. The intracellular iron storage will determine future iron storage, transport and metabolism. Primary iron stores are found in the cells of the liver, spleen and bone marrow (National Center for Biotechnology Information, 2001).

Iron may be lost through bleeding via menstruation or pregnancy; basal loss in women not menstruating; or lost in the urine, gastrointestinal tract, sweat, and feces as stated by Bothwell, Charlton, Cook and Finch (1979). Bothwell et al. (1979) continued to state that only a small amount of iron is lost per day due to the high regulation of iron status. The range of iron lost can vary from 0.5 mg/day, when the body is experiencing iron deficiency anemia, or may be as high as 2 mg/day when an individual is experiencing iron overload.

Iron Food Sources. As Johnson-Wimbley and Graham (2011) explained, heme iron is found primarily in meat products such as beef, pork, poultry, and seafood and is better absorbed than non-heme iron, which is the iron form found primarily in fortified cereals, beans, meat, some vegetables such as spinach and peas, and dried fruits including raisins and apricots (Mayo Clinic, 2019). It is important to note that meat contains about 55-60% of non-heme and 40-45%

of heme iron, while plant foods contain a very small amount of heme iron with the majority found as non-heme iron (“Iron We Consume,” n.d.). Individuals consuming a plant-based diet are at higher risk of developing iron deficiency as non-heme iron is less bioavailable than heme iron, with multiple factors that may inhibit absorption (Mayo Clinic, 2019).

Iron Requirements. The recommended dietary allowance for iron was determined by estimating iron losses to meet 97.5% of the healthy general population with an 18% upper limit of iron absorbed (“Dietary Reference,” 2001). According to “Dietary Reference” (2001), the requirement for menstruating females was calculated utilizing a simple equation; iron requirement = basal losses + menstrual losses. It is noted that oral contraceptives may lower menstrual blood loss, which in turn reduces the amount of iron loss, lowering the requirement of iron consumed. When individuals consume a plant-based diet, the main source of iron is found in the non-heme form. Non-heme iron is less bioavailable than heme iron, making the recommended dietary allowance for iron 1.8 times higher for individuals consuming a plant-based diet due to the lower bioavailability (“Dietary Reference,” 2001).

Approximately 1.75 mg of iron is lost per day in male athletes, and 2.3 mg of iron is lost per day in female athletes (Weaver & Rajaram, 1992). It has also been explained by Ehn and colleagues (1980) that long distance runners have a significantly lower amount of half-life of body iron than sedentary individuals due to the consistent foot pounding that occurs during distant running. According to Weaver and Rajaram (1992), the estimated average requirement for female athletes may be even 70% higher than sedentary females. This increase in iron requirement is caused by the increased sweat production, blood loss in the urine and GI tract, and the continuous mechanical force of the foot pounding leading to a shorter life span of erythrocytes (Gaudiani, 2018).

Risk Factors of Iron Deficiency Anemia. There are specific populations that are at a higher risk of developing iron deficiency anemia. These groups include athletes, women, infants, children, vegetarians, frequent blood donors, individuals with colon cancer, certain gastrointestinal disorders, individuals with a history of gastrointestinal surgery, and/or diagnosed with heart failure (Office of Dietary Supplements, n.d.).

Women are at an increased risk for developing this nutritional deficiency due to frequent blood loss via menstruation (Mayo Clinic, 2019). According to “Mayo Clinic” (2019), infants born prematurely or with a low birth rate who may not be consuming enough breast milk or formula are at an increased risk. If children are not consuming a healthy, varied diet with adequate iron rich foods, their risk increases due to rapid growth. Vegetarians are likely to develop iron deficiency due to inadequate amounts of iron-rich foods consumed.

Individuals who frequently donate blood are at an increased risk for this deficiency as hemoglobin levels are greatly reduce after the donation (Mayo Clinic, 2019). For example, 2,425 blood donors remained iron deficient for up to 24-weeks post blood donation if they were not consuming a daily oral iron supplement (Cable et al., 2011). The study conducted by Cable et al. (2011) discussed that men who had donated blood for a minimum of at least three times and women for a minimum of at least two times in the previous year, were more than five times more likely to show signs of iron deficiency anemia.

Up to 60% of individuals diagnosed with colon cancer have also been diagnosed with secondary iron deficiency anemia, which is likely caused by either chronic blood loss, cancer-induced anorexia or chemotherapy-induced anemia (Office of Dietary Supplements, n.d.). As the Office of Dietary Supplements (n.d.) explained, individuals with gastrointestinal disorders including celiac disease, ulcerative colitis, and Crohn’s disease, or who have a history of gastrointestinal surgery including gastrectomy or intestinal resection, are at increased risk of iron deficiency anemia secondary to problems with iron absorption. Individuals diagnosed with heart failure are at high risk of developing this deficiency caused by poor diet, malabsorption, cardiac cachexia and the use of medications such as aspirin, which may impede the absorption of iron.

Athletes are at risk of developing iron deficiency anemia as iron is lost through sweat, the skin and urine (Gaudiani, 2018). Gaudiani (2018) states that when athletes participate in high intensity and endurance activities, up to 70% of circulating iron can be lost when compared to sedentary individuals. In athletes who compete in sports with high amounts of running, the mechanical force of the continuous foot pounding breaks down erythrocytes, leading to a shorter life span and thus less iron is found circulating within the blood.

Female Endurance Athletes. Endurance is defined as the ability to perform a high physical activity for a prolonged duration, whether it involves running, cycling, swimming, rowing, dancing, or playing sports such as basketball, tennis, volleyball, or soccer ("Endurance," n.d.). Multiple factors may impact an individual's endurance ability such as aerobic capacity, VO2max, muscle strength, cardiovascular endurance, and lactate threshold ("Lactate Threshold Training," 2014). Continuous endurance training allows an athlete to improve their ability to tolerate fatigue, the main factor that negatively impacts athletic performance ("Endurance Definition: What is Endurance?," n.d.).

Iron Deficiency Anemia Stages. Iron deficiency is characterized into five stages. Stage one is indicated by the decreased levels of ferritin which fall below 20 ng/mL (Braunstein, 2018). Braunstein (2018) explained this is caused by a decrease in bone marrow iron stores, causing an increase level of transferrin, a protein that binds and transports iron throughout the body. In stage two, transferrin levels remain increased. However, the level of serum iron decreases. Erythropoiesis is diminished when serum iron levels fall below < 50 μg/dL, transferrin saturation is < 16%, and the serum transferrin receptor rises to > 8.5 mg/L. In stage three, erythrocytes remain to appear normal, but red blood cell indices begin to evolve. The red blood cell indices are part of the complete blood count and involves the average size of red blood cells, hemoglobin per red blood cell ratio, and the concentration of hemoglobin per red blood cell. Stage four of iron deficiency involves the microcytosis, defined as smaller red blood cells than normal, and hypochromia, decreased hemoglobin causing a paler looking red blood cell. Stage five of iron deficiency will begin to impact tissues, causing signs and symptoms such as exhaustion, pale skin, headaches, inflamed tongue, brittle nails and pica (Braunstein, 2018).

Symptoms of Iron Deficiency Anemia. Symptoms vary from individual to individual and worsen as iron deficiency becomes more severe (Gaudiani, 2018). Per Gaudiani (2018), when athletes experience iron deficiency, they may experience symptoms more noticeably when compared to sedentary individuals. As iron is essential for oxygen transportation and energy metabolism, symptoms may be more prominent in athletes as iron is an essential component for fueling aerobic exercise, increasing exercise capacity and VO2 max. Symptoms of iron deficiency may include weakness, fatigue, exhaustion, decreased athletic performance, increased heart rate, headaches, dizziness, and pica (Gaudiani, 2018). Signs specific to iron deficiency anemia may include the symptoms previously listed, as well as pale skin, cold extremities, inflammation or soreness of the tongue, poor appetite, and brittle nails (Mayo Clinic, 2019). If iron deficiency anemia is left untreated, Mayo Clinic (2019) stated it can create more serious health issues including heart problems, problems with pregnancy and growth problems in children and infants.

Iron Deficiency Treatment and Current Practice. As mentioned by "Mayo Clinic" (2019), iron deficiency may be caused by a lack of iron consumed within the diet, frequent blood donations, impaired gastrointestinal absorption caused by an underlying health condition, increased need requirements due to higher physical activity, or increased iron loss due to heavy menstrual bleeding, pregnancy, or intestinal bleeding. Labs including a complete blood count, hemoglobin and hematocrit levels, and a mean corpuscular volume will provide the necessary information to determine if an individual has iron deficiency anemia (National Heart, Lung and Blood Institute, n.d.). The National Heart, Lung and Blood Institute (n.d.) stated if more information is required, a ferritin lab value will be drawn to determine iron stores, and a peripheral smear may be conducted to determine if red blood cells look smaller and paler when compared to normal red blood cells.

Several treatment options exist for treating iron deficiency, including the use of an oral iron supplementation, diet changes to include more iron-rich food sources, procedures, and surgery (National Heart, Lung and Blood Institute, n.d.). The National Heart, Lung and Blood Institute (n.d.) mentioned, when utilizing oral iron supplements, individuals may be prescribed to consume an iron pill several times per day over a time span of three to six months to replenish the body's iron stores. However, several side effects may occur from taking oral iron supplements including vomiting, diarrhea, constipation, upset stomach or cause a trace mineral deficiency. A diet change nutrition intervention may be prescribed for individuals to consume more iron-rich foods within their diet. These foods include red meats, fish, poultry, dried beans, eggs, iron-fortified breads and cereals, and dark green leafy vegetables. Foods rich in vitamin C including peppers, oranges, and strawberries can help with the absorption of non-heme iron. Black tea and calcium rich foods including yogurt and cheese should be avoided when consuming iron-rich foods, as they are shown to inhibit iron absorption due to their calcium content (National Heart, Lung, and Blood Institute, n.d.).

If oral iron supplements or dietary changes do not replenish iron stores, several other treatments may be provided. Per the National Heart, Lung, and Blood Institute (n.d.), the use of parenteral IV iron may be infused when severe iron deficiency anemia is diagnosed, or if an individual has chronic kidney disease or celiac disease that is impeding their ability for adequate iron absorption. A red blood cell transfusion may be recommended if an individual is having life-threatening side effects, as red blood cells rich in iron will directly enter within the bloodstream to provide the oxygen required throughout the body. Surgery of the upper endoscopy or colonoscopy may be a means of intervention to stop internal bleeding if that is the etiology of the deficiency (National Heart, Lung, and Blood Institute, n.d.).

Plant-Based Diet. A plant-based diet is commonly used interchangeably with a plant-forward or vegetarian diet (McManus, 2018). As mentioned by McManus (2018), the focus of a plant-based diet revolves around the consumption of fruits, vegetables, nuts, seeds, oils, whole grains, and legumes. The plant-based diet does allow meat and dairy in small amounts. However, the primary focus of calories and nutrients consumed are obtained from plant food sources. The plant-based diet provides all the nutrients our body require. This includes the necessary macronutrients of protein, carbohydrates and fats; the micronutrients, including vitamins, minerals, phytochemicals, antioxidants, and fiber, that our bodies require for longevity and increased quality of life (McManus, 2018).

A vegetarian diet is an umbrella term used to define numerous plant-based dietary patterns including vegan, lacto-vegetarian, ovo-vegetarian, lacto-ovo vegetarian, pescatarian and the flexitarian diet (“Vegetarian Diet: How to Get the Best Nutrition,” 2019). “Vegetarian Diet:

How to Get the Best Nutrition” (2019) explained that the vegan diet excludes all animal-based products, while the lacto-, ovo-, lacto-ovo, pescatarian and flexitarian diets only partially exclude animal products from the diet. In general, the vegetarian diets focus on a plant-based diet approach while partially or completely limiting the consumption of animal food products.

The vegetarian diets are similar to the plant-based diet as both focus on the high consumption of fiber rich foods and lean proteins. However, the difference between the two is that the plant-based diet does not eliminate animal foods, it just limits the consumption. This reasoning is due to animal foods containing certain micronutrients that are found to be more bioavailable when compared to plant-based foods. With the incorporation of animal products within the plant-based diet, nutrients including vitamin B12, zinc and heme iron will continue to be absorbed at optimal rates (McManus, 2018). McManus (2018) explained that a plant-based diet is high in nutrient content yet low in empty calories. This is due to the plant-based diet having a low consumption of pre-packaged foods that are commonly high in sodium, added sugars and saturated fats.

A plant-based diet has been shown in many previous research studies to play a key role in overall health status (“Plant-Based Diets”, 2019). As mentioned by “Plant-Based Diets” (2019), it has been shown that this type of eating pattern may improve plasma lipid concentrations, blood pressure, promote weight loss, improve blood glucose control, and help decrease the risk of developing chronic diseases such as diabetes, obesity, heart disease and certain cancers. “Plant-Based Diets” (2019) continued to mention that these health benefits are due to the high consumption of vegetables, fruits, whole grains, and leans proteins along with the vast number of vitamins, minerals, antioxidants, phytonutrients, and fiber found in these food sources. Foods within this eating pattern are low in cholesterol, saturated fat, trans fat, sodium, and calories, dietary factors that have been shown to have a detrimental impact on overall health. Eating a variety of nutrient dense foods included within this diet will provide the macronutrients and micronutrients essential to health, while sustaining a healthy lifestyle that promotes optimal quality of life (“Plant-Based Diets”, 2019).

The plant-based eating pattern has been around for as long as history dates back (Hultin, 2019). Hultin (2019) mentions that the trend of plant-based eating has increased in the past several years but have not always been trendy. With the plant-based eating pattern becoming more popular, it will be crucial for dietitians to educate on the importance of a well-planned plant-based eating pattern to ensure individuals are consuming a reliable source of iron, vitamin B12, omega-3 fatty acids, iron, zinc, and calcium (Hultin, 2019).

Current Research

Influence of dietary iron on measures of iron status among female runners. Snyder et al. (1989) conducted a randomized experimental study to determine whether female runners consuming a vegetarian diet have different measures of blood iron than female runners consuming a diet that included red meat. Snyder et al. (1989) hypothesized inadequate dietary intake, low bioavailability of non-heme iron, and high rates of iron loss as the multiple factors implicating iron deficiency within this population. The purpose of this study was to investigate whether female vegetarian runners are at an increased risk for developing iron deficiency, when compared to female runners consuming a diet including red meat.

A questionnaire conducted by Snyder et al. (1989) was completed by 18 local female, menstruating, distance runners. Based on their answers, subjects were separated into two groups with a total of nine subjects informed to consume a diet including red meat, and the other nine subjects informed to consume a modified vegetarian diet defined as one that included milk, eggs, fish, poultry, and < 100 grams to no consumption of red meat. Blood samples were obtained in a fasted state at the midpoint of the subject's menstrual cycles, then classified into three stages of iron deficiency based on their lab results. Stage one was indicated as a depletion of iron storage with a serum ferritin value of less than 12 ng/100 mL. Stage two was indicated by iron deficiency erythropoiesis with a serum iron value below 60 ug/100 mL, total iron binding capacity above 400 ug/100 mL, and percent saturation below 16%. Stage three was indicated by hemoglobin levels below 12 gm/dL to determine iron deficiency anemia. A nutritional breakdown involving the number of calories, macronutrient composition, percentage of the recommended dietary allowances for vitamins and minerals, and bioavailability of iron consumed within subject's meals was calculated (Snyder et al. 1989).

Results indicated no significant differences between the two groups as stated by Snyder et al. (1989). Three subjects from the modified vegetarian group and one subject from the group consuming red meat had stage two iron deficiency. Both groups had an average consumption of less than 1,800 calories per day and consumed mean values of iron below the recommended dietary allowance of 18 mg that is recommended for menstruating females (Snyder et al. 1989). Snyder et al. (1989) discussed that iron deficiency within this population may impede physical performance due to excess lactate production and reduced endurance capacity, making it essential for female athletes to be consuming adequate calories and iron. Future research is required to determine what nutritional interventions may work for improving iron status within this population.

The small sample size, short duration of the study, and collection of only three dietary records were several limitations within this study. The use of multiple iron labs to determine iron status, assessing for multiple factors that may impede iron status, and determined aerobic capacity strengthened this study. By utilizing multiple iron labs, subjects were grouped into the stages of iron deficiency, providing more thorough details on how several factors may influence this nutritional deficiency. The results from this study indicate both groups were not consuming adequate amounts of iron. This is crucial for dietitians to understand as higher amounts of iron may be recommended for this high-risk group of female runners, whether they follow a plant-based diet or not.

Dietary iron intervention for improvement of iron in female runners. A prospective, experimental study designed by Alaunyte, Stojceska, Plunkett, & Derbyshire (2014) utilized a nutrition intervention to determine if a staple food product improved iron status in female runners. The purpose of this study was to determine whether Teff bread, a whole grain high in non-heme iron, provided adequate iron to prevent iron deficiency in recreational female endurance runners during a six-week intervention (Alaunyte et al., 2014).

A total of 15 females volunteered from local running clubs and athletic centers, however, based on the inclusion criteria, a total of 11 female subjects participated within the study (Alaunyte et al., 2014). Alaunyte et al. (2014) informed subjects to continue their daily diet and exercise habits but to include Teff bread in place of their usual bread. Diet, exercise regimens, anthropometric measurements, iron labs and exercise performance were assessed at baseline (week 0), midpoint (week 3), and end (week 6). Subjects completed a Teff bread consumption log to monitor compliance. Multiple 24-hour dietary recalls were completed at baseline, midpoint and end, collecting data on dietary intakes and monitored for use of oral supplements (Alaunyte et al., 2014).

Prior to the beginning of the study conducted by Alaunyte et al. (2014), all subjects consumed diets low in iron. During the intervention, total dietary iron increased from 10.7 to

18.5 mg/day ($p < 0.05$). Consuming Teff bread versus their usual bread, 7.0 ± 3.3 mg iron contributed to 45% of daily recommendations. This increase in iron consumption improved hematological values. However, no statistically significant differences were observed in the lab values including serum transferrin, serum transferrin receptor, serum ferritin, and total iron binding capacity when comparing pre- and post-intervention. A significant positive relation was observed post-intervention between increased dietary iron and increase in iron body stores (Alaunyte et al., 2014).

As stated by Alaunyte et al. (2014), research continues to indicate that female athletes are not consuming a diet that is meeting their nutritional needs. Regardless, the results from this study indicate positive outcomes from the intervention. The subjects with depleted iron stores showed the greatest improvements in hematological indices. An increase in dietary iron can positively impact female athletes in relation to iron stores (Alaunyte et al., 2014).

Alaunyte et al. (2014) thoroughly discussed external and internal variables that may have altered their results, assessed for under-reporting during the 24-hour diet recalls with the use of the Goldberg cut-off limits, and informed subjects to complete a bread consumption log to monitor compliance of consuming the Teff bread which are all strengths to this study. However, many limitations did exist within this study. The small sample and short duration of the study did not indicate a recommendation for the female athlete endurance population. The selection of the subjects was bias as the researchers found them through local running clubs and physical centers. The researchers did not account for non-heme iron enhancers and inhibitors of absorption nor did they account for heme iron subjects consumed in their daily diets. Potential bias may have existed within this study as the researchers were the ones who created and baked the Teff bread used as the nutrition intervention (Alaunyte et al., 2014).

This study provides a base for current treatment research studies to understand that a dietary iron intervention does improve iron status in female endurance athletes. Future research is necessary to better understand this topic.

Iron status in female endurance athletes and in non-athletes. The study conducted by Malczewska, Raczynski, & Stupnicki (2000) focused on iron status in female endurance athletes and non-athletes. The purpose of this study was to identify factors that promote iron deficiency within these populations accounting for nutritional status and menstruation. This study included 126 female endurance athletes and 52 female non-athletes in a prospective, cohort, observational study design (Malczewska et al., 2000).

The study conducted by Malczewska et al. (2000) included 126 female endurance athletes that participated in various sports including rowing, swimming, running, cross-country skiing, and modern pentathlon, with data collected in the autumn-winter and spring seasons from 1992-1995. The total amount of physical activity per week was 15 hours, about two and a half hours per day. The control group included general collegiate females participating in recreational swimming and low or moderate physical activity. Multiple 24-hour dietary recalls were conducted including both weekdays and weekends to determine the typical diets of the subjects, accounting for iron coming from heme iron and non-heme iron food sources as well as foods containing non-heme iron enhancers or inhibitors. Variables accounted for by the researchers included iron stores, hematological values, iron intake from heme and non-heme food sources, iron metabolism, menstrual bleeding, and training factor specific to the athletic group (Malczewska et al., 2000).

Iron deficiency was shown to be as high as 50% in the control group, and 26% in the athletic group, as mentioned by Malczewska et al. (2000). Iron stores and iron deficiency did not differ significantly regarding age or somatic variables in both groups, nor did training volume and athletic experience differ in the athletic group. Both iron deficient subgroups were shown to have lower iron stores, overall iron consumption, and iron metabolism. Within the iron deficient athletic group, these subjects were shown to have a higher menstrual bleeding index than the normal iron stores subgroup (Malczewska et al., 2000).

Research has been variable on the impact physical activity has on iron stores. Several research studies have concluded lower iron stores in athletes when compared to sedentary individuals. However, the study conducted by Malczewska et al. (2000) indicated the opposite – it was found that iron deficiency symptoms were more common in control subjects, with higher iron stores found in athletes. According to the results, low iron intake, dietary imbalance, and menstruation were the factors responsible for the development of iron deficiency in women. Within the control group, lack of iron intake was the dominant factor indicating iron deficiency. Within the athletic group, the higher intake of calcium, a known non-heme iron inhibitor, and menstrual bleeding were the dominate factors promoting iron deficiency (Malczewska et al., 2000).

Malczewska et al. (2000) defined and explained the variables thoroughly and separated the subjects within different subgroups to conclude a more concise conclusion. The adequate use of multiple iron lab values, the 24-hour dietary recalls assessing for both heme and non-heme iron and non-heme iron enhancers and inhibitors, calculating the differences in menstrual length and intensity, sample size, and the length of time strengthened this study design. A limitation to this study included not providing the iron deficient subgroups with an intervention to indicate whether non-heme iron may positively impact iron levels when compared to heme iron. The conclusions from this study provides insight on the adequacy a plant-based diet nutrition intervention would be for this high-risk population.

Comparison of vegetarian and non-vegetarian diet in Indian female athletes. Khanna et al. (2006) designed a prospective, observational study focusing on the affect a vegetarian and non-vegetarian diet have on nutritional status and exercise performance amongst Indian female athletes. When nutritional deficiencies occur, athletic performance declines. This study examined a vegetarian diet to determine whether nutritional deficiencies are more common in a vegetarian or non-vegetarian diet and whether it relates to performance (Khanna et al., 2006).

A total of 64 female athletes aged 16-25 years were divided by Khanna et al. (2006) into three groups based on their dietary consumption. Group one included non-vegetarians who consumed both plant and animal-based foods, group two included lacto-vegetarians who included plant and dairy products, and group three included ovo-lacto vegetarians who consumed plant food along with dairy products and eggs. Anthropometrics, body density calculated from skin fold measurements, percentage body fat, lean body mass, and nutrient intakes via 24-hour recalls were collected. Subjects were informed to continue consuming their normal dietary habits. Aerobic capacity was calculated by a treadmill test to determine maximal endurance performance. A venous blood test was completed to determine hemoglobin concentrations (Khanna et al., 2006).

Results indicated 39 subjects were non-vegetarians, 14 subjects were lacto-vegetarians, and 11 were ovo-lacto vegetarians, as stated by Khanna et al. (2006). Between the three groups, no significant differences were found between the height, weight and lean body mass, but body fat was significantly higher in lacto-vegetarians when compared to non-vegetarians and ovo-lacto vegetarians. All subjects within this study consumed a range of 3,030 to 3,449 calories with most of the calories coming from carbohydrates, fat and then protein. Iron was found to be significantly higher in non-vegetarians ranging from 22.7 +1.88 mg, 21.8 +1.67 in lacto vegetarians, and 20.8 +2.33 in ovo-lacto vegetarians. Non-vegetarians had the highest hemoglobin concentration when compared to ovo-lacto and lacto vegetarians. When hemoglobin is present in higher amounts, the body has more iron available which provides the body with required oxygen needed for optimal physical performance (Khanna et al., 2006).

Strengths included the use of multiple 24-hour dietary recalls to gather information related to diet and a total of 64 female athletes within the study. However, many limitations existed within this study. More labs should have been collected to determine nutrient biomarkers. Menstrual cycles for the female athletes were not taken into consideration, nor was the use of a possible nutritional supplement or oral contraceptives that may have altered the results. The findings from this study will allow future studies to understand the affect different vegetarian diets may have on the iron status in female athletes (Khanna et al., 2006).

Summary

Iron is an essential micronutrient crucial in blood production, oxygen transportation, and cell proliferation and maturation ("The Crucial Role of Iron in the Body," n.d.). The recommended dietary allowance is 18 mg of iron per day for premenopausal women, which is a higher recommendation than any other population group due to monthly menstruation and pregnancy ("Dietary Reference", 2001). Two forms of iron exist including heme and non-heme iron (Johnson-Wimbley & Graham, 2011). As Johnson-Wimbley and Graham (2011) discussed, heme iron is found primarily in meat products and is more bioavailable than non-heme iron, which is found primarily in plant products. Due to the lower bioavailability of non-heme iron, individuals consuming a plant-based diet require 1.8 times the recommended dietary allowance to ensure adequate iron stores to prevent deficiency (“Dietary Reference,” 2001).

As mentioned by Weaver and Rajaram (1992), the estimated average requirement for female athletes may be 70% higher than the recommended dietary allowance for females aged 19-50. This is due to their increased sweat production, blood loss in the urine and GI tract, and the continuous mechanical force of foot pounding leading to a shorter life span of erythrocytes (Gaudiani, 2018). Gaudiani (2018) explained signs and symptoms may be more noticeable in athletes due to less oxygen to fuel aerobic exercise, decreased exercise capacity and VO2 max with iron deficiency symptoms ranging from exhaustion to dizziness. As deficiency progresses, symptoms may worsen to include poor appetite, brittle nails and potential cardiovascular and/or pregnancy problems if the deficiency is not reversed (Mayo Clinic, 2019).

The several research articles summarized within this literature review included menstruating female athletes as the subjects. All studies had a small sample size for a short duration of time, yet surprisingly, all studies concluded upon a similar finding. Within the studies, most subjects were consuming diets that consisted of a lower amount of iron than what is recommended for this population. A low iron intake, dietary imbalance, and menstruation were the factors responsible for the development of iron deficiency in menstruating females, independent of whether they consumed a plant-based or animal-based diet. The study conducted by Alaunyte et al. (2014) was the only study to utilize a non-heme iron source as an intervention to determine if this served as an acceptable recommendation to prevent deficiencies within menstruating athletes. This indicates a gap within the literature. There is a lack of conclusive research studies utilizing a plant-based nutrition intervention to provide the recommended dietary allowance of iron within female endurance athletes who are menstruating while maintaining iron labs indicative of anemia within normal range. The current research available indicates that registered dietitians should be providing nutritional tips to all menstruating females on the importance of iron consumption, as current research indicates most females are lacking sufficient amounts within their diets indifferent from what type of diet they consume and whether they participate in an endurance sport. Future research studies are essential within this area to determine if a plant-based diet provides the recommended dietary allowance of iron in menstruating female endurance athletes while maintaining iron labs indicative of anemia within normal range.

Chapter Three: Methodology

Iron deficiency is a common nutritional concern for menstruating female endurance athletes, however, this deficiency is not regularly assessed and monitored for (Mayo Clinic, 2019). The purpose of this research proposal is to investigate if a plant-based diet provides the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. This chapter will review the research design of this 17-week randomized, controlled trial, discussing the intricate details developed to create a strong research study. The inclusion and exclusion criteria set to recruit subjects for this study will be discussed, as well as the reasoning behind why this criterion was chosen. The protocol will be explained to review the forms used to collect dietary information consumed by both groups with the use of the NHANES Food Frequency Questionnaire and three unannounced 24-hour dietary recalls; these forms will be used to assess and monitor for diet compliance within the intervention and control group, and analyzed to discuss comparisons that may be shown by the data collected between the two groups. The descriptive and inferential statistical tests that will be used to assess and analyze the collected data will be evaluated, as will the description of threats that may alter the validity. Lastly, the ethical procedures that will be taken to protect the health and safety of the participating subjects will be reviewed.

Research Design

This research proposal will be a 17-week randomized, controlled trial to investigate if a plant-based diet provides the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. The research questions is, Does a plant-based diet provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range? The null hypothesis is that a plant-based diet will not provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. Alternatively, it is hypothesized that a plant-based diet will provide the recommended dietary allowance of iron for menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range.

The variables in this study are shown in Table 1. The independent variable within this study is the plant-based diet which will be consumed by the intervention group and the normal diet which will be consumed by the control group. Dependent variables include the iron labs indicative of iron deficiency anemia that will be collected during week zero and week 17. It is noted that week zero is the week prior to the start date for both team's first practice of the season. This study was purposefully curated to begin the week prior to the team's practices, as the first week of the study will be when the research dietitian spends the most time collecting data; this will ensure no time is taken from practice. A nominal scale will be used to assess this information to determine whether each lab value collected is within normal range. If iron labs are below normal range, iron deficiency anemia may be suspected. When suspected, the research dietitian will provide the necessary information to the subject and recommend a visit to their physician for further evaluation. The research dietitian will then analyze the data collected by the physician, if subjects are willing to share this information.

Diet assessment will be measured with the use of three, unannounced 24-hour dietary recalls completed during week three, week nine, and week 15, shown in table 4. These 24-hour dietary recalls will be used to evaluate the consumption of both heme and non-heme iron food sources for both groups, and to measure compliance of the intervention group to determine if they are consuming the plant-based diet designed to provide enough iron. Compliance from the control group will also be monitored to determine if they are continuing to consume their normal diet throughout this study. A nominal scale will be used to measure the results depicting whether subjects within both the intervention and control group are consuming the recommended dietary allowance of iron, of 18 mg/day.

Table 1

Description of Variables

Variable Type	Variable Name	Variable Source	Potential Responses	Level of Measurement
Independent	Plant-based diet, normal diet	Assigned Group	Yes or No	Nominal Scale
Dependent	Hemoglobin, hematocrit, ferritin, serum iron, transferrin saturation, and total iron binding capacity	Labs collected before and after the study	Yes - Within Normal Limits No – Not Within Normal Limits	Nominal Scale
Dependent	Diet assessment	Three 24-hour dietary recalls	Yes 18 mg or No 18 mg	Nominal Scale

Setting and Sample

Sample Size. Sample size will be determined by the number of participants on the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee cross-country teams who are willing to participate within this study. It is estimated that approximately 40 cross-country female runners will participate for both university teams combined.

Before subjects will be included within this study, females will be screened based on questions related to the inclusion criteria: if they are between the ages of 19 and 25, are menstruating, and if they are a part of either the University of Wisconsin-Madison or the University of Wisconsin-Milwaukee women's cross country teams who are expected to be running 55 +/- 14 miles per week. Females will also be screened based on questions related to the exclusion criteria: if they are not menstruating, are pregnant, are vegan or have any dietary limitations, are using an oral iron supplement recommended by their physician, or have a history of a disease that may impair their iron absorption such as celiac disease or hemochromatosis that is known to impact iron levels. Females that pass this criterion will be included within this study and randomly placed into either the intervention or control group as designed by the computer numbering system. All participating subjects will sign an informed consent (see appendix A) before they may begin participating within the study, and all subjects will be informed they may drop-out of this study at any time without any ramifications.

Recruitment. The research dietitian will begin this recruitment process during the 2020 women's cross-country season, to begin the conversation with the team's coaches to discuss the study and the importance it holds. Speaking with both coaches the year prior will help determine the interest of the study. The research dietitian will remain in contact with the coaches throughout the year, from the initial conversation until the start of the next season, when the study is scheduled to begin. During this time, the research dietitian will answer any questions or concerns the coaches may have regarding the study and will provide information related to the methods. The amount of time to collect data for the duration of this study will be discussed, as it is anticipated to be less than 15 hours total with no hinder on the time allocated for team practices. During these conversations with the coaches, the research dietitian will also thoroughly explain the importance of iron status within this high-risk population and the benefits each team may acquire from their participation in this study, such as peak performance rates.

The purpose of the previous conversations with the coaches will be to provide detailed information of the study and to influence their participation. Once both teams commit to their involvement, the research dietitian will begin to recruit subjects at the beginning of the season in July 2021. An IRB approval form will be completed and submitted to begin the start of this study (see appendix B). Inclusion criteria will consist of menstruating females aged 19-25 years of old, and subjects participating on either the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee women's cross-country teams who are expected to be running 55 +/- 14 miles per week. This criterion has been set specifically to include females that are losing additional iron during their monthly menstrual cycle. The age range is to compare iron consumption to the recommended dietary allowance set specifically for females aged 19-50 years old. Including female subjects from the both University of Wisconsin-Madison and the University of Wisconsin-Milwaukee is due to the convenience of the research dietitian living within this area, the geographical location involving minimal elevation as high elevation has been shown to promote iron deficiency, and to include a number of subjects to participate within this study to strengthen the design.

Exclusion criteria includes females who are not menstruating, are pregnant, are vegan or who have dietary limitations that include the elimination of animal food sources, are using an oral iron supplement, have a history of chronic blood loss from a peptic ulcer, a hiatal hernia, colorectal cancer, or who have a history of an intestinal disorder such as celiac disease, or other diseases such as hemochromatosis that impacts iron levels.. This criterion was set due to the possible effects these variables may have on the collected results. Subjects who have eliminated animal food sources prior to the start of this study will not be able to participate within the intervention group when randomly placed, due to the requirement of consuming some amounts of animal proteins. Subjects consuming an oral iron supplement will not be included in this study as their labs may impact overall collected results, showing false readings. By setting these inclusion and exclusion criterions, the results from this study will provide generalized data that will be valuable for future research studies related to this topic.

Instrumentation

All subjects will complete the NHANES Food Frequency Questionnaire (see appendix C) before the beginning of the study during week zero, to collect semi-quantitative data related to previous dietary intakes from the past 12 months. The data collected by the NHANES Food Frequency Questionnaire will provide important information as it relates to previous calorie and iron consumption within the subjects. The data collected from the NHANES Food Frequency Questionnaire will provide insight as to why labs indicative of iron deficiency anemia may be low for the lab analysis completed during week zero, while also being used to compare to the 24-hour dietary recalls to determine how diet may improve for all subjects over the duration of this study.

The research dietitian will meet face-to-face with all subjects in both the intervention and control group unannounced during week three, week nine and week 15 to assess subject diet compliance with the use of a 24-hour dietary recalls (see appendix D) and answer any personal questions subjects may have while also providing individualized nutrition education as needed. If subjects are unable to attend an in-person 24-hour dietary recall session during the scheduled times, a phone interview will be completed as necessary, within reason. The purpose of the 24-hour dietary recalls is to measure the compliance of the individuals within the intervention and control group, while also measuring if an improvement in calorie consumption is seen in the control group as the study progresses from the nutrition education provided by the research dietitian (see appendix F).

Labs indicative of iron deficiency anemia will be drawn during week zero and week 17 to determine any lab value changes for both groups. These labs include hemoglobin, hematocrit, ferritin, serum iron, transferrin saturation, and total iron-binding capacity, and will be drawn and analyzed at a local hospital, for convenience.

Protocol

During week zero, a week before the start of the team's seasonal practice begins, the research dietitian will obtain all informed consents from each participating subject (see appendix A). Once forms are collected, each subject will be assigned a random number that will be generated by a computer to place them within either the control or the intervention group. Once groups are compiled, the research dietitian will educate all subjects of the design and layout of the study. The research dietitian will also educate participants on the accuracy needed to be obtained during the study and will encourage compliance and honesty for each subject as they participate within this controlled trial to produce accurate results. Compliance of the intervention is indicated as following the guidelines set for the plant-based diet within the intervention, and compliance of the control group will be indicated as consuming normal eating patterns as shown from the NHANES Food Frequency Questionnaire results. If a subject in the intervention group continuously does not consume the plant-based diet as they are educated by the third collected 24-hour dietary recall, their results will not be included within the results for this study.

The NHANES Food Frequency Questionnaire (see appendix C) will be completed by all subjects during week zero to collect information on previous eating patterns consumed for the past 12 months prior to the start of the study. The NHANES Food Frequency Questionnaire will be completed during week zero in a classroom setting for both teams to complete, one week before the start of their team's practice. The research dietitian will be present when both teams are completing this questionnaire to answer questions any of the subjects may have related to completing the form. Depending on the team's schedules, the research dietitian will meet with the University of Wisconsin-Milwaukee on the first day of the study in the morning to complete the form. The research dietitian will then commute to Madison, in which these subjects will complete the questionnaire in the early afternoon.

The research dietitian will provide directions to both teams before they fill-out the food frequency questionnaire. The research dietitian will define a food frequency questionnaire as a finite list of foods and beverages frequently consumed. The research dietitian will review the directions to take the questionnaire, such as using a no. 2 pencil, circling answers that seem the most fit, and stating that the test should take about 45 minutes to complete. After the NHANES Food Frequency Questionnaire is completed, the research dietitian will spend about a half hour educating both teams on the importance of consuming adequate calories, protein and fluids based on their high activity levels, and answering any general questions or concerns that may arise (see appendix F). The results from the NHANES Food Frequency Questionnaire will be compared to the 24-hour dietary recalls near the end of the study, to determine the change in overall eating patterns for all subjects, from before the start to the end of the study.

All subjects will have labs drawn during week zero to assess the prior eating patterns, as also indicated by the NHANES Food Frequency Question, and current iron status. At this time, subjects will also provide their age, information related to their training habits including training frequency per week, running distance per week in miles, and running time per week in hours, which will be confirmed by each team's coach. Body mass index (BMI) of each subject will be calculated to determine if they are underweight, normal weight or overweight, keeping in consideration high muscle mass. Labs will be drawn at the local hospital in the morning during week zero for all subjects. The purpose of drawing labs before the beginning of the study is to determine the iron status of the subjects before they begin consuming the plant-based diet. This will be important to know, to prevent any disruption in results collected.

During week zero, the research dietitian will provide a team-based approach for all subjects, providing generalized nutrition education specifically related to increased portion sizes to meet the increased physical activity demands of these individuals (see appendix F). However, education regarding the plant-based diet will only be provided to the subjects on each team that were randomly placed within the intervention group, in a group setting (see appendix E). This education for the intervention group will include plant-based food options they may consume for their breakfast, lunch, and dinner meals, weekend meals, and snacks. The research dietitian will also exemplify a list of foods the subjects within the intervention group may consume on the plant-based diet including iron-fortified foods, what foods to pair together for the best non-heme absorption rates, what foods to limit consuming together to decrease the inhibition of non-heme iron absorption, and recipe links to assist in creating a variety of plant-based meals. The intervention group will consume a plant-based diet including a minimum of 4 cups of vegetables, 3 cups of fruit, 6 ounces of whole grains, 3 cups of dairy including soy products, 1 serving of iron-fortified foods, and 5.5 ounces of protein with more than half of the protein coming from plant-based food sources, which is based on a 2,000 calorie intake. Individuals within this group will be educated on the importance of focusing on pairing non-heme iron with absorption enhancers including food sources high in vitamin C. It will be noted that some portions may be above or below the minimum requirement for subjects based on their weight, height, and personal needs that may influence caloric needs.

Team-based educational sessions will be completed during week zero for all subjects, discussing the importance of calories due to their high physical demands. The research dietitian will meet face-to-face with all subjects in both the intervention and control group unannounced during week three, week nine and week 15 to measure subject compliance with the use of a 24-hour dietary recalls (see appendix D) and answer any personal questions subjects may have regarding their group's specified nutrition education, providing individualized nutrition education as needed. The time scheduled to complete these 24-hour dietary recalls will be confirmed by both coaches for the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee prior to the start of their practice. If subjects are not able to participate within the scheduled 24-hour dietary recalls, the research dietitian will set-up a time that works best, within reason, for a phone call to complete the task.

During week three and week nine, the unannounced 24-hour dietary recalls conducted by the research dietitian will focus specifically on subject compliance in both the intervention and control group. The 24-hour dietary recalls will be assessed with the use of ESHA, a diet analysis software. If a subject does not consume the required number of portions within each food group for one or all three of the 24-hour dietary recalls, further education will be completed. If their results for the 24-hour dietary recall during week 15 indicates non-compliance, their data will not be included within the results for this study.

During week 17 of the study, all subjects will have their labs drawn one last time to determine if their iron labs indicative of anemia are within normal range. The control group's labs will also be drawn during this week to determine if there is a comparison between the two groups.

Data Analysis Plan

Descriptive Statistics. A normal distribution will be used to ensure data is normally distributed, so no wrong conclusions are made. A central tendency will be applied to collect the mean, mode and median to determine the typical value in the dataset. The data collected from the NHANES Food Frequency Questionnaire will be useful in comparing the eating patterns for the subjects within the intervention group and the control group prior to the start of the study. Data collected will include the mean age of the participants, body mass index, and training habits. This data will be collected during week zero and analyzed with a central tendency.

Inferential Statistics. A chi-square test will be utilized for all analysis in this study as the dependent variable is categorical. The results from this study will be compared between the intervention and control group to determine if the intervention provides the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. Data collected from the NHANES Food Frequency Questionnaire and the three, 24-hour dietary recalls will be evaluated with the use of ESHA, a dietary analyzer. The final 24-hour dietary recall conducted during week 15 will provide the p-values that will determine if the hypothesis will be accepted or rejected. A p-value less than 0.05 will show a statistically significant change that will reject the null hypothesis. Table 2 provides an overview of the variables including name, source, potential response, and level of measurement.

Threats to Validity

To ensure clarity, comprehensibility, and appropriateness, the NHANES Food Frequency Questionnaire will be used to collect semi-quantitative data on all subject's previous dietary consumption. Threats to the validity of this design include the memory, compliance and honesty of the subjects, lack of blinding that may cause negative social interactions between the two groups, and generalizability. Due to the small sample size, the results from this study will not be able to be generalized for the entire population of menstruating, female endurance athletes. Future research studies are needed on this topic.

Ethical Procedures

Before the start of the study, the Institutional Review Board (IRB) approval will be received (see appendix B). Subjects will not be put at risk for harm throughout the duration of this study. However, discomfort may occur during and a short time after the lab draws are completed during week zero and week 17. An informed consent (see appendix A) will be obtained from each subject prior to the start of this study. The informed consent form will explain the procedures, risks, safeguards, freedom to withdraw, and the confidentiality that will be taken within this study. All data collected will be stored in a confidential web-based folder requiring a password to enter. Data will be entered per team using initials, age and their number assigned to each subject during the randomization process to code each subject's information. Subjects will be aware that they may withdraw from the study at any time with no consequence.

Summary

This 17-week randomized, controlled trial will provide insight related to providing a nutrition intervention using a plant-based diet, to determine if it provides the recommended dietary allowance of iron while maintaining iron labs indicative of anemia within normal range for menstruating, female endurance athletes. All subjects will be provided with generalized nutrition education (see appendix F) specifically related to their increased calorie range due to their high physical activity status during week zero, three, nine, and 15. Subjects within the intervention group will be provided with additional nutrition education specific to a plant-based diet, and will be provided with plant-based recipes they may follow to ensure highest compliance (see appendix E).

Central tendency and a chi-square test will be used to analyze the collected data to compare the intervention and control group to demonstrate if they are similar, to determine if the intervention is the reason for the outcome. Labs indicative of iron deficiency will be drawn during weeks zero and 17 to determine if they are within normal range or not within normal range. Descriptive statistics will be used to describe the population, while inferential statistics will look at an association between the nutrition intervention and if it provides the recommended dietary allowance while maintaining labs indicative of iron deficiency anemia within normal limits. Chapter four will review the anticipated results for this study.

Chapter 4: Anticipated Results

A total of 40 female endurance runners from both the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee cross country teams will participate within this 17-week randomized controlled trial. All 40 female members of both cross-country teams will be included within this study. Twenty female participants will be randomly selected to participate within the intervention group consuming the plant-based diet, while the other 20 female participants will be placed within the control group consuming their normal eating patterns.

Characterization of Study Population

Measures of central tendency will be computed to summarize the data for the age, body mass index, training habits and duration of the diet consumed within this study for both the intervention and control group. It is expected that two dropouts from the intervention and one dropout from the control group will occur due to the possible transferring of schools, inability to stay compliant with the plant-based diet for the intervention subjects, and other personal reasons. Measures of dispersion will be computed to understand the variability of score. Anticipated results are shown in Table 2.

Table 2

Characterization of the study population

	Intervention	Control
Age, years	22 +/-3	22 +/-3
BMI, kg/m^2	19.5 +/-1	19.5 +/- 1
Training Habits		
Training Frequency per week	5.19 ± 0.90	5.04 ± 0.98
Running distance per week, mi	55.41 ± 14.53	55.03 ± 14.66
Running time per week, h	19.38 ± 1.43	19.72 ± 1.11
Dropout Rate	17 weeks +/-2	17 weeks +/-1

NHANES Food Frequency Questionnaire

The NHANES Food Frequency Questionnaire will be used to collect information on previous eating patterns consumed by all participants before the start of the study. Table 3 below indicates the averaged results for both the intervention group with the control group, the p-value will be anticipated to indicate no significant difference. A central tendency test will be used to assess the data compiled from all completed NHANES Food Frequency Questionnaires within each group. This data will be useful in determining the comparisons of eating patterns of the subjects within the intervention group versus the control group, while also assessing for changes that may occur from the beginning to the end of the study when comparing the NHANES Food Frequency Questionnaire to the 24-hour dietary recalls.

Table 3

NHANES Food Frequency Questionnaire Averaged Results

Group	Intervention Group	Control Group	P-value
Energy intake	1800 calories	1800 calories	P = 1.0
Vegetable Intake	2 cups	2 cups	P = 1.0
Fruit Intake	1 cup	1 cup	P = 1.0
Whole Grain Intake	5 ounces	5 ounces	P = 1.0
Animal Protein Intake	4 ounces	4 ounces	P = 1.0
Iron Intake	14 mg	14 mg	P = 1.0
Dairy Intake	2 cups	2 cups	P = 1.0
Processed Foods Intake	4 servings	4 servings	P = 1.0

24-Hour Dietary Recall

Throughout the duration of the study, diet compliance will be assessed with the use of three unannounced 24-hour dietary recalls conducted by the research dietitian, as shown in table 4. The 24-hour dietary recalls will be collected during week three, nine and 15 for both the intervention and control group to assess the amount of energy, vegetable, fruit, whole grain, animal protein, plant protein, iron, dairy, and processed foods consumed. It is anticipated that 75% of the subjects in the intervention group will be compliant with the plant-based diet as shown by the averaged 24-hour diet recalls collected during week three, and the control group will continue to consume their normal eating patterns with a gradual increase in calorie consumption.

The anticipated results for weeks nine and 15 are anticipated to indicate significant differences between the intervention and control groups for the animal protein, plant protein and processed foods. It is noted that energy consumption will improve as the study progresses for the control group. The results collected for the 24-hour dietary recalls will be compared with the results from the NHANES Food Frequency Questionnaire as shown in table 3, to understand the overall dietary changes that are anticipated to occur throughout the duration of this study for both groups involved.

Table 4

Average Nutrient Intake of the Study Population Determined via 24-hour Dietary Recall, Weeks 3, 9, and 15

	Week 3		Week 9		Week 15		P - Value		
Group	Intervention	Control	Intervention	Control	Intervention	Control	Week 3	Week 9	Week 15
Energy	2100 cal	1850 cal	2200 cal	2100 cal	2300 cal	2200 cal	0.05	0.30	0.30
Vegetable	4 c	3 c	4 c	3 c	4 c	4 c	0.80	0.80	1
Fruit	3 c	2 c	3 c	2 c	3 c	2 c	0.80	0.80	0.80
Whole Grain	6 oz	5 oz	6 oz	7 oz	6 oz	7 oz	0.90	1	0.90
Animal Protein	1 oz	5 oz	1 oz	6 oz	1 oz	7 oz	0.04	0.04	0.03
Plant Protein	5 oz	1 oz	5 oz	1 oz	5 oz	1 oz	004	0.04	0.03
Iron	18 mg	16 mg	18 mg	18 mg	18 mg	19 mg	0.28	0.70	0.3
Dairy	3 c	2 c	3 c	2 c	3 c	4 c	1	1	0.28
Processed Foods	1 serv	4 serv	1 serv	4 serv	1 serv	4 serv	0.05	0.05	0.05

Lab Analysis

As shown in table 5, it is anticipated that there will be no significant difference between the intervention or control group for the lab analysis collected during week zero. This is anticipated to be caused by similar eating patterns consumed prior to the start of the study as shown by the NHANES Food Frequency Questionnaire. It will also be anticipated that lab values for hemoglobin, hematocrit, ferritin, serum iron, transferrin saturation, and total iron-binding capacity will all be borderline low for both the intervention and control group during week zero's lab analysis.

The anticipated results from the lab analysis for both the intervention and control group during week 17's lab draw is also displayed in table 5. The lab results collected during week 17 are anticipated to indicate no statistically significant differences between the intervention and control group. This is expected as both groups will be educated by the research dietitian on the topic of consuming a higher number of calories to meet nutritional needs due to high physical activity; the energy increase for the control group can be found in table 4 when comparing week three to week 15. Table 5 presents the finding that all iron labs indicative of iron deficiency anemia will improve for both groups when comparing week zero with week 17.

Table 5

Average Lab Analysis of the Study Population Determine via Lab Draws Week Zero and Seventeen

	Week 0		Week 17		P - Value	
Iron Labs	Intervention	Control	Intervention	Control	Week 0	Week 17
Hemoglobin	10.4 g/dl +/- 2.04	11.2 g/dl +/- 3.83	13.2 g/dl +/- 2.04	15.3 g/dL +/- 3.83	P = 0.06	P = 0.07
Hematocrit	38%	39%	40%	46%	P = 0.07	P = 0.09
Ferritin	<30 ng/mL	<33 ng/mL	<38 ng/mL	<43 ng/mL	P = 0.07	P = 0.06
Serum Iron	75 mcg/dL	80 mcg/dL	80 mcg/dL	87 mcg/dL	P = 0.07	P = 0.07
Transferrin Saturation	<21%	<24%	<25%	<29%	P = 0.07	P = 0.07
Total Iron Binding Capacity	455 mcg/dL	459 mcg/dL	440 mcg/dL	435 mcg/dL	P = 0.06	P = 0.06

Diagnosis of Iron Deficiency Anemia

The labs drawn and analyzed during week zero and 17 are iron labs indicative of iron deficiency anemia. These labs are anticipated to improve for both groups by the end of the study, likely related to the increase in calorie and iron consumption to better meet nutritional needs due to the high activity level for all subjects participating in this study. It is anticipated that no subjects from the intervention or control group will have labs indicative of iron deficiency anemia during week zero or week 17.

Chapter 5: Discussion

A plant-based diet plays a key role in optimal health status (“Plant-Based Diets”, 2019). Despite knowing this, research has been lacking as it relates to a nutrition intervention of plant-based eating in endurance athletes. A gap in the literature exists with the use of a plant-based nutrition intervention to provide the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining iron labs indicative of anemia within normal range. This chapter will discuss the anticipated results from this study, compare these anticipated results to the research studies conducted by Alaunyte et al. (2014), Khanna et al. (2006), Malczewska et al. (2000), and Snyder et al, (1989), and conclude with suggestions recommended for future research studies.

Interpretation of Results

This 17-week randomized controlled trial will investigate if a plant-based diet provides the recommended dietary allowance of iron in menstruating, female endurance athletes. It is anticipated that the null hypothesis will be rejected, and the alternative hypothesis will be accepted as the plant-based diet will provide the recommended dietary allowance of iron in menstruating female endurance athletes while maintaining labs indicative of iron deficiency anemia within normal range. This will be indicated by comparing the NHANES Food Frequency Questionnaire to the 24-hour dietary recalls, showing an increase in iron consumption from eating habits prior to the start to the end of the study for the intervention group. The iron labs indicative of iron deficiency anemia will support the alternative hypothesis as iron labs are anticipated to increase from week zero to week 17, for the intervention group specifically.

The use of the NHANES Food Frequency Questionnaire and three unannounced 24-hour dietary recalls will be used to compare both assessment tools within the intervention and control group. This will allow the research dietitian to analyze results between the two groups, confident that both groups will display lab results portraying the true amount of heme and non-heme iron consumed within their specified diet.

Characterization of Study Population. Subjects participating within this study are expected to be menstruating females aged 22 +/- 3 years old. The body mass index for both the intervention and control group is expected to be within the normal range. Training habits for both groups are expected to be similar and indicate no significant differences. Similar characteristics between the two groups will be important as differences could alter the end results, indicating a false conclusion.

NHANES Food Frequency Questionnaire. The NHANES Food Frequency Questionnaire will be used to collect data during week zero to gather information on previous eating patterns consumed by all participants. The data collected from this questionnaire is located on Table 3, page 55. The anticipated results will indicate that both groups will consume on average, 1,800 calories per day, which is less calories than what is recommended based on the high physical activity levels within this population. This low-calorie consumption will also signify a low consumption of vegetables, fruits, whole grains, and food sources high in iron within the studied population. A low-calorie and iron consumption has previously been shown in the study conducted by Snyder et al. (1989) whose findings indicated that their female running subjects were consuming calorie ranges of 1,600-1,800 calories and inadequate intakes of food sources high in iron. It was discussed in the study conducted by Snyder et al. (1989) that the low-calorie consumption was one of the factors influencing a low iron status as subjects were not consuming enough nutrients based on their high activity levels.

A nutritional breakdown of previous eating patterns as shown by the NHANES Food Frequency Questionnaire will be analyzed to determine the number of calories, macronutrient composition and amount of iron consumed within subject's diet with the use of ESHA. It is anticipated that female subjects in both groups will not consume the recommended dietary allowance of iron prior to the start of this study. This finding will also be supported by the 24-hour dietary recalls indicating less than or equal to 18 mg/day for the first two 24-hour dietary recalls within the control group. This research proposal's findings are similar to Snyder et al. (1989) who found that subjects were consuming 14.7 +/- 2.0 mg.d-1 for the modified vegetarian group and 14.0 +/- 2.2 mg.d-1 for the group consuming red meat, which is less than the recommended dietary allowance of 18 mg per day.

24-Hour Dietary Recall. The results from the three unannounced 24-hour dietary recalls will reveal some differences in nutrient intake between the two groups as the study progresses. This information can be viewed on Table 4, page 57. These 24-hour dietary recalls will assess total energy, vegetable, fruit, whole grain, animal protein, plant-protein, iron, dairy, and processed food intake. The control group will gradually improve their eating patterns as the study progresses, indicating the importance of nutrition education provided by the research dietitian. The study conducted by Snyder et al. (1989) found that calorie consumption was initially low within their subjects, which was a factor that influenced iron deficiency. However, a finding from this study indicated that as calories increased by 1,000 calories, so did iron intake by 6 mg, signifying the importance of subjects consuming their total energy nutritional needs (Snyder et al., 1989).

The research dietitian will continue to provide nutrition education for subjects within the intervention group throughout the duration of the study. However, this education will be most important during week zero of the study where some information may be unknown knowledge for some subjects (see appendix E). It will be expected that all subjects within the intervention group will be 75% percent compliant with the intervention by week three and throughout the duration of the study as shown by the unannounced 24-hour dietary averaged recalls.

The control group will be provided with generalized nutrition education throughout the duration of the study, focusing on increasing calories to better meet nutritional needs (see appendix F). It is expected that calorie amounts will increase for the control group, as the research dietitian will be providing several team education sessions on the importance of increased nutrition based on the subject's high physical activity levels.

Due to the intervention group consuming more plant-based meals compared to the control group, it is expected that the dietary pattern consumption will be higher in several areas due to consuming a plant-based diet. Although not measured, the intervention group is expected to be consuming higher amounts of fiber, iron, folate, vitamin C, B-vitamins, calcium and zinc when compared the control group. Consumption of total fat and saturated fat is expected to be higher in the control group versus the intervention group due to the higher consumption of animal food products, although this will not be measured either.

The studies conducted by Alaunyte et al. (2014) and Khanna et al. (2006) utilized 24-hour dietary recalls to collect dietary assessment from their subjects. Alaunyte et al. (2014) discovered a higher amount of fiber, vitamin C, B-vitamins, calcium, iron and zinc, and lower levels of saturated fat and total fat post-intervention of utilizing the Teff bread. Khanna et al. (2006) analyzed data from the 24-hour dietary recalls to assess macronutrient percentages. The findings indicated that carbohydrate and energy was not significantly different between the two groups, yet protein percentages were higher for the non-vegetarian group and fat percentage was higher for the lacto-ovo vegetarian group. Other variations from this study included calcium intake found to be significantly higher in lacto-vegetarians, iron and niacin intake higher in non-vegetarians, and no significant difference in vitamin C intake between the groups (Khanna et al., 2006). These studies correlate with the several findings from this study in the perspective that non-vegetarians typically have higher iron levels due to the consumption of heme iron, and that plant-based diets do offer the recommended dietary allowance for iron when calories needs are met.

Lab Analysis. Labs will be drawn during week zero and week 17 for all 40 subjects participating within both the intervention and control group. The anticipated results collected in week zero will indicate that half of the subjects participating in this study will report inadequate iron intake as shown by the NHANES Food Frequency Questionnaire. Alaunyte et al. (2014) discovered similar results, with over a third of their subjects showing depleted bodily iron stores due to inadequate dietary iron intake at the start of their study.

As previously shown on Table 5 page 59, it is anticipated that all hematological lab values will be borderline low during week zero for both the intervention and control group. As the study progresses to week 17, it is anticipated that both groups will have an improvement in all labs including hemoglobin, hematocrit, ferritin, serum iron, transferrin saturation, and total iron-binding capacity. This increase in iron labs indicative of iron deficiency anemia is likely be an effect from the nutrition education provided.

Diagnosis of Iron Deficiency Anemia. It is indicated by the anticipated results that iron levels will increase for the intervention group, as it coincides with the nutrition education for increased calorie amounts (see appendix F) and the pairing of non-heme iron with non-heme absorption enhancers (see appendix E). However, it is expected that the control group will have slightly higher iron labs when comparing week zero with week 17 due to the consumption of animal food products and increased calorie consumption. This finding is similar to Khanna et al. (2006) whose study found that iron levels were higher in the non-vegetarian group which they also contributed to the consumption of heme iron found in animal food products.

Comparison to Other Studies

The anticipated results from this current study are consistent with previous research conducted by Alaunyte et al. (2014), Khanna et al. (2006), Malczewska et al. (2000), and Snyder et al, (1989). These research studies indicated that female athletes may have various ranges of iron deficiency due to low calorie consumption, low bioavailability of non-heme iron, and loss of iron from monthly menstruation. Yet, research indicates a gap in the literature. Many studies related to athletes and iron status involved an intervention including an oral iron supplement or increasing animal protein, not a plant-based intervention as this study proposes.

The research study conducted by Malczewska et al. (2000) showed most menstruating female endurance athletes were not consuming adequate calories or iron consumption to meet their higher estimated nutritional needs based on their increased physical activity. The study also indicated that the amount of blood loss during monthly menstruation impacts iron status; the more blood loss during menstruation increases the individual’s risk of developing iron deficiency due to their higher amount of iron lost on a monthly basis. Due to the complicated nature of estimating blood loss during menstruation, this factor was not included within this proposal.

Other differences and similarities between this research proposal with the studies conducted by Alaunyte et al. (2014), Khanna et al. (2006), Malczewska et a. (2000), and Snyder et al, (1989) include focusing on a plant-based diet to increase optimal health within female athletes. However, only one study conducted by Alaunyte et al. (2014) utilizes a plant-based nutrition intervention. In this study subjects were instructed to replace their current bread with teff bread, a whole grain that is high in iron. The other studies conducted by Khanna et al. (2006), Malczewska et al. (2000), and Snyder et al, (1989) only compared a plant-based diet to a diet high in animal meat consumption.

The use of a food frequency questionnaire and 24-hour dietary recalls were used to collect dietary information within the studies conducted by Alaunyte (2014), Khanna et al. (2006), and Malczewska et al (2000). The study conducted by Malczewska et al. (2000) ensured that the 24-hour dietary recalls were conducted to include both weekdays and weekends to determine typical diets of the subjects, accounting for both non-heme and heme iron sources as well as food containing non-heme iron enhancers or inhibitors. By collecting data on diet assessment, these studies indicated an improvement in iron labs as diets improved, like this research proposal. Multiple iron labs were assessed to determine the level of iron status within participating subjects to determine whether there was a statistically significant difference in iron levels over-time, as was also assessed within this proposal.

Variables accounted for within these several studies by Alaunyte (2014), Khanna et al. (2006), Malczewska et al (2000), and Snyder et al. (1989) included iron stores, hematological values, iron intake from both heme and non-heme iron sources, menstrual bleeding and training levels. These variables, other than the menstrual bleeding, were accounted for within this research proposal as they are factors that may have an impact on iron status. Accounting for these numerous factors will be useful in drawing a strong conclusion.

Strengths and Limitations

Strengths of this study include the use of several iron labs indicative of iron deficiency anemia to determine iron status, utilizing a research dietitian to offer group and individualized nutrition education for subjects participating within the intervention and control group, collecting dietary information with the use of NHANES Food Frequency Questionnaire before the start of the study to understand prior eating habits, conducting three unannounced 24-hour dietary recalls, and assessing the training habits of the female subjects.

Limitations to this study include the small sample size of 40 female endurance athletes. This small sample size is associated with low statistical power, inflated false discovery rate, and inflated effect size estimation which may compromise the conclusions drawn from the study. This research proposal does not assess total blood loss via monthly menstruation, which was found by Malczewska et al. (2000) to be a principal cause of iron deficiency in female athletes whose iron intake was sufficient. The short duration of the study involving 17-weeks is also a limitation as the lifespan of red blood cells is around 120 days. To understand if a plant-based nutrition intervention can provide the recommended dietary allowance of iron while maintaining iron labs indicative or iron deficiency anemia, a study longer than three months is warranted.

As previously mentioned by Weaver and Rajaram (1992), the estimated average requirement for iron for female athletes may be 70% higher than the recommended dietary allowance for females aged 19-50. This is due to their increased sweat production, blood loss in the urine, monthly menstruation and GI tract, and the continuous mechanical force of foot pounding leading to a shorter life span of erythrocytes. It is estimated that 2.3 mg of iron is lost per day in female athletes (Weaver & Rajaram, 1992). This is another limitation in this study as the research question was asking if the menstruating female endurance athletes are meeting the recommended dietary allowance versus the estimated average requirement or each individual's estimated amount.

Suggestions for Future Studies

The anticipated results from this study demonstrate that a plant-based nutrition intervention is beneficial within this high-risk population. The anticipated results also indicate the importance of providing nutrition education for menstruating, female endurance athletes to ensure they are consuming their estimated nutrition needs. Future studies should continue to utilize a plant-based nutrition intervention within a larger sample size to limit low statistical power, inflated false discovery rate and inflated effect size estimation. Future research should conduct long-term studies to understand the impact a plant-based nutrition intervention has on iron status, while considering the lifespan of red blood cells that is around 120 days. When strengthening the limitations within this study design, future studies have the potential to provide general plant-based nutrition interventions to all high-risk population groups as it relates to iron deficiency anemia. More research is warranted.

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Appendix A

Consent Form

Research Participant Information and Consent Form

Mount Mary University

Title of Study: Research Proposal: Plant-Based Nutrition Intervention Providing the Recommended Dietary Allowance for Iron in Menstruating, Female Endurance Athletes

Invitation to Participate and Purpose of the Research You are invited to participate in a research study that seeks female athletes aged 19-24 years old participating on the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee cross country teams. Participants will be asked to participate in a 17-week randomized, controlled trial to investigate if a plant-based diet provides the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining labs indicative of iron deficiency within normal range. Data will be de-identified and analyzed by researchers. Participants will be randomized into the control or intervention group. All subjects will complete the NHANES Food Frequency Questionnaire, three unannounced 24-hour dietary recalls, and labs will be drawn for all subjects.

Benefits and Risks This research is designed to benefit the dietetics profession to investigate if a plant-based diet provides the recommended dietary allowance of iron in menstruating, female endurance athletes. Participants may or may not benefit personally from being in this research study. Participants within the intervention group will be provided with education related to a plant-based diet to provide adequate calorie and iron amounts based on their individualized needs. The findings generated by this research will provide a better understanding if a plant-based diet provides the recommended dietary allowance for menstruating, female endurance athletes, and information for future study designs to further knowledge on this topic. There will be no monetary compensation. Discomfort may occur during and a short time after the lab draws completed during week zero and week 17. Please address any questions or issues of concern to the researchers using the contact information provided above.

Confidentiality All information obtained will be kept confidential by the researchers who will be the only people with access to the data. The anonymity and confidentiality will be kept private, all data collected will be stored in a confidential web-based folder requiring a password to enter. Data will be entered per team using initials, age and their number assigned to each subject during randomization to code subject's information. Per the U.S. Office of Human Research Protections (code §46.115), all data will be destroyed 3 years after the end of data collection. Paper files will be shredded, and electronic files will be deleted. Individual participants will not be identified in any report or publication about this study.

Contact Information If you have questions about this research study, your rights as a research subject, or would like to know the outcome of the research, please contact Abby Fenske, 715-651-9228, fenskea@mtmary.edu or Dr. Dana Scheunemann, 414-930-3502, scheuned@mtmary.edu. If you have any questions regarding your rights or privacy as a participant in this study, please contact Dr. Tammy Scheidegger, Mount Mary University Institutional Review Board Chair, 2900 North Menomonee River Parkway, Milwaukee, Wisconsin, 53222-4597, telephone (414) 930-3434 or email schediet@mtmary.edu.

Consent By signing below, you are indicating that you have read this consent form, have been given the opportunity to ask questions, and have agreed to voluntarily participate. You may withdraw from participation at any time, or refuse to answer any question herein, without penalty or loss of benefits to which other participants are entitled.

You may request a copy of this page for your records. Thank you for your participation.

Signature of participant____ Date _______________

Appendix B

IRB Form

Mount Mary University
Institutional Review Board (IRB)
for the Protection of Human Subjects

Application for IRB Review

<u>I. Required Documentation</u> - No action will be taken without these attachments.

Are the following attached to the IRB application?

Informed Consent Document	√ Yes	Informed Consent Documents should include an explanation of procedures, risk, safeguards, freedom to withdraw, confidentiality, offer to answer inquiries, third party referral for concerns, signature and date. See Appendix.A and use the **MMU Informed Consent Template** to avoid delays in the process.
Questionnaire/Survey Instrument(s)	√ Yes	If a survey is being administered in any written format (e.g., survey monkey, qualtrics), a copy of that survey must accompany this application. If a survey is being conducted verbally, a copy of the introductory comments and survey questions being asked must be attached to this application. If survey includes focus group questions, a complete list of the question must be attached. For research using a published/purchased instrument, a photocopy of the instrument will suffice.
Verification of Human Subjects Training	√ Yes	Copy of transcript, certificate or other evidence that ALL members of the research team have completed the required training.

		.
Copy of cooperating institution's IRB approval.	N/A Yes	Not required if there is no cooperating institution. .

II. Investigator(s):

Name: Abigail Fenske Phone: 715-651-9228
Affiliation with Mount Mary University (e.g. faculty, student, etc.): Dr. Dana Scheunemann
Email: scheuned@mtmary.edu

Signature: _Abigail Fenske______________________ Date: 5/8/20

If student, list Research Advisor and complete the application. Research Advisor must provide requested information and verify.

Department:
Research Advisor's Name:
Email: Phone:

Research Advisor: Have you completed Human Subject's Training? ☐ Yes ☐ No

Research advisor's signature indicates responsibility for student compliance with all IRB requirements.

Signature: Date:

____
Research Advisor

III. Project Description – Required by all applicants

1) Objectives (purpose of project):

The purpose of this randomized, controlled trial is to investigate if a plant-based diet provides the recommended dietary allowance of iron in menstruating, female endurance athletes while maintaining labs indicative of iron deficiency within normal range.

2) Relevance to practice/body of knowledge:

This study has high significance as there is a lack of conclusive research studies utilizing a plant-based diet nutrition intervention to provide the recommended dietary allowance for menstruating, female endurance athletes. This research proposal will provide important information on whether a plant-based diet provides the recommended dietary allowance of iron within this high-risk group.

3) Describe the research design:

This research proposal will be a 17-week randomized, controlled trial to investigate if a plant-based diet provides the recommended dietary allowance of iron in menstruating, female endurance athletes. Sample size will be determined using previous research sample sizes and specified inclusion and exclusion criteria. Subjects will be recruited from the Women's Cross-Country teams from both the University of Wisconsin-Madison and the University of Wisconsin-Milwaukee during the cross-country season occurring in the fall of 2021. Each subject will be assigned a random number that will be generated by a computer to place them within either the control or intervention group. Both groups will complete the NHANES Food Frequency Questionnaire, have labs drawn, and complete three unannounced 24-hour dietary recalls throughout the study. Nutrition education will be provided to both groups on portion sizes to meet individualized nutrition needs in the beginning of the study. However, only the intervention group will be provided with nutrition education on plant-based food options to consume for meals and snacks, what foods to pair together for the best non-heme absorption rates, what foods to limit, and recipes to assist in creating a variety of plant-based meals and snacks. A normal distribution will be used to ensure data is normally distributed, so no wrong conclusions are made. A central tendency will be applied to collect the mean, mode and median to determine the typical value in the dataset. A chi-square test will be utilized in this study as the dependent variables are categorical.

4) What measurement/data collection tools are being used?

NHANES Food Frequency Questionnaire and three unannounced 24-hour dietary recalls will be collected throughout the study. Several labs will be drawn at the beginning and end of the study to determine iron status.

IV. Additional Project Information – Required by all applicants

1) What human subjects training has the researcher completed (e.g. course work, online certification)?

Researcher has completed CITI and HIPPA training.

2) What process is used for obtaining informed consent (attach the informed consent application)? See Appendix for consent application.
Note Appendix A – Consent Form.

3) Does the research include special populations?

Minors under 18 years of age?	☐ Yes	√No
Persons legally incompetent?	☐ Yes	√No
Prisoners?	☐ Yes	√No
Pregnant women, if affected by research?	☐ Yes	√No
Persons institutionalized?	☐ Yes	√No
Persons mentally incapacitated?	☐ Yes	√No

4) If **<u>YES,</u>** describe additional precautions included in the research procedures.
N/A.

5) Does the research involve any of the following procedures?

False or misleading information to subjects?	☐ Yes	√No
Withholds information such that their informed consent might be questioned?	☐ Yes	√No
Uses procedures designed to modify the thinking, attitudes, feelings, or other aspects of the behavior of the subjects?	☐ Yes	√No

6) If **<u>YES</u>**, describe the rationale for using procedures, how the human subjects will be protected and what debriefing procedures are used.
N/A.

7) Does the research involve measurement in any of the following areas?

Sexual behaviors?	☐ Yes	√No
Drug use?	☐ Yes	√No
Illegal conduct?	☐ Yes	√No
Use of alcohol?	☐ Yes	√No

8) If **<u>YES</u>**, describe additional precautions included in the research procedures.
N/A.

9) Are any portions of the research being conducted online?

Survey posted on a website?	√Yes	☐ No	If yes, assure anonymity

URL for survey includes information that could identify participants?	√Yes	☐ No	If yes, assure anonymity
Invitation to participate sent by email?	√Yes	☐ No	If yes, assure anonymity
Items use drop-down box?	√Yes	☐ No	If yes, assure that items allow choice of "no response"

10) If **<u>YES</u>**, describe additional procedures.
The anonymity and confidentiality will be kept private, all data collected will be stored in a confidential web-based folder requiring a password to enter. Data will be entered per team using initials, age and their number assigned to each subject during randomization to code subject's information. Subjects will be aware that they may withdraw from the study at any time with no consequence.

11) Describe the methods used to ensure confidentiality of data obtained.
The anonymity and confidentiality will be kept private, all data collected will be stored in a confidential web-based folder requiring a password to enter. Data will be entered per team using initials, age and their number assigned to each subject during randomization to code subject's information.

Risks and Benefits
1) Describe risks to the subjects and the precautions that will be taken to minimize them. (Risk includes any potential or actual physical risk of discomfort, harassment, invasion of privacy, risk of physical activity, risk to dignity and self-respect, and psychological, emotional or behavioral risk.)
Multiple steps will be taken during this study to ensure research ethics. Subjects will not be put at risk for harm throughout the duration of this study.

2) Describe the benefits to subjects and/or society. (These will be balanced against risk.)
This randomized, controlled trial will provide a better understanding if a plant-based diet provides the recommended dietary allowance of iron for menstruating, female endurance athletes, and information for future study designs to further knowledge on this topic.

V. <u>Is the proposed project "research" as defined by Institutional Review Board requirements? - Required by all applicants</u>

- Research is defined as a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge.
- A human subject is defined as a living individual about whom an investigator obtains either 1) data through intervention or interaction with the individual; or 2) identifiable private information.

Does the research involve human subjects or official records about human subjects?

√Yes
☐ No

If the results will be available in the library, presented at a professional conference (includes any presentation to group(s) outside of the classroom), or published, please check the Yes box:

☐ Yes
√No

Appendix C

NHANES Food Questionnaire

NHANES Food Questionnaire

More than one member of your household may have received a questionnaire. Please make sure this is your booklet before answering any questions.

LABEL HERE

GENERAL INSTRUCTIONS

- Answer each question as best you can. Estimate if you are not sure. A guess is better than leaving a blank.
- Use only a No. 2 pencil.
- Be certain to completely blacken in each of the answers.
- Erase completely if you make any changes.
- Do not make any stray marks on this form.
- If you blacken NEVER or NO for a question, please follow any arrows or instructions that direct you to the next question.

PLEASE DO NOT WRITE IN THIS AREA

SERIAL #

Public reporting burden of this collection of information is estimated to be 45 minutes per response for total participation, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. An agency may not conduct or sponsor, and a person is not required to respond to collection of information unless it displays a currently valid OMB control number. Send comments regarding this burden estimate or any other aspects of this collection of information, including suggestions for reducing burden to: CDC/ATSDR Reports Clearance Officer, 1800 Clifton Road, MS D-24, Atlanta, GA 30333, Attention: PRA (0920-0237).

1. Over the past 12 months, how often did you drink **tomato juice** or **vegetable juice**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

2. How often did you drink **orange juice** or **grapefruit juice?**

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

3. How often did you drink **apple juice?**

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

4. How often did you drink **grape juice?**

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

5. How often did you drink **other 100% fruit juice** or **100% fruit juice mixtures** (such as pineapple, prune, or others)?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

6. How often did you drink other **fruit drinks** (such as cranberry cocktail, Hi-C, lemonade, or Kool-Aid, diet or regular)?

- NEVER (GO TO QUESTION 7)
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

6a. How often were your fruit drinks **diet** or **sugar-free drinks**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

7. How often did you drink **milk as a beverage** (NOT in coffee, NOT in cereal)? (Please include chocolate milk and hot chocolate.)

- NEVER (GO TO QUESTION 8)
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

7a. What kind of **milk** did you usually drink?

- Whole milk
- 2% fat milk
- 1% fat milk
- Skim, nonfat, or 1/2% fat milk
- Soy milk
- Rice milk
- Raw, unpasteurized milk
- Other

BAR
CODE
LABEL
HERE

Question 8 appears on the next page.

3

Over the past 12 months...

8. How often did you drink **meal replacement, energy, or high-protein beverages** such as Instant Breakfast, Ensure, Slimfast, Sustacal or others?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

9. Over the past 12 months, did you drink **soft drinks, soda,** or **pop**?

- NO (GO TO QUESTION 10)
- YES

9a. How often did you drink **soft drinks, soda,** or **pop IN THE SUMMER**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

9b. How often did you drink **soft drinks, soda,** or **pop DURING THE REST OF THE YEAR**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

9c. How often were these soft drinks, soda, or pop **diet** or **sugar-free**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

9d. How often were these soft drinks, soda, or pop **caffeine-free**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 10 appears in the next column.

10. Over the past 12 months, did you drink **beer**?

- NO (GO TO QUESTION 11)
- YES

10a. How often did you drink **beer IN THE SUMMER**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

10b. How often did you drink **beer DURING THE REST OF THE YEAR**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

11. How often did you drink **wine** or **wine coolers**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

12. How often did you drink **liquor** or **mixed drinks**?

- NEVER
- 1 time per month or less
- 2–3 times per month
- 1–2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

Over the **past 12 months...**

13. Did you eat **oatmeal, grits,** or **other cooked cereal?**

- ○ NO (GO TO QUESTION 14)
- ○ YES

13a. How often did you eat **oatmeal, grits,** or **other cooked cereal IN THE WINTER**?

- ○ NEVER
- ○ 1–6 times per winter
- ○ 7–11 times per winter
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

13b. How often did you eat **oatmeal, grits,** or **other cooked cereal DURING THE REST OF THE YEAR?**

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

13c. How often was the cooked cereal you ate **oatmeal**?

- ○ Almost never or never
- ○ About 1/4 of the time
- ○ About 1/2 of the time
- ○ About 3/4 of the time
- ○ Almost always or always

14. How often did you eat **cold cereal**?

- ○ NEVER (GO TO QUESTION 15)
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

Question 15 appears in the next column.

5

14a. How often was the cold cereal you ate a **whole grain type** (such as shredded wheat, Wheaties, Cheerios, Raisin Bran or other bran, oat, or whole wheat cereal)?

- ○ Almost never or never
- ○ About 1/4 of the time
- ○ About 1/2 of the time
- ○ About 3/4 of the time
- ○ Almost always or always

14b. Was **milk** added to your cold cereal?

- ○ NO (GO TO QUESTION 15)
- ○ YES

14c. What kind of **milk** was usually added?

- ○ Whole milk
- ○ 2% fat milk
- ○ 1% fat milk
- ○ Skim, nonfat, or 1/2% fat milk
- ○ Soy milk
- ○ Rice milk
- ○ Raw, unpasteurized milk
- ○ Other

15. How often did you eat **applesauce**?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

16. How often did you eat **apples**?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

17. How often did you eat **pears** (fresh, canned, or frozen)?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

Over the past 12 months...

18. How often did you eat **bananas** ?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

19. How often did you eat **pineapple**?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

20. How often did you eat **dried fruit**, such as prunes or raisins?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

21. Over the past 12 months, did you eat **peaches, nectarines,** or **plums**?

- ○ NO **(GO TO QUESTION 22)**
- ○ YES

21a. How often did you eat **fresh peaches**, **nectarines**, or **plums WHEN IN SEASON**?

- ○ NEVER
- ○ 1–6 times per season
- ○ 7–11 times per season
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

Question 22 appears in the next column.

21b. How often did you eat **peaches, nectarines,** or **plums** (fresh, canned, or frozen) **DURING THE REST OF THE YEAR**?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

22. How often did you eat **grapes**?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

23. Over the past 12 months, did you eat **melons** (such as cantaloupe, watermelon, or honeydew)?

- ○ NO **(GO TO QUESTION 24)**
- ○ YES

23a. How often did you eat **fresh melons** (such as cantaloupe, watermelon, or honeydew) **WHEN IN SEASON**?

- ○ NEVER
- ○ 1–6 times per season
- ○ 7–11 times per season
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

23b. How often did you eat **fresh or frozen melons** (such as cantaloupe, watermelon, or honeydew) **DURING THE REST OF THE YEAR**?

- ○ NEVER
- ○ 1–6 times per year
- ○ 7–11 times per year
- ○ 1 time per month
- ○ 2–3 times per month
- ○ 1 time per week
- ○ 2 times per week
- ○ 3–4 times per week
- ○ 5–6 times per week
- ○ 1 time per day
- ○ 2 or more times per day

Question 24 appears on the next page.

Over the past 12 months...

24. Did you eat **strawberries**?

- NO **(GO TO QUESTION 25)**
- YES

24a. How often did you eat **fresh strawberries WHEN IN SEASON?**

- NEVER
- 1–6 times per season
- 7–11 times per season
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

24b. How often did you eat **fresh** or **frozen strawberries DURING THE REST OF THE YEAR?**

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

25. Over the past 12 months, did you eat **oranges, tangerines, clementines,** or **tangelos**?

- NO **(GO TO QUESTION 26)**
- YES

25a. How often did you eat **fresh oranges, tangerines, clementines,** or **tangelos WHEN IN SEASON?**

- NEVER
- 1–6 times per season
- 7–11 times per season
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

25b. How often did you eat **oranges, tangerines, clementines,** or **tangelos** (fresh or canned) **DURING THE REST OF THE YEAR?**

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

26. Over the past 12 months, did you eat **grapefruit**?

- NO **(GO TO QUESTION 27)**
- YES

26a. How often did you eat **fresh grapefruit WHEN IN SEASON?**

- NEVER
- 1–6 times per season
- 7–11 times per season
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

26b. How often did you eat **grapefruit** (fresh or canned) **DURING THE REST OF THE YEAR?**

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

27. How often did you eat **other kinds of fruit**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Over the past 12 months...

28. How often did you eat **COOKED greens** (such as spinach, turnip, collard, mustard, chard, or kale)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

29. How often did you eat **RAW greens** (such as spinach, turnip, collard, mustard, chard, or kale)? (*We will ask about lettuce later.*)

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

30. How often did you eat **coleslaw**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

31. How often did you eat **sauerkraut** or **cabbage** (other than coleslaw)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

32. How often did you eat **carrots** (fresh, canned, or frozen)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

33. How often did you eat **string beans** or **green beans** (fresh, canned, or frozen)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

34. How often did you eat **peas** (fresh, canned, or frozen)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

35. Over the past 12 months, did you eat **corn**?

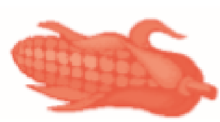
- ◯ NO **(GO TO QUESTION 36)**
- ◯ YES

35a. How often did you eat **corn** (fresh, canned, or frozen) **WHEN IN SEASON**?

- ◯ NEVER
- ◯ 1–6 times per season
- ◯ 7–11 times per season
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

35b. How often did you eat **corn** (fresh, canned, or frozen) **DURING THE REST OF THE YEAR**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day



Question 36 appears on the next page.

Over the past 12 months...

36. How often did you eat **broccoli** (fresh or frozen)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

37. How often did you eat **cauliflower** or **Brussels sprouts** (fresh or frozen)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

38. How often did you eat **mixed vegetables**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

39. How often did you eat **onions** (including in mixtures)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

40. Over the past 12 months, how often did you eat **sweet or hot peppers** (green, red, or yellow)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

41. How often did you eat **raw cucumbers** (not including pickles)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

42. Over the past 12 months, did you eat **fresh tomatoes** (including those in salads)?

- ◯ NO **(GO TO QUESTION 43)**
- ◯ YES

42a. How often did you eat **fresh tomatoes** (including those in salads) **WHEN IN SEASON?**

- ◯ NEVER
- ◯ 1–6 times per season
- ◯ 7–11 times per season
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

42b. How often did you eat **fresh tomatoes** (including those in salads) **DURING THE REST OF THE YEAR?**

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

Question 43 appears on the next page.

Over the past 12 months...

43. Did you eat **summer squash** (include yellow and green squash)?

- NO (GO TO QUESTION 44)
- YES

43a. How often did you eat **summer squash WHEN IN SEASON** (include yellow and green squash)?

- NEVER
- 1–6 times per season
- 7–11 times per season
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

43b. How often did you eat **summer squash DURING THE REST OF THE YEAR** (include yellow and green squash)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

44. How often did you eat **lettuce salads** (with or without other vegetables)?

- NEVER (GO TO QUESTION 45)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

44a. How often were the lettuce salads you ate made with **dark green leaves**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 45 appears in the next column.

45. How often did you eat **salad dressing** (including low-fat) on salads or other vegetables?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

46. How often did you eat **sweet potatoes** or **yams**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

47. How often did you eat **French fries, home fries, hash browned potatoes**, or **tater tots**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

48. How often did you eat **potato salad**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

49. How often did you eat **baked, boiled**, or **mashed potatoes**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Over the past 12 months...

50. How often did you eat **salsa**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

51. How often did you eat **catsup**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

52. How often did you eat **pickles** or **pickled vegetables**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

53. How often did you eat **stuffing, dressing,** or **dumplings**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

54. How often did you eat **chili**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

55. How often did you eat **tortillas** or **tacos**?

- NEVER **(GO TO QUESTION 56)**
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

55a. How often were your tortillas or tacos **corn tortillas** or **tacos**?

- Almost never or never
- About $^{1}/_{4}$ of the time
- About $^{1}/_{2}$ of the time
- About $^{3}/_{4}$ of the time
- Almost always or always

56. How often did you eat **cooked dried beans** (such as baked beans, pintos, kidney, blackeyed peas, lima, lentils, soybeans, or refried beans)? *(Please don't include bean soups or chili.)*

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

57. How often did you eat **other kinds of vegetables**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

58. How often did you eat **rice** or **other cooked grains** (such as bulgur, cracked wheat, or millet)?

- NEVER **(GO TO QUESTION 59)**
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Question 59 appears on the next page.

Over the past 12 months...

58a. How often was the rice or other cooked grains you ate **brown rice, cracked wheat, or millet**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

59. How often did you eat **pancakes, waffles, or French toast**?

- NEVER (GO TO QUESTION 60)

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

59a. How often was **syrup** added to your pancakes, waffles, or French toast?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

60. How often did you eat **lasagna, stuffed shells, stuffed manicotti, ravioli, or tortellini**? *(Please do not include spaghetti or other pasta.)*

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

61. How often did you eat **macaroni and cheese**?

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

62. How often did you eat **pasta salad or macaroni salad**?

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

63. Other than the pastas listed in Questions 60, 61, and 62, how often did you eat **pasta, spaghetti, or other noodles**?

- NEVER (GO TO QUESTION 64)

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

63a. How often did you eat your pasta, spaghetti, or other noodles with **tomato sauce or spaghetti sauce made WITH meat**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

63b. How often did you eat your pasta, spaghetti, or other noodles with **tomato sauce or spaghetti sauce made WITHOUT meat**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

63c. How often did you eat your pasta, spaghetti, or other noodles with **margarine, butter, oil, or cream sauce**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 64 appears on the next page.

Over the past 12 months...

64. How often did you eat **bagels** or **English muffins**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

The next questions ask about your intake of breads other than bagels or English muffins. First, we will ask about bread you ate as part of sandwiches only. Then we will ask about all other bread you ate.

65. How often did you eat **breads** or **rolls AS PART OF SANDWICHES** (including burger and hot dog rolls)?

- NEVER **(GO TO QUESTION 66)**
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

65a. How often were the breads or rolls that you used for your sandwiches **white bread** (including burger and hot dog rolls)?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

66. How often did you eat **breads** or **dinner rolls, NOT AS PART OF SANDWICHES**?

- NEVER **(GO TO QUESTION 67)**
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

66a. How often were the breads or rolls you ate **white bread**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 67 appears in the next column.

67. How often did you eat **jam, jelly,** or **honey** on bagels, muffins, bread, rolls, or crackers?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

68. How often did you eat **peanut butter** or **other nut butter**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

69. How often did you eat **roast beef** or **steak IN SANDWICHES**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

70. How often did you eat **turkey** or **chicken COLD CUTS** (such as loaf, luncheon meat, turkey ham, turkey salami, or turkey pastrami)? *(We will ask about other turkey or chicken later.)*

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

71. How often did you eat **luncheon** or **deli-style ham**? *(We will ask about other ham later.)*

- NEVER **(GO TO QUESTION 72)**
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Question 72 appears on the next page.

Over the past 12 months...

71a. How often was the luncheon or deli-style ham you ate **light, low-fat, or fat-free**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

72. How often did you eat **other cold cuts** or **luncheon meats** (such as bologna, salami, corned beef, pastrami, or others, including low-fat)? *(Please do not include ham, turkey, or chicken cold cuts.)*

◯ NEVER **(GO TO QUESTION 73)**

◯ 1–6 times per year	◯ 2 times per week
◯ 7–11 times per year	◯ 3–4 times per week
◯ 1 time per month	◯ 5–6 times per week
◯ 2–3 times per month	◯ 1 time per day
◯ 1 time per week	◯ 2 or more times per day

72a. How often were the other cold cuts or luncheon meats you ate **light, low-fat,** or **fat-free**? *(Please do not include ham, turkey, or chicken cold cuts.)*

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

73. How often did you eat **canned tuna** (including in salads, sandwiches, or casseroles)?

◯ NEVER

◯ 1–6 times per year	◯ 2 times per week
◯ 7–11 times per year	◯ 3–4 times per week
◯ 1 time per month	◯ 5–6 times per week
◯ 2–3 times per month	◯ 1 time per day
◯ 1 time per week	◯ 2 or more times per day

74. How often did you eat **GROUND chicken** or **turkey**? *(We will ask about other chicken and turkey later.)*

◯ NEVER

◯ 1–6 times per year	◯ 2 times per week
◯ 7–11 times per year	◯ 3–4 times per week
◯ 1 time per month	◯ 5–6 times per week
◯ 2–3 times per month	◯ 1 time per day
◯ 1 time per week	◯ 2 or more times per day

75. How often did you eat **beef hamburgers** or **cheeseburgers**?

◯ NEVER **(GO TO QUESTION 76)**

◯ 1–6 times per year	◯ 2 times per week
◯ 7–11 times per year	◯ 3–4 times per week
◯ 1 time per month	◯ 5–6 times per week
◯ 2–3 times per month	◯ 1 time per day
◯ 1 time per week	◯ 2 or more times per day

75a. How often were the beef hamburgers or cheeseburgers you ate made with **lean ground beef**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

76. How often did you eat **ground beef in mixtures** (such as meatballs, casseroles, chili, or meatloaf)?

◯ NEVER

◯ 1–6 times per year	◯ 2 times per week
◯ 7–11 times per year	◯ 3–4 times per week
◯ 1 time per month	◯ 5–6 times per week
◯ 2–3 times per month	◯ 1 time per day
◯ 1 time per week	◯ 2 or more times per day

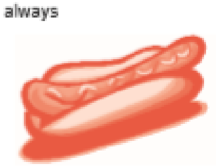
77. How often did you eat **hot dogs** or **frankfurters**? *(Please do not include sausages or vegetarian hot dogs.)*

◯ NEVER **(GO TO QUESTION 78)**

◯ 1–6 times per year	◯ 2 times per week
◯ 7–11 times per year	◯ 3–4 times per week
◯ 1 time per month	◯ 5–6 times per week
◯ 2–3 times per month	◯ 1 time per day
◯ 1 time per week	◯ 2 or more times per day

77a. How often were the hot dogs or frankfurters you ate **light** or **low-fat hot dogs**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always



Question 78 appears on the next page.

Over the <u>past 12 months</u>...

78. How often did you eat beef mixtures such as **beef stew, beef pot pie, beef and noodles,** or **beef and vegetables**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

79. How often did you eat **roast beef** or **pot roast**? *(Please do not include roast beef or pot roast in sandwiches.)*

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

80. How often did you eat **steak** (beef)? (*Do not include steak in sandwiches*)

- ◯ NEVER **(GO TO QUESTION 81)**
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

80a. How often was the steak you ate **lean steak**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

81. How often did you eat **pork** or **beef spareribs**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

82. How often did you eat **roast turkey, turkey cutlets,** or **turkey nuggets** (including in sandwiches)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

83. How often did you eat **chicken** as part of **salads, sandwiches, casseroles, stews,** or **other mixtures**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

84. How often did you eat **baked, broiled, roasted, stewed,** or **fried chicken** (including nuggets)? *(Please do not include chicken in mixtures.)*

- ◯ NEVER **(GO TO QUESTION 85)**
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

84a. How often was the chicken you ate **fried chicken** (including deep fried) or **chicken nuggets**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

84b. How often was the chicken you ate **WHITE meat**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

Question 85 appears on the next page.

Over the past 12 months...

84c. How often did you eat chicken **WITH skin**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

85. How often did you eat **baked ham** or **ham steak**?

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

86. How often did you eat **pork** (including chops, roasts, and in mixed dishes)? *(Please do not include ham, ham steak, or sausage.)*

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

87. How often did you eat **gravy** on meat, chicken, potatoes, rice, etc.?

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

88. How often did you eat **liver** (all kinds) or **liverwurst**?

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

89. How often did you eat **bacon** (including low-fat)?

- NEVER (GO TO QUESTION 90)

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

89a. How often was the bacon you ate **light, low-fat,** or **lean bacon**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

90. How often did you eat **sausage** (including low-fat)?

- NEVER (GO TO QUESTION 91)

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

90a. How often was the sausage you ate **light, low-fat,** or **lean sausage**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

91. How often did you eat **smoked fish** or **seafood** (such as smoked salmon, lox, or others)?

- NEVER

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

92. How often did you eat **sushi**?

- NEVER (GO TO QUESTION 93)

- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Question 93 appears on the next page.

Over the past 12 months...

92a. How often did the **sushi** you ate contain **raw fish** or **seafood** (including shellfish)?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

93. How often did you eat **raw oysters, raw clams,** or **other raw fish** (not including raw fish in sushi)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

94. How often did you eat **fish sticks** or **fried fish** (including fried seafood or shellfish)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

95. How often did you eat **all other fish** or **seafood** (including shellfish) that was **NOT FRIED, SMOKED,** or **RAW** ?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

96. How often did you eat **tofu**, **soy burgers**, or **soy meat-substitutes**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

97. Over the past 12 months, did you eat **soups**?

- ◯ NO **(GO TO QUESTION 98)**
- ◯ YES

97a. How often did you eat **soup DURING THE WINTER**?

- ◯ NEVER
- ◯ 1–6 times per winter
- ◯ 7–11 times per winter
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

97b. How often did you eat **soup DURING THE REST OF THE YEAR**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

97c. How often were the soups you ate **bean soups**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

97d. How often were the soups you ate **cream soups** (including chowders)?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

97e. How often were the soups you ate **tomato** or **vegetable soups**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

Question 98 appears on the next page.

Over the past 12 months...

97f. How often were the soups you ate **broth soups** (including chicken) **with** or **without noodles** or **rice**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

98. How often did you eat **pizza**?

- NEVER (GO TO QUESTION 99)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

98a. How often did you eat pizza with **pepperoni, sausage,** or **other meat**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

99. How often did you eat **crackers**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

100. How often did you eat **corn bread** or **corn muffins**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

101. How often did you eat **biscuits**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

102. How often did you eat **potato chips** (including low-fat, fat-free, or low-salt)?

- NEVER (GO TO QUESTION 103)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

102a. How often were the potato chips you ate **low-fat** or **fat-free chips**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

103. How often did you eat **tortilla chips** or **corn chips** (including low-fat, fat-free, or low-salt)?

- NEVER (GO TO QUESTION 104)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

103a. How often were the tortilla or corn chips you ate **low-fat** or **fat-free chips**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

104. How often did you eat **popcorn** (including low-fat)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

105. How often did you eat **pretzels**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Over the past 12 months...

106. How often did you eat **peanuts, walnuts, seeds, or other nuts**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

107. How often did you eat **granola bars**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

108. How often did you eat **yogurt** (NOT including frozen yogurt)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

109. How often did you eat **cottage cheese** (including low-fat)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

110. How often did you eat **cheese** (including low-fat; including on cheeseburgers or in sandwiches or subs)?

- NEVER (GO TO QUESTION 111)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Question 111 appears in the next column.

110a. How often was the cheese you ate **light** or **low-fat cheese**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

111. How often did you eat **frozen yogurt, sorbet,** or **ices** (including low-fat or fat-free)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

112. How often did you eat **ice cream, ice cream bars,** or **sherbet** (including low-fat or fat-free)?

- NEVER (GO TO QUESTION 113)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

112a. How often was the ice cream you ate **light, low-fat**, or **fat-free ice cream** or **sherbet**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

113. How often did you eat **pudding or custard**?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

114. How often did you eat **cake** (including low-fat or fat-free)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

Over the <u>past 12 months</u>...

115. How often did you eat **cookies** or **brownies** (including low-fat or fat-free)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

116. How often did you eat **doughnuts, sweet rolls, Danish,** or **pop-tarts**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

117. How often did you eat **sweet muffins** or **dessert breads** (including low-fat or fat-free)?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

118. How often did you eat **fruit crisp, cobbler,** or **strudel**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

119. How often did you eat **pie**?

- ◯ NEVER **(GO TO QUESTION 120)**
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

Question 120 appears in the next column.

119a. How often was the pie you ate **fruit pie** (such as apple, cherry, peach, blueberry, or others)?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

120. How often did you eat **chocolate candy**?

- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

121. How often did you eat **other candy**?

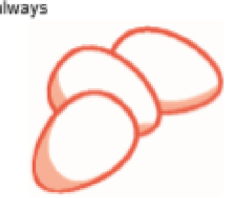
- ◯ NEVER
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

122. How often did you eat **eggs, egg whites,** or **egg substitutes** (NOT counting eggs in baked goods and desserts)? *(Please include eggs in salads, quiche, and souffles.)*

- ◯ NEVER **(GO TO QUESTION 123)**
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

122a. How often were the eggs you ate **egg substitutes**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always



Question 123 appears on the next page.

Over the past 12 months...

122b. How often were the eggs you ate **egg whites only**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

122c. How often were the eggs you ate **regular whole eggs**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

122d. How often were the eggs you ate part of **egg salad**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

123. How many cups of **coffee,** caffeinated or decaffeinated, did you drink?

◯ NONE **(GO TO QUESTION 124)**

- ◯ Less than 1 cup per month
- ◯ 1–3 cups per month
- ◯ 1 cup per week
- ◯ 2–4 cups per week
- ◯ 5–6 cups per week
- ◯ 1 cup per day
- ◯ 2–3 cups per day
- ◯ 4–5 cups per day
- ◯ 6 or more cups per day

123a. How often was the coffee you drank **decaffeinated**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

124. How many glasses of **ICED tea,** caffeinated or decaffeinated, did you drink?

◯ NONE **(GO TO QUESTION 125)**

- ◯ Less than 1 cup per month
- ◯ 1–3 cups per month
- ◯ 1 cup per week
- ◯ 2–4 cups per week
- ◯ 5–6 cups per week
- ◯ 1 cup per day
- ◯ 2–3 cups per day
- ◯ 4–5 cups per day
- ◯ 6 or more cups per day

Question 125 appears in the next column.

124a. How often was the iced tea you drank **decaffeinated** or **herbal tea**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

125. How many cups of **HOT tea**, caffeinated or decaffeinated, did you drink?

◯ NONE **(GO TO QUESTION 126)**

- ◯ Less than 1 cup per month
- ◯ 1–3 cups per month
- ◯ 1 cup per week
- ◯ 2–4 cups per week
- ◯ 5–6 cups per week
- ◯ 1 cup per day
- ◯ 2–3 cups per day
- ◯ 4–5 cups per day
- ◯ 6 or more cups per day

125a. How often was the hot tea you drank **decaffeinated** or **herbal tea**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

126. How often did you add **sugar** or **honey** to your coffee or tea?

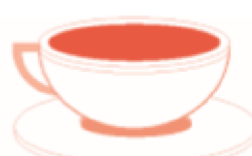
◯ NEVER

- ◯ Less than 1 time per month
- ◯ 1–3 times per month
- ◯ 1 time per week
- ◯ 2–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2–3 times per day
- ◯ 4–5 times per day
- ◯ 6 or more times per day

127. How often did you add **artificial sweetener** to your coffee or tea?

◯ NEVER

- ◯ Less than 1 time per month
- ◯ 1–3 times per month
- ◯ 1 time per week
- ◯ 2–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2–3 times per day
- ◯ 4–5 times per day
- ◯ 6 or more times per day



Over the past 12 months...

128. How often was **non-dairy creamer** added to your coffee or tea?

- NEVER (GO TO QUESTION 129)
- Less than 1 time per month
- 1–3 times per month
- 1 time per week
- 2–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

128a. What kind of **non-dairy creamer** did you usually use?

- Regular powdered
- Low-fat or fat-free powdered
- Regular liquid
- Low-fat or fat-free liquid

129. How often was **cream** or **half and half** added to your coffee or tea?

- NEVER
- Less than 1 time per month
- 1–3 times per month
- 1 time per week
- 2–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

130. How often was **milk** added to your coffee or tea?

- NEVER (GO TO QUESTION 131)
- Less than 1 time per month
- 1–3 times per month
- 1 time per week
- 2–4 times per week
- 5–6 times per week
- 1 time per day
- 2–3 times per day
- 4–5 times per day
- 6 or more times per day

130a. What kind of **milk** was usually added to your coffee or tea?

- Whole milk
- 2% milk
- 1% milk
- Skim, nonfat, or 1/2% milk
- Evaporated or condensed (canned) milk
- Soy milk
- Rice milk
- Raw, unpasteurized milk
- Other

Question 131 appears in the next column.

131. How often was **sugar** or **honey** added to foods you ate? (Please do not include sugar in coffee, tea, other beverages, or baked goods.)

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

132. How often did you eat **margarine** on breads, bagels, English muffins, other muffins, pancakes, or waffles?

- NEVER (GO TO QUESTION 133)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

132a. How often was the margarine you ate on these breads **low-fat** or **fat-free**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

133. How often did you eat **butter** on breads, bagels, English muffins, other muffins, pancakes, or waffles?

- NEVER (GO TO QUESTION 134)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

133a. How often was the butter you ate on these breads **low-fat** or **fat-free**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 134 appears on the next page.

Over the past 12 months...

134. How often did you eat **margarine** on potatoes, cooked vegetables, rice, grains, or beans?

- ◯ NEVER (GO TO QUESTION 135)
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

134a. How often was the margarine you ate on these cooked potatoes, cooked vegetables, rice, grains, or beans **low-fat** or **fat-free**?

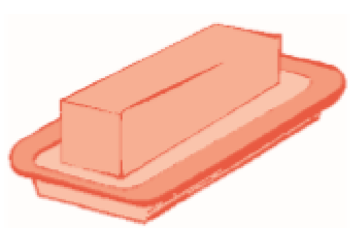
- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

135. How often did you eat **butter** on potatoes, cooked vegetables, rice, grains, or beans?

- ◯ NEVER (GO TO QUESTION 136)
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

135a. How often was the butter you ate on these cooked potatoes, cooked vegetables, rice, grains, or beans **low-fat** or **fat-free**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always



Question 136 appears in the next column.

136. How often did you eat **mayonnaise** as a spread or as part of food mixtures?

- ◯ NEVER (GO TO QUESTION 137)
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

136a. How often was the mayonnaise you ate **low-fat** or **fat-free**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

137. How often did you eat **cream cheese**?

- ◯ NEVER (GO TO QUESTION 138)
- ◯ 1–6 times per year
- ◯ 7–11 times per year
- ◯ 1 time per month
- ◯ 2–3 times per month
- ◯ 1 time per week
- ◯ 2 times per week
- ◯ 3–4 times per week
- ◯ 5–6 times per week
- ◯ 1 time per day
- ◯ 2 or more times per day

137a. How often was the cream cheese you ate **low-fat** or **fat-free**?

- ◯ Almost never or never
- ◯ About 1/4 of the time
- ◯ About 1/2 of the time
- ◯ About 3/4 of the time
- ◯ Almost always or always

Question 138 appears on the next page.

Over the past 12 months...

138. How often did you eat **sour cream**?

- NEVER (GO TO QUESTION 139)
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

138a. How often was the sour cream you ate **low-fat** or **fat-free**?

- Almost never or never
- About 1/4 of the time
- About 1/2 of the time
- About 3/4 of the time
- Almost always or always

Question 139 appears in the next column.

139. How often did you eat foods with **oils added** or with **oils used in cooking** (do not include baked goods or salads)?

- NEVER
- 1–6 times per year
- 7–11 times per year
- 1 time per month
- 2–3 times per month
- 1 time per week
- 2 times per week
- 3–4 times per week
- 5–6 times per week
- 1 time per day
- 2 or more times per day

139a. What kind of **oils** do you **usually eat**? *(Mark all that apply.)*

- Olive
- Corn
- Canola/rapeseed
- Other

Thank you very much for completing this questionnaire! Because we want to be able to use all the information you have provided, we would greatly appreciate it if you would please take a moment to review each page making sure that you:

- ***Did not skip any pages,***
- ***Completely blackened-in each answer, and***
- ***Completely erased any changes you may have made.***

Appendix D

24-Hour Dietary Recall

DAY: 1 2 3 4 DATE: ___/___/___ DAY OF WEEK: ________________ TIME AT START OF RECALL: _________hrs (24 hour clock) University of London

3	Quick list

Time	Place	Description of food or drink	Brand	Amount (P/H/W)	Leftovers (P/H/W)	Food code	P/H/W	Portion code	N

Appendix E

Nutrition Education Specifically for Intervention Group

In this study, a plant-based diet will include a minimum of 4 cups of vegetables, 3 cups of fruit, 6 ounces of whole grains, 3 cups of dairy including soy products, 1 serving of iron-fortified foods, and 5.5 ounces of protein with more than half of the protein coming from plant-based food sources, focusing on pairing non-heme iron with enhancers.

According to Johnson-Wimbley and Graham (2011), ascorbic acid, citrate, and amino acids from meat and fish enhance the absorption of non-heme iron. Plant phytates found in legumes, rice and grains, tannins found in berries, tea and wine, calcium found in dairy products, tofu and leafy greens, polyphenols found in fruits, vegetables, dry legumes and chocolate, iron overload, and antacids (which decrease stomach acidity) inhibit the absorption of non-heme iron. These inhibitors of non-heme iron will be educated by the research dietitian to be avoided when consuming food sources high in non-heme iron.

Good Sources of Plant-Based Iron:

- Lentils, chickpeas, beans, tofu, cashew nuts, chia seeds, pumpkin seeds, hemp seeds, leafy greens, tomato paste, potatoes, mushrooms, prune juice, mulberries, amaranth, spelt, oats, quinoa, dark chocolate

How to Increase Iron Absorption:

- Eat vitamin C rich foods with high iron foods
- Avoid coffee and tea with iron rich foods
- Soak, sprout and ferment grains and legumes

Meal Ideas:

- Kiwi with lentil curry
- Broccoli with a tofu stir-fry

- Pepper to a bean chili or green salad

Recipe Ideas:

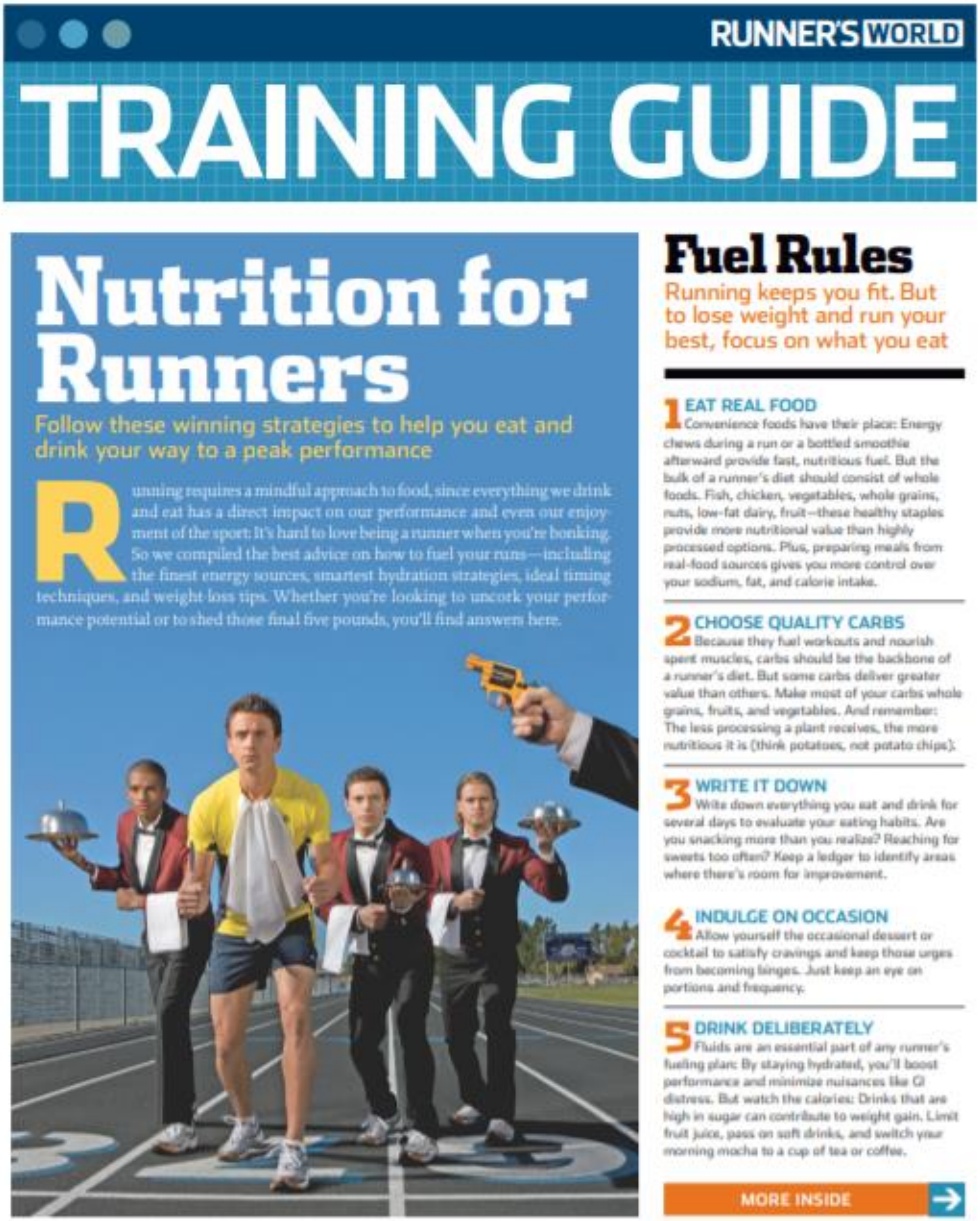
https://www.onegreenplanet.org/vegan-food/plant-based-iron-recipes/

https://www.verywellhealth.com/iron-rich-vegetarian-meals-4143255

https://www.foodnetwork.com/healthyeats/healthy-tips/2013/06/plant-based-sources-of-iron

Appendix F

Nutrition Education Handouts for Intervention and Control Group



RUNNER'S WORLD

TRAINING GUIDE

Nutrition for Runners

Follow these winning strategies to help you eat and drink your way to a peak performance

Running requires a mindful approach to food, since everything we drink and eat has a direct impact on our performance and even our enjoyment of the sport: It's hard to love being a runner when you're bonking. So we compiled the best advice on how to fuel your runs—including the finest energy sources, smartest hydration strategies, ideal timing techniques, and weight-loss tips. Whether you're looking to uncork your performance potential or to shed those final five pounds, you'll find answers here.

Fuel Rules

Running keeps you fit. But to lose weight and run your best, focus on what you eat

1 EAT REAL FOOD Convenience foods have their place: Energy chews during a run or a bottled smoothie afterward provide fast, nutritious fuel. But the bulk of a runner's diet should consist of whole foods. Fish, chicken, vegetables, whole grains, nuts, low-fat dairy, fruit—these healthy staples provide more nutritional value than highly processed options. Plus, preparing meals from real-food sources gives you more control over your sodium, fat, and calorie intake.

2 CHOOSE QUALITY CARBS Because they fuel workouts and nourish spent muscles, carbs should be the backbone of a runner's diet. But some carbs deliver greater value than others. Make most of your carbs whole grains, fruits, and vegetables. And remember: The less processing a plant receives, the more nutritious it is (think potatoes, not potato chips).

3 WRITE IT DOWN Write down everything you eat and drink for several days to evaluate your eating habits. Are you snacking more than you realize? Reaching for sweets too often? Keep a ledger to identify areas where there's room for improvement.

4 INDULGE ON OCCASION Allow yourself the occasional dessert or cocktail to satisfy cravings and keep those urges from becoming binges. Just keep an eye on portions and frequency.

5 DRINK DELIBERATELY Fluids are an essential part of any runner's fueling plan: By staying hydrated, you'll boost performance and minimize nuisances like GI distress. But watch the calories: Drinks that are high in sugar can contribute to weight gain. Limit fruit juice, pass on soft drinks, and switch your morning mocha to a cup of tea or coffee.

MORE INSIDE →

TRAINING GUIDE

RUNNER'S PANTRY

Stock up on these essentials to ensure an at-the-ready supply of run-fueling foods

GRAINS
Sure, pasta's a grain—but it's highly processed, so round it out with unrefined grains such as bulgur, which cooks fast and makes great salads and breakfast cereal. Brown and wild rice provide variety and fiber. Try quinoa, one of the few sources of complete protein. And don't overlook oats.

OLIVE OIL
Choose extra-virgin, which is less processed than other types. Its monounsaturated fat has been shown to lower "bad" cholesterol and improve heart health. Drizzle it over salads, potatoes, pasta.

BEANS
Beans are cheap, low in fat, and high in protein, iron, and fiber. Eat beans as side dishes, add them to salads, and stir them into pasta sauces (where they make a healthy alternative to meat).

FRESH HERBS
They elevate other healthy foods from so-so to sensational. Mint freshens up salads, potatoes, even beverages. Basil enhances beans and tomatoes. Rub rosemary into chicken or salmon.

EGGS
Packed with protein, eggs are inexpensive—and stay fresh for weeks.

LONG-KEEPING VEGETABLES AND FRUITS
Carrots, kale, zucchini, and lemons keep for a week or more; potatoes, onions, and garlic last even longer. Buy frozen spinach and corn to enjoy these fast-fading veggies anytime.

CANNED TOMATOES
Indispensable for making superfast sauces for pasta or chicken.

DRIED FRUIT AND NUTS
Having these healthy snacks on hand keeps you from overeating at meals. They also make tasty add-ins for salads and grain-based side dishes.

Eat This Now

Eat seasonally for maximum flavor and nutritional value

FOOD	SEASON	WHAT YOU GET
Rhubarb	March–June	Vitamins C and K. A 26-calorie serving (one cup) also delivers minerals such as calcium, potassium, and manganese, which helps turn protein and carbohydrates into energy.
Pineapple	March–June	Immunity-boosting antioxidants. Get your Daily Value of vitamin C in just one cup, along with bromelain—an enzyme that fights inflammation, aids digestion, and reduces swelling.
Arugula	April–October	Bone-strengthening nutrients. One cup contains 28 percent of your Daily Value for vitamin K, plus calcium and folate.
Asparagus	April–early June	B vitamins. One cup provides 65 percent of your Daily Value for folate, a B vitamin that promotes healthy blood cells.
Wild Salmon	May–September	Inflammation-quashing protein. Catch wild coho, sockeye, and salmon for environmentally friendly fish rich in omega-3s.
Tart Cherries	Late June–August	Natural painkillers. Runners who drank tart cherry juice twice daily for a week before and during the 197-mile Hood to Coast Relay reported feeling less pain than placebo drinkers.
Beets	June–September	More stamina. A 2009 study found that cyclists who drank 500 milliliters of beet juice exercised 16 percent longer than those who drank a placebo.
Apples	September–October	Improved endurance. Apples are among the best food sources of quercetin, an antioxidant that can boost endurance.
Pumpkin Seeds	September–November	Muscle-fueling minerals. Rich in magnesium and iron, protein, vitamin K, and heart-healthy mono- and polyunsaturated fats—all for less than 200 calories per half-cup.
Spaghetti Squash	September–November	A nutritious noodle. One cup contains 42 calories and two grams of fiber; it's also a good source of vitamin B_6, vitamin C, manganese, potassium, and iron.

TRAINING GUIDE RUNNER'S WORLD

How Much Do I Need?

Your calorie needs vary by body weight and activity level. Here's how to estimate what's right for you

1 → Multiply your goal weight by 10.
2 → Add to that: 20 percent of that number if you're a desk jockey; 50 percent if you're moderately active; 70 percent if you're moving all day.
3 → Add the calories burned during your workouts.
4 → Reduce the total by 15 percent.
5 → The final figure = the number of calories you should consume daily to achieve or maintain your goal weight while maintaining enough energy for exercise and your daily activities.

CALORIES BURNED	130 POUNDS	160 POUNDS	190 POUNDS
12 min/mile	472 cal/hour	582 cal/hour	691 cal/hour
11 min/mile	532 cal/hour	655 cal/hour	734 cal/hour
10 min/mile	591 cal/hour	727 cal/hour	864 cal/hour
9 min/mile	650 cal/hour	800 cal/hour	950 cal/hour
8 min/mile	709 cal/hour	873 cal/hour	1036 cal/hour
7 min/mile	827 cal/hour	1018 cal/hour	1209 cal/hour
6 min/mile	945 cal/hour	1163 cal/hour	1382 cal/hour

MEASURE UP

Estimate portion size—without using a scale—by using your own yardsticks

ONE CLOSED FIST → One cup of beverage

ONE CUPPED HAND → A half-cup of pasta, rice, cut fruit, berries, or beans; one ounce of nuts

TWO CUPPED HANDS → One cup of flaky breakfast cereal, soup, chili, curry; one ounce of chips or pretzels

PALM OF THE HAND → Three ounces of cooked meat, fish, or canned tuna

ONE THUMB → One ounce of cheese

TWO THUMBS TOGETHER → One tablespoon of condiments such as peanut butter, salad dressing, guacamole, or mayonnaise


TRAINING GUIDE

RUNNER'S WORLD

UNSATURATED FATS (20-35%)

LEAN PROTEIN (10-35%)

CARBOHYDRATES (55-65%)

A RUNNER'S PLATE

To make sure each meal delivers the nutrients you need, give key food groups their place on your plate

CARBOHYDRATES (55-65%) → Such as fruits, whole-grain breads, pasta, and vegetables

UNSATURATED FATS (20-35%) → Such as olive oil, walnuts, and avocados

LEAN PROTEIN (10-35%) → Such as chicken, sirloin, tofu, nuts, and seeds