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Association of Micronutrient Inadequacy and Body Mass Index in Young Adults

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Abstract

Background

Micronutrient inadequacy has been found at higher levels in overweight and obese individuals in a broad range of ages relative to healthy weight. Insufficient micronutrient levels can have a negative impact on physical and mental health along with excess weight.

Objective

Due to health consequences related to inadequate micronutrient intake and the understanding that the general population not only fails to meet the majority of micronutrient recommendations, but is also overweight or obese, the objective of this study is to first, determine if young adults in the Northwest Arkansas Region are consuming adequate levels of micronutrients and second, if the adequacy of their micronutrient intake correlates with their BMI. Hypotheses were one, young adults are not consuming adequate levels of micronutrients and two, inadequate micronutrient intake correlates with BMI.

Design

This study uses data from a larger parent study as follows: five 24-hour dietary recalls within 30 days using the ASA24 Dietary Recall Tool and height and weight measurements for calculation of body mass index in 150 participants.

Results

Poor intake of individual nutrients was not associated with BMI or BMI category except in the case of vitamin K and vitamin C in χ^2 analysis. In regression analyses for each nutrient, controlling for age and sex, there was a positive relationship between BMI and intake of sodium ($p = 0.04$). Less than 25% of participants met the Estimated Average Requirement (EAR) threshold for the following nutrients: copper, vitamin D, vitamin E, choline, and potassium. The

EAR threshold for copper was not met by any participants. No EAR threshold for any individual micronutrient was met by 100% of the participants. Moreover, no single participant in this study met the EAR threshold for all of the nutrients.

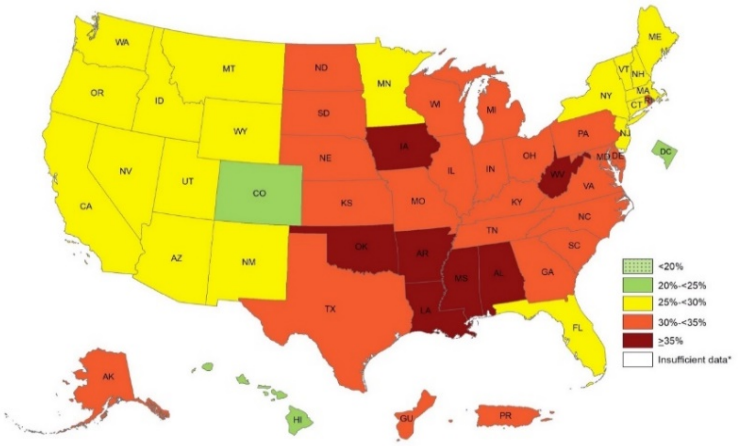
Introduction

Nutritional imbalances are associated with high risk of mortality and morbidity and therefore, been deemed a severe public health concern (Munoz & Bernstein, 2018). The term malnutrition specifies nutritional imbalance as it describes either under- or over-nourishement in individuals (Munoz & Bernstein, 2018). With malnutrition, attention is often drawn to macronutrients as macronutrients play an important role in health (Kim et al., 2019). However, micronutrient deficiencies not only cause diseases solely related to their deficits, but they also have a negative impact on the management of existing diseases and overall health (Tulchinsky, 2010).

Over a century ago, micronutrient deficiency was called hidden hunger and was found to be present in all weight categories (Kim et al., 2019). A measure often used to determine weight-related health is body mass index (BMI). BMI has four categories: underweight <18.5, normal weight 18.5-24.9, overweight 25-29.9, and obese >30. According to the 2015-2016 National Health and Nutrition Examination Survey (NHANES) data, 39.8% of American adults were overweight or obese (Fryar et al., 2018). In Arkansas, the percentage of adults in or above the overweight category is 66.3% (Centers for Disease Control, 2012). As displayed in Figure 1, Arkansas and its neighboring states are among the most obese states across the country (Centers for Disease Control, 2019). Due to the number of adults who are overweight, malnutrition could be present due to various circumstances, with many relating back to the lack of a nutritionally adequate diet. The purpose of the present study is to assess whether inadequate micronutrient intake status is associated with BMI in young adults ages 18-24.

Figure 1

Prevalence of Self-Reported Obesity Among U.S. Adults by State and Territory (taken from Adult Obesity Prevalence Maps (Centers for Disease Control, 2019))



Review of Literature

Micronutrients: Roles and Functions

Vitamins and minerals are grouped together and termed micronutrients because they are only needed in small amounts compared to the three macronutrients, proteins, carbohydrates, and lipids (Whitney & Rolfes, 2015). Micronutrients are non-energy yielding nutrients, but they serve important roles in body function and maintenance (Whitney & Rolfes, 2015).

Adequacy of micronutrient intake by healthy people can be assessed using the Dietary Reference Intakes (DRI). DRI is an overarching term used to describe the specific reference values which include Recommended Dietary Allowance (RDA), Adequate Intake (AI), Estimated Average Requirement (EAR), and Tolerable Upper Intake Level (UL) (National Institutes of Health). The terms are further defined in Table 1.

Table 1

Dietary Reference Intakes

DRI	Definition
Recommended Dietary Allowance (RDA)	the average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a group
Adequate Intake (AI)	a value based on observed or experimentally determined approximations of nutrient intake by a group (or groups) of healthy people—used when an RDA cannot be determined
Tolerable Upper Intake Level (UL)	the highest level of daily nutrient intake that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the risk of adverse effects increases
Estimated Average Requirement (EAR)	a nutrient intake value that is estimated to meet the requirement of half the healthy individuals in a group

*adapted from *Dietary Reference Intakes: A Risk Assessment Model for Establishing Upper Intake Levels for Nutrients* (Institute of Medicine, 1998)

The Institute of Medicine (US) Food and Nutrition Board states the EAR is the proper DRI to use when comparing the distribution of usual intakes with the distribution of requirements in a group of individuals (Institute of Medicine, 1998). Because the EAR estimates the mean requirement of healthy individuals in a group, it is only possible to estimate the probability of nutrient inadequacy from dietary data alone (Institute of Medicine, 2000).

The majority of micronutrients have a reported EAR and are included in the Automated Self-Administered 24-Hour (ASA24®) Dietary Recall Tool (ASA24), which is the source of micronutrient data collection for this study (Food and Nutrition Board, 2015; National Cancer Institute, 2019). However, ASA24 does not collect data on all nutrients with a set EAR, and not all nutrients have a set EAR. The nutrients not incorporated into ASA24 include: pantothenic

acid, biotin, chromium, fluoride, iodine, manganese, molybdenum and chloride. The nutrients which are not included in ASA24 and do not have a set EAR are not reported as under-consumed nutrients in the 2015-2020 Dietary Guidelines for Americans and are therefore not nutrients of concern for the present study. Potassium, choline, magnesium, calcium, and vitamins A, D, E, and C are the micronutrients commonly under-consumed by Americans according to the Guidelines and are calculated by ASA24 (Dietary Guidelines Advisory et al., 2015). EARs have not been established for vitamin K, potassium, sodium, pantothenic acid, biotin, choline, chromium, fluoride, manganese, or other nutrients not yet evaluated via the DRI process (Food and Nutrition Board, 2015). Each micronutrient and its functions are defined in Tables 2 and 3.

Table 2

Vitamins and their Functions

Vitamin	Function in the Body
Vitamin A	▪ Needed for the formation and maintenance of mucus membrane, skin and bone ▪ Needed for vision in dim light
Vitamin B1 Thiamin	▪ Coenzyme in metabolism ▪ Required for growth and maintenance of nerve and muscle tissues ▪ Required for normal appetite
Vitamin B2 Riboflavin	▪ Coenzyme in metabolism and cell division ▪ Promotes growth and tissue repair ▪ Promotes normal vision
Vitamin B3 Niacin	▪ Coenzyme in metabolism ▪ Maintain normal nervous system functions
Vitamin B6	▪ Coenzyme in metabolism and neurotransmitter synthesis ▪ Coenzyme in the conversion of tryptophan to niacin ▪ Needed for normal red blood cell formation and synthesis of lipids
Vitamin B9 Folate	▪ Needed for DNA synthesis, gene expression and regulation ▪ Required for normal function of red blood and other cells ▪ Needed to convert homocysteine to methionine
Vitamin B12	▪ Coenzyme involved in the synthesis of DNA, RNA and myelin ▪ Needed to convert homocysteine to methionine ▪ Needed for normal RBC development
Biotin	▪ Required by many enzymes involved in fat, protein and glycogen metabolism

Pantothenic Acid	▪ Coenzyme in metabolism of carbohydrates, fats and protein
Vitamin C	▪ Required for collagen synthesis ▪ Acts as an antioxidant ▪ Required for neurotransmitters and steroid hormone synthesis
Vitamin D	▪ Required for calcium and phosphorus absorption and for metabolism in the intestines and bone, and for their utilization in bone and teeth formation, nerve and muscle activity ▪ Inhibits inflammation ▪ Participates in insulin secretion and blood glucose level maintenance
Vitamin E	▪ Acts as an antioxidant ▪ Participates in the regulation of gene expression
Vitamin K	▪ Regulation and synthesis of blood-clotting proteins ▪ Aids in the incorporation of calcium into bones
Choline (vitamin like)	▪ Structural and signaling component of cell membranes ▪ Required for normal development of memory and attention process during early life ▪ Required for the transport and metabolism of fat and cholesterol

*adapted from Table 1.9 in Nutrition Through the Lifecycle (Brown, 2019)

Table 3

Minerals and their Functions

Mineral	Function in the Body
Calcium	▪ Component of bones and teeth ▪ Required for muscle and nerve activity and blood clotting
Chloride	▪ Component of hydrochloric acid ▪ Maintenance of acid-base balance of body fluids ▪ Maintenance of water balance
Chromium	▪ Required for the normal utilization of glucose and fat
Copper	▪ Component of enzymes involved in the body's utilization of iron and oxygen ▪ Functions in growth, immunity, cholesterol and glucose utilization and brain development
Fluoride	▪ Component of bones and teeth
Iron	▪ Transports oxygen as a component of hemoglobin in RBCs ▪ Component of myoglobin ▪ Required for certain reactions involving energy formation
Iodine	▪ Required for synthesis of thyroid hormones that help regulate energy production and growth ▪ Required for normal brain development
Magnesium	▪ Component of bones and teeth ▪ Needed for nerve activity ▪ Activates enzymes involved in metabolism

Manganese	▪ Required for the formation of body fat and bone
Molybdenum	▪ Component of enzymes involved in the transfer of oxygen from one molecule to another
Phosphorous	▪ Component of bones and teeth ▪ Component of substances involved in energy production ▪ Required for maintenance of acid-base balance of body fluids
Potassium	▪ Regulation of acid-base balance of body fluids ▪ Maintenance of water balance in body tissues ▪ Activation of muscles and nerves
Selenium	▪ Acts and an antioxidant in conjunction with vitamin E ▪ Needed for thyroid hormone production
Sodium	▪ Regulation of acid-base balance of body fluids ▪ Maintenance of water balance in body tissues ▪ Activation of muscles and nerves
Zinc	▪ Required for activation of many enzymes in the reproduction of proteins ▪ Component of insulin and many enzymes

*adapted from table 1.13 in Nutrition Through the Lifecycle (Brown, 2019)

Micronutrients and Health

The micronutrients of concern for the American population have several roles in common. Nerve activity and some muscle activity is influenced by calcium, chloride, magnesium, potassium, vitamin C, and vitamin D. Potassium and chloride are also vital in the regulation of the body's acid-base and water balances. The body can enter metabolic acidosis or alkalosis if either acid-base balance or water balance are disrupted. Many vitamins are needed for the function of other compounds and processes. For example, vitamin A is needed for the formation of mucus membranes, skin, and bone, while vitamin E participates in the regulation of gene expression. Each micronutrient serves a specific purpose and can slow or inhibit the functions of the body if sufficient amounts are not available to the body (Brown, 2019).

Vitamins and minerals are necessary for metabolic function and are components of many vital compounds as described in Tables 1 and 2. Adequate vitamin and mineral levels are therefore essential in the proper functioning of the body (Ames, 2006). Even if there is not a frank deficiency, insufficient intake of micronutrients can have a negative effect on health. When

the balance is disrupted, risk for disease is increased. Inadequate nutrition is associated with greater risk of cancer, heart disease, and diabetes (Ames, 2006). Kim et al. (2019) made a similar statement about disease risk of individuals who are obese and included dementia and shortening of lifespan in the list of consequences. A specific micronutrient deficiency can be associated with its own deficiency disease in addition to exacerbating the risk or conditions of many other diseases (Ames, 2006). Depicted in Table 4 are the deficiency diseases and conditions associated with each micronutrient.

Table 4

Deficiency Conditions and Diseases related to Micronutrient Inadequacy

Vitamins and Minerals	Deficiency Condition and Diseases
Vitamin A	▪ Night blindness ▪ Xerophthalmia ▪ Increased risk of mortality in children and pregnant women
Vitamin B1 Thiamin	▪ Beriberi (cardiac and neurologic) ▪ Wernicke and Korsakov syndromes (alcoholic confusion and paralysis)
Vitamin B2 Riboflavin	▪ Fatigue ▪ Eye change ▪ Dermatitis ▪ Brain dysfunction ▪ Impaired iron absorption
Vitamin B3 Niacin	▪ Pellagra (dermatitis, diarrhea, dementia, death)
Vitamin B6	▪ Dermatitis ▪ Neurological disorders ▪ Convulsions ▪ Anemia ▪ Elevated plasma homocysteine
Vitamin B9 Folate	▪ Megaloblastic anemia ▪ Neural tube and other birth defects ▪ Heart disease ▪ Stroke ▪ Impaired cognitive function ▪ Depression
Vitamin B12	▪ Megaloblastic anemia (associated with Helicobacter pylori induced gastric atrophy)
Biotin	▪ Seizures ▪ Vision problems

	▪ Hearing loss ▪ Weakness
Pantothenic Acid	▪ Fatigue ▪ Sleep disturbances ▪ Impaired coordination ▪ Numbness ▪ Nausea and vomiting
Vitamin C	▪ Scurvy (fatigue, hemorrhages, low resistance to infection, anemia)
Vitamin D	▪ Rickets ▪ Osteomalacia ▪ Osteoporosis ▪ Colorectal cancer
Vitamin E	▪ Muscle loss ▪ Nerve damage ▪ Anemia ▪ Weakness
Vitamin K	▪ Bleeding ▪ Bruises ▪ Decreases calcium in bones
Choline (vitamin like)	▪ Fatty liver ▪ Infertility ▪ Hypertension
Calcium	▪ Decreased bone mineralization ▪ Rickets ▪ Osteoporosis
Chloride	▪ Muscle cramps ▪ Apathy ▪ Poor appetite ▪ Long-term mental retardation in infants
Chromium	▪ Elevated blood glucose and triglyceride levels ▪ Weight loss
Copper	▪ Anemia ▪ Seizures ▪ Nerve and bone abnormalities in children ▪ Growth retardation
Fluoride	▪ Increased dental decay ▪ Affects bone health
Iron	▪ Iron deficiency anemia ▪ Reduced learning and work capacity ▪ Increased maternal and infant mortality ▪ Low birth weight
Iodine	▪ Goiter ▪ Hypothyroidism ▪ Increased risk of stillbirth ▪ Birth defects infant mortality

	▪ Cognitive impairment
Magnesium	▪ Stunted growth in children ▪ Weakness ▪ Muscle spasms ▪ Personality changes
Manganese	▪ Weight loss ▪ Rash ▪ Nausea and vomiting
Molybdenum	▪ Rapid heartbeat and breathing ▪ Nausea and vomiting ▪ Coma
Phosphorous	▪ Loss of appetite ▪ Nausea and vomiting ▪ Weakness ▪ Confusion ▪ Loss of calcium from bones
Potassium	▪ Weakness ▪ Irritability ▪ Irregular heartbeat ▪ Paralysis
Selenium	▪ Cardiomyopathy ▪ Increased cancer and cardiovascular risk
Sodium	▪ Weakness ▪ Apathy ▪ Poor appetite ▪ Muscle cramps ▪ Headache ▪ Swelling
Zinc	▪ Poor pregnancy outcome ▪ Impaired growth (stunting) ▪ Genetic disorders ▪ Decreased resistance to infectious diseases

*adapted from Table 1 in Micronutrient Deficiency Conditions: Global Health Issues (Tulchinsky, 2010), Tables 1.9 and 1.13 in Nutrition Through the Lifecycle (Brown, 2019)

Micronutrient Inadequacy in Young Adults

While most nutrients are consumed in adequate amounts by Americans, there are a select few that are consistently consumed below the RDA (Dietary Guidelines Advisory et al., 2015). Insufficient intake is often related to the unhealthy eating patterns of American society and causes deficits in the following nutrients: potassium, choline, magnesium, calcium, and vitamins A, D, E, C, and iron, specifically in females (Dietary Guidelines Advisory et al., 2015).

Micronutrient deficiencies are not typically seen individually, but as a collection of deficiencies due to poor nutrient-dense food consumption or a medical condition. Many micronutrient inadequacies are seen in the United States due to eating habits which consist of energy dense foods that are nutrient poor (Ames, 2006). Kim et al. (2019) discusses many potential causes for micronutrient deficiency in all individuals. There is a high risk for deficiency when food intake is low or unbalanced. There is greater risk of deficiency in individuals with anorexia nervosa, chronic disease, low socioeconomic status, or those who follow fad diets (Kim et al., 2019). Young adults are especially at risk for those factors. They also tend to be the main age group that follows restrictive diets that exclude foods, and even entire food groups, in an attempt to obtain a figure that reflects the social norm (Mirzaeian et al., 2013).

Compounded with the contribution body image has on micronutrient inadequacies, this is also the age group that tends to move out of their parents' homes, go off to college, and become their own primary caretakers. Sogari et al. (2018) determined barriers to healthful eating for college students to be time constraints, unhealthy snacking, mood, stress, university dining services, and a lack of knowledge. In addition to those factors, the major micronutrient food groups, namely dairy, fruits, and vegetables, are difficult to keep and prepare in dorm rooms (Mirzaeian et al., 2013). Many of those factors cause food intake to be unbalanced and could be potential causes of a micronutrient deficiency or inadequacy.

A previous study done by Mirzaeian et al. compared nutrient intake of females ages 18-25 to the RDAs by recording dietary information in Food Processor 2, a nutrient analysis software. This study concluded "macronutrient intake was appropriate, but the problem mainly existed in the consumption of micronutrients" with inadequate consumption of B12, folate, magnesium, potassium, and calcium (Mirzaeian et al., 2013). Three of the five nutrients noted

for poor intake in that study are nutrients of concern for the entire US population according to the Dietary Guidelines for Americans (Dietary Guidelines Advisory et al., 2015).

BMI and Micronutrient Inadequacy

Body mass index (BMI) is a measure of body composition. BMI is calculated based on height and weight via the following equation $BMI = \frac{weight(kg)}{height(m)^2}$. This method has been criticized because it cannot differentiate between fat and lean tissue. However, this method is often used as it is inexpensive to obtain. A study by Ortega et al strongly supports the use of BMI as a measure in clinical epidemiology (Ortega et al., 2016). Their study included over 60,000 participants to determine if body fat or BMI was a superior predictor of cardiovascular disease compared to body fat percent. They concluded BMI was a greater predictor because it normalizes weight based on height.

BMI varies more so with weight that height because height is fairly stable in adulthood. A major contributor to heavier weights in the United States population can be attributed to diets that are generally high in carbohydrates and fats, but low in micronutrients (Ames, 2006). Individuals may become overweight or obese and micronutrient deficient if their diet consists of high calorie foods and beverages that are low in vitamin and mineral content (Kim et al., 2019). Pathologies that often accompany obesity may be provoked by a diet lacking micronutrients (Ames, 2006). For example, chronic metabolic disruption can be associated with an insufficient consumption of micronutrients on a regular basis and can lead to further disruption of the body's processes (Ames, 2006).

Garcia et al completed a review article concluding deficient levels of some micronutrients may be associated with increased fat deposition in the body (García et al., 2009). However, it is unknown if that relationship is causal and in what direction (García et al., 2009). A study

conducted by Aasheim et al, included in the review paper found morbidly obese adults ages 28-52 tended to have lower serum levels of multiple micronutrients including: vitamins A, B-6, C, 25-hydroxyvitamin D, and lipid-standardized vitamin E (Aasheim et al., 2008). Their study also found that vitamin B-1 levels were higher for obese patients compared to the normal weight control group. Also included in the review was a study by Kimmons et al in which participants were of age 19 years or older and selected from the NHANES III study 1988-1994 (Kimmons et al., 2006). This study determined overweight adults were more likely to have suboptimal micronutrient levels, especially in vitamins C and D. Overall, antioxidants, vitamin A, vitamin D, B-complex vitamins, calcium, iron, and zinc are nutrients which have been associated with obesity in multiple studies included in the review (Aasheim et al., 2008; García et al., 2009). Compared to individuals of a normal weight, individuals who are overweight have lower levels of many serum micronutrients (García et al., 2009; Kimmons et al., 2006).

Few studies focus on a narrow age range specific to young adults. Correcting this gap in knowledge could have great effects on the population as stated by Dietz in his opinion piece (Dietz, 2017). Dietz stated young adulthood is a time of many transitions and leads to circumstances that escalate obesity risk factors, such as leaving the household, entering relationships, and entering into parenthood. Reducing obesity in one person could reduce obesity in an entire family due to influence among family and social networks (Christakis & Fowler, 2007). It would be beneficial to know if correcting micronutrient inadequacies in this age range helped lower obesity rates in individuals due to the link between relationship networks and obesity.

Measuring Micronutrient Intake

Recording Dietary Intake

There are many methods to recording nutrient data, each having various strengths and limitations. The food record is beneficial because it is open ended and does not rely on memory; however, it does require the subject to record every item as they go and could cause changes in consumption behavior to limit the amount of time they have to put into recording a meal. Another factor in the time commitment dilemma of the food record is the need to measure and record accurate portion sizes and brand information. For nutrients that are highly specific to a select number of foods and consumed inconsistently, a Food Frequency Questionnaire (FFQ) can target those specific nutrients to get a better understanding of actual intake. Again, this method relies on memory which can affect its accuracy. A diet history does not alter intake, but does rely on memory and a requires a skilled interviewer (World Health Organization, 1998). Similar to the diet history, the 24-hour dietary recall does not alter intake behavior because the recall is filled out the following day. Another advantage the 24-hour recall has over methods such as the food frequency questionnaire (FFQ) is that it records absolute intake as opposed to relative estimates (World Health Organization, 1998). The major shortcomings with this method are due to the reliance on participant memory, participant difficulty estimating portion sizes, and the need for a highly skilled interviewer or software. Skilled interviewers conduct interviewer administered 24-hour recalls using the USDA's Automated Multiple-Pass Method (AMPM) which has been validated (Subar et al., 2012). This method completes the following sequence through five passes: quick list, forgotten foods, time and occasion, detail cycle, and the final probe. Memory cues are recited by the interviewer at each stage of the method to prompt participant recall (Steinfeldt et al., 2013). The present study employs the use of ASA24 as it is

based on the AMPM style of participant prompting and can be accessed online by participants at their convenience and without the need for skilled interviewers. An additional benefit of this method is that the nutritional data is collected as a participant goes through the recall as opposed to other methods that require the recall data to be transferred into a nutritional software afterwards. A description of ASA24's application of the AMPM is shown in Table 5.

Table 5

ASA24 Passes (Subar et al., 2012)

ASA24 passes	Description of information collected
Meal-based Quick List	Respondents are asked to report meal name, time, and optionally: location, TV/computer use, who one ate with. Foods and drinks consumed are reported without details by browsing or searching.
Meal Gap Review	Respondents are asked if they consumed anything during any 3-hour gaps between eating occasions, between midnight and the first eating occasion, and between the last eating occasion and midnight. "Yes" responses return the respondent to the Quick List to add foods or drinks.
Details	Respondents are asked for details about the foods and drinks they recorded during the Quick List, including form, preparation methods, the amount eaten, and any additions.
Forgotten Foods	Respondent are asked about the consumption of commonly forgotten foods and drinks and report them as necessary by returning to the Quick List.
Final Review	Respondents are prompted to review all of the foods and drinks reported for the intake day; they can make edits and add meals and foods and drinks as desired.
Last Chance	Respondents are given another opportunity to add foods or drinks.
Usual intake	Respondents are asked: "Was the amount of food that you ate yesterday more than usual, usual, or less than usual?"

*adapted from The Automated Self-Administered 24-Hour Dietary Recall (ASA24): A Resource for Researchers, Clinicians, and Educators from the National Cancer Institute (Subar et al., 2012)

Several studies have looked into measuring micronutrient intake. A study comparing the accuracy of interviewer-administered recall and ASA24 administered recall in adolescents conducted by Hughes et al determined there to be no significant difference in the accuracy of the recalls between the two (Hughes et al., 2017). A limitation of this study is the age range of 12-17 years of age. The knowledge gap could be narrowed in the future by repeating the study with an

expanded age range or with multiple age groups. Kirkpatrick et al performed a study in adults that confirms the results of Timon et al in an older population (Kirkpatrick et al., 2014). The study concluded ASA24 performed almost as well as the interviewer administered AMPM, 80% accuracy compared to 83% accuracy. These researchers stated the cost savings of ASA24 made the 3% accuracy difference worth giving up.

An advantage that the ASA24 has over an interviewer-administered recall is the ability to incorporate images to display portion sizes and increase reporting accuracy. A second study by Kirkpatrick et al concluded that respondents overestimated portion sizes in interviewer-administered recalls with mean differences between the actual and estimated portion sizes three times that of the ASA24 report (Kirkpatrick et al., 2016).

A disadvantage of assessing nutrient intake in any dietary assessment method is the presence of misreporting. Widaman et al stated that individuals who are overweight tend to underreport their intake more often than those who are a normal weight (Widaman et al., 2017). Difficulties specific to ASA24 include: its length, availability of food items for selection, and the need for memory recall (Widaman et al., 2017).

Studies measuring micronutrient intake often make use of ASA24 due to its affordability compared to other methods and ease of use for participants, especially with younger individuals (Hewawitharana et al., 2018; Jerome et al., 2017; Raffoul et al., 2019). Other studies have used the interviewer administered 24-hour recalls (Mirzaeian et al., 2013). In the study by Mirzaeian et al, interviewer administered 24-hour recalls were taken and then input into Food Processor 2 (Mirzaeian et al., 2013). The additional step required by this method could lead to inaccurate results (World Health Organization, 1998). Another method used to collect nutrient information is a blood draw which requires more time, money, and resources and is a greater burden on

participants. Hospitals are a more appropriate setting for that method and was used in a clinical study by Aasheim et al (Aasheim et al., 2008). Nutrient adequacy can only be estimated from dietary data alone as it is rare to have precise, representative data from an individual (Institute of Medicine, 2000).

Number of Dietary Recalls Needed

There is some controversy regarding the number of 24-hour recalls it takes to estimate an individual's overall dietary intake. World Health Organization (WHO) food based guidelines state at least two nonconsecutive days are needed to determine an overall intake estimation, but 3-4 days of dietary intakes are required for depicting usual individual intake of energy and macronutrients (World Health Organization, 1998). Many studies follow that guideline and take one recall from a weekday and one from a weekend day (Jerome et al., 2017; World Health Organization, 1998). Two separate studies from the Nurses' Health Study (NHS) and the Nurses' Health Study II (NHS II) used four 24-hour dietary recalls over the course of a year, one per season (Yuan et al., 2018; Yuan et al., 2017). The study by Yuan et al, comparing the validity of nutrient intakes, used four recalls, one each season to account for seasonal foods in the individual's overall dietary intake (Yuan et al., 2018). However, Yuan et al concluded a small number of recall days were inaccurate for some nutrients to be fully assessed (Yuan et al., 2018). For nutrients that are highly variable such as cholesterol, vitamins A and C, and alcohol, up to 50 recalls may be required to estimate overall intake. For nutrients such as those, which are not available in a wide range of foods, a food frequency questionnaire is a more accurate representation of intake (World Health Organization, 1998).

Yuan et al also developed a study to compare the results of nutrient intake in an FFQ and the ASA24. This study also had participants complete one ASA24 online per season along with

two FFQs, one at the beginning and one at the end of the yearlong study. The conclusion of this study indicated FFQs are more valid and consistent for measuring nutrient intake than the ASA24 is among women. Comparable results are produced when within-person variation was accounted for between the two methods. This study suggests making use of both the ASA24 and FFQs to produce optimal accuracy (Yuan et al., 2017).

Due to health consequences related to inadequate micronutrient intake and the understanding that the general population, and particularly young adults, not only fails to meet the majority of micronutrient recommendations, but is also overweight, the objective of this study is to first, determine if young adults in the Northwest Arkansas Region are consuming adequate levels of micronutrients and second, if their micronutrient intake levels correlate with their BMI. Hypotheses were one, young adults are not consuming adequate levels of micronutrients and two, inadequate micronutrient intake correlates with BMI.

Methods

Participants

This study is part of a larger study assessing the effects of multivitamin-mineral supplementation on psychological and physical health in young adults with excess weight and of a healthy weight. Inclusion criteria for the parent study were: 18-24 years old; working or going to school part or full time; no diagnosis related to impaired liver or renal failure; no diagnosis of malabsorption or related gastrointestinal diagnoses; no mental health diagnosis (e.g., general anxiety disorder, depression, bipolar-related diagnoses or eating disorder); not on medication for a mental health diagnoses; willing to abstain from taking any other supplements or herbal products during the study; and able to pick up supplements from the study office located on a southern university campus on a weekly basis. A total of 150 participants were enrolled in the

study, with 73 participants of a normal BMI and 77 of an overweight or obese BMI. This study was approved by the Institutional Review Board.

Study Design

Participants were recruited via flyers, advertisements in the school Newswire via email, digital announcements, and class announcements from a southern university. To participate in the study, potential participants contacted the study office with interest, then received a phone call and completed an over the phone screening. Eligible participants came into the study office, gave their informed and written consent, had their height and weight taken and completed two questionnaires, a demographic survey and the initial 24-hour recall through ASA24. Participants returned to the study office the following Tuesday to pick up supplements. Participants began taking the supplement on Wednesday and continued to take two pills per day for 30 days. Each Tuesday, participants returned to the study office to pick up seven days of supplements.

On days 0 (day of the week varied), 3 (Friday), 4 (Saturday), 15 (Wednesday), and 30 (Thursday), participants completed the two questionnaires. Text message or email reminders were sent to participants prior to supplement pick up days and questionnaire days. On day 31 participants visited the study office for the last time to have their final height and weight taken. Cash compensation of $100 was administered in increments on days 7, 21 and 31 based on compliance.

Data Collection

Data collection took place October 23rd, 2018 through August 16th, 2019. Data was stored in Microsoft Excel, Qualtrics, and ASA24. Demographic information was collected in the initial survey through Qualtrics.

Automated Self-Administered 24-Hour Dietary Recall Tool

Nutrient intake data was collected through the National Cancer Institute's ASA24 Dietary Recall Tool. "The ASA24 system consists of a Respondent Website used to collect dietary intake data and a Researcher Website used to manage study logistics and obtain nutrient and food group data files" (National Cancer Institute, 2019). It is important to note that for this study, supplement data was not collected, only dietary intake because participants were instructed to abstain from taking any supplements other than the supplement prescribed by the study.

Each participant was assigned 24-hour dietary recalls to be completed online through the ASA24, using unique log-in information given by the study coordinators, on days 0, 3, 4, 15, and 30. Days 3, 4, 15, and 30 were completed on the same day of the week for every participant, Friday, Saturday, Wednesday and Thursday respectively, no matter what their start date was. Day 0 was different for each participant based on the day they visited the study office to give their informed consent, receive the study schedule, and complete the initial surveys.

A total of five 24-hour recalls from each participant was collected on varying days throughout the week to enhance accuracy of estimated dietary intake while minimizing participant burden. Two consecutive days, Friday and Saturday, were recorded based on recommendations in the literature (Jerome et al., 2017; World Health Organization, 1998). For each participant, intake was estimated using an average from all of their individual recalls.

BMI

Each participant's BMI was determined by calculation using their height and weight data collected by trained study staff on two separate occasions, day 0 and day 31. Participants were asked to remove their shoes, and anything heavy or bulky from their person to obtain the most accurate measurements. Height was recorded in centimeters using a stadiometer and converted to

meters to be used in the calculations. Weight was taken in kilograms by a portable scale with accuracy up to 100g.

Statistical Analysis

The current study investigates the micronutrient intake of 150 individuals. First, descriptive statistics and bivariate correlations were conducted on all study variables. Due to the small sample size, covariates were only included if they showed significant relationships with any other covariates or nutrient data. After running bivariate correlations, no significant interactions were identified, and as such, they were not included in the analyses. Next, two analyses were conducted to assess how BMI interfaces with micronutrient intake. The micronutrient intake of participants was determined by the average of up to five 24-hour recalls completed by participants. For each of the 150 participants, their average intake was included in the nutrient intake analyses, regardless of the number of recalls they completed. The first was a linear regression analysis to determine if BMI is correlated with micronutrient intake, controlling for age and sex. Second, an approach was used to see if participants met the EAR threshold or not. The threshold was defined by the specific EAR for each micronutrient taking into account the different thresholds based on age and sex and was further categorized into a met or not met category. If there was not an EAR available for a nutrient, the AI was used (Drake, 2017). Differences in meeting the EAR thresholds between BMI categories was assessed by a χ^2 test. All analyses were conducted using SPSS, v24 (IBM, Armonk, NY).

Results

Participant Characteristics

This study of 150 participants consisted of 32 males and 118 females ages 18-24, shown in Table 6. In the normal BMI category (18.5-24.9) there were 73 participants. The average BMI

(± Standard Deviation; SD) of participants in this category was 21.83 ± 1.82. In the overweight/obese BMI category (>25) there were 77 participants. The average BMI (± SD) of participants in this category was 31.21 ± 6.24. The lowest BMI was 18.5 and the highest was 54.5 in this overall sample. The level of education completed in this sample is as follows: 1% completed some high school, 21% completed high school, 55% of participants completes some college, 4% completed an associate degree, 17% completed a bachelor's degree, and 1% completed a post-graduate degree. In addition to education completed, data on current student status was also collected. Only 3% of participants were not students, 5% were part-time and 92% were full-time students. Regarding employment, 31% of participants were unemployed, 60% were employed part-time, and 9% were employed full-time.

Table 6

Participant Characteristics

Characteristic	N	% of Sample	Mean	±	SD	Range
Males	32	21%	-		-	-
Females	118	79%	-		-	-
Age (yrs)	-	-	20.75	±	1.82	18-24
BMI normal	73	49%	21.83	±	1.78	18.5-24.9
BMI overweight/obese	77	51%	31.21	±	6.24	25-54.5
Level of Education Completed						
Some high school	1	1%	-		-	-
High school	32	21%	-		-	-
Some college	83	55%	-		-	-
Associate's degree	6	4%	-		-	-
Bachelor's degree	26	17%	-		-	-
Post-graduate degree	2	1%	-		-	-
Student Status						
Not a student	5	3%	-		-	-
Part-time	7	5%	-		-	-
Full-time	138	92%	-		-	-
Employment Status						

Unemployed	46	31%	-	-	-
Part-time	90	60%	-	-	-
Full-time	14	9%	-	-	-
Geographic living location					
Urban	132	88%	-	-	-
Rural	18	12%	-	-	-

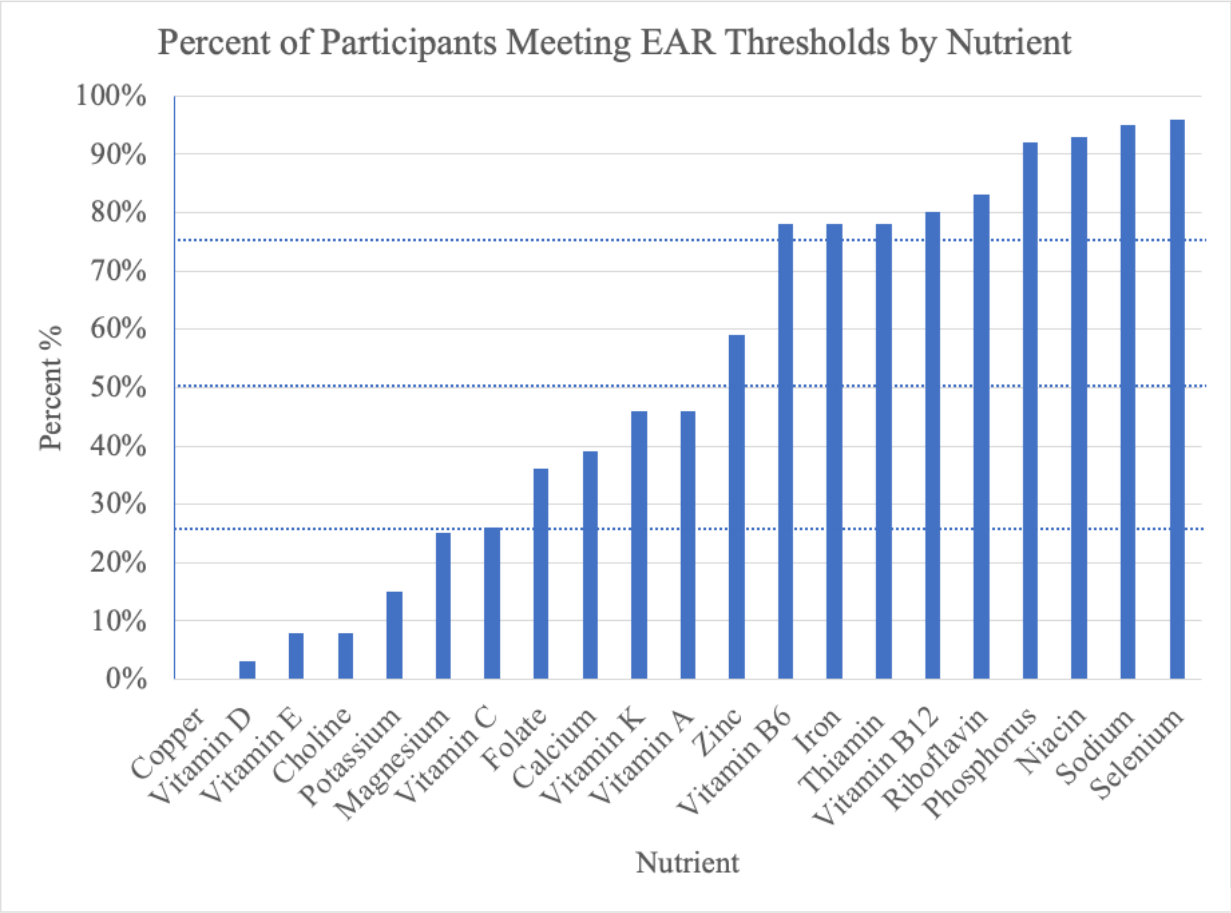
Participants achieving the threshold

To address the first objective, determine if young adults in NWA are consuming adequate levels of micronutrients, the average intake for each nutrient was calculated using the five 24-hour dietary recalls completed by participants and compared to the EAR for their age and sex. However, only 65% of participants completed all five recalls; 17% completed four, 9% completed three, 5% completed two, and 4% completed one. Of the 65% who completed five recalls, one participant completed six and one completed seven due to noncompliance.

Greater than 75% of participants met the EAR for the following nutrients: vitamin B6, iron, thiamin, riboflavin, niacin, vitamin B12, phosphorus, selenium, and sodium. Selenium, sodium, niacin, and phosphorus were met by 96%, 95%, 93%, and 92% of participants respectively. The EAR for zinc was met by 50-75% of participants. 25-50% of participants met the EAR for magnesium, vitamin C, folate, calcium, vitamin K, and vitamin A. Less than 25% of participants met the EAR for the following nutrients: copper, vitamin D, vitamin E, choline, and potassium, shown in Figure 2. The EAR for copper was not met by any participants. No EAR for any individual micronutrient was met by 100% of the participants in this study. Moreover, no participant in this study met the EAR for all of the nutrients.

Figure 2

Percent of Participants Meeting EAR Thresholds by Nutrient



BMI and micronutrient intake

To address the second objective, regression analyses were conducted to determine correlation between micronutrient inadequacy and BMI as continuous variables. In regression analyses for each nutrient, controlling for age and sex, there was a positive relationship between BMI and intake of sodium ($p = 0.04$); as BMI increased, intake of this mineral increased as well. The average sodium intake for those with an overweight or obese BMI was 3,150 mg (Table 7) compared to an average intake of 2,760 mg in the normal BMI group. No relationships were observed between BMI and the other nutrients.

Table 7

Regression Analyses T-test

Nutrient	BMI Category	N	Mean Intake	Std. Deviation	t-test
Vitamin A	normal BMI	73	588.52	518.96	n.s.
	overweight/obese BMI	77	487.87	265.24	
Thiamin	normal BMI	73	1.23	0.54	n.s.
	overweight/obese BMI	77	1.31	0.54	
Riboflavin	normal BMI	73	1.52	0.87	n.s.
	overweight/obese BMI	77	1.51	0.63	
Niacin	normal BMI	73	20.52	10.26	n.s.
	overweight/obese BMI	77	21.86	8.03	
VitB6	normal BMI	73	1.77	1.10	n.s.
	overweight/obese BMI	77	1.82	0.92	
Folate	normal BMI	73	305.16	163.21	n.s.
	overweight/obese BMI	77	320.19	178.50	
Vitamin B12	normal BMI	73	3.84	5.97	n.s.
	overweight/obese BMI	77	3.73	2.05	
Vitamin C	normal BMI	73	55.19	59.04	n.s.
	overweight/obese BMI	77	51.48	62.06	
Vitamin D	normal BMI	73	2.92	2.47	n.s.
	overweight/obese BMI	77	3.52	3.41	
Vitamin E	normal BMI	73	6.76	4.23	n.s.
	overweight/obese BMI	77	6.78	3.40	
Vitamin K	normal BMI	73	133.36	161.05	n.s.
	overweight/obese BMI	77	114.38	156.64	
Choline	normal BMI	73	259.20	165.77	n.s.
	overweight/obese BMI	77	291.66	142.87	
Calcium	normal BMI	73	729.34	387.91	n.s.
	overweight/obese BMI	77	781.76	353.68	
Copper	normal BMI	73	0.91	0.45	n.s.
	overweight/obese BMI	77	0.94	0.46	
Iron	normal BMI	73	10.86	6.03	n.s.
	overweight/obese BMI	77	11.80	6.01	
Magnesium	normal BMI	73	224.10	111.36	n.s.
	overweight/obese BMI	77	225.40	98.83	
Phosphorus	normal BMI	73	1086.47	529.33	n.s.
	overweight/obese BMI	77	1180.59	445.06	

Potassium	normal BMI	73	1944.93	1000.05	n.s.
	overweight/obese BMI	77	2060.78	1033.83	
Selenium	normal BMI	73	94.20	39.89	n.s.
	overweight/obese BMI	77	102.58	39.14	
Sodium	normal BMI	73	2759.41	1176.02	0.04
	overweight/obese BMI	77	3148.16	1163.60	
Zinc	normal BMI	73	8.18	4.43	n.s.
	overweight/obese BMI	77	8.90	4.19	

equal variances assumed
n.s. - not significant

BMI and micronutrient thresholds

To further address the second objective, χ^2 analyses were conducted to determine correlation between micronutrient inadequacy and BMI. In χ^2 analyses by BMI category (normal or overweight/obese) and individual nutrient threshold category (met or not met), participants in the overweight/obese BMI category were more likely to have not met the EAR thresholds for vitamin K ($p = 0.04$) and vitamin C ($p = 0.06$). For vitamin K, 62% of participants in the overweight/obese BMI category compared to 45% of participants in the normal BMI category did not meet the EAR threshold. 67% of participants in the normal BMI category did not meet the EAR threshold for vitamin C while 80% of participants in the overweight/obese category did not meet the EAR threshold. No other differences by BMI category were observed for any other micronutrient.

Table 8

χ^2 Analyses

Nutrient	Met/not met	Normal BMI	Overweight/ obese BMI	Total	%	p value
Vitamin A	# met	36	33	69	46%	n.s.
	# not met	37	44	81	54%	
Thiamin	# met	57	60	117	78%	n.s.
	# not met	16	17	33	22%	
Riboflavin	# met	63	61	124	83%	n.s.

	# not met	10	16	26	17%	
Niacin	# met	65	74	139	93%	n.s.
	# not met	8	3	11	7%	
VitB6	# met	57	60	117	78%	n.s.
	# not met	16	17	33	22%	
Folate	# met	26	28	54	36%	n.s.
	# not met	47	49	96	64%	
Vitamin B12	# met	56	64	120	80%	n.s.
	# not met	17	13	30	20%	
Vitamin C	# met	24	15	39	26%	0.06
	# not met	49	62	111	74%	
Vitamin D	# met	2	2	4	3%	n.s.
	# not met	71	75	146	97%	
Vitamin E	# met	6	6	12	8%	n.s.
	# not met	67	71	138	92%	
Vitamin K	# met	40	29	69	46%	0.04
	# not met	33	48	81	54%	
Choline	# met	5	7	12	8%	n.s.
	# not met	68	70	138	92%	
Calcium	# met	24	35	59	39%	n.s.
	# not met	49	42	91	61%	
Copper	# met	0	0	0	0%	n.s.
	# not met	73	77	150	100%	
Iron	# met	56	61	117	78%	n.s.
	# not met	16	16	32	21%	
Magnesium	# met	17	20	37	25%	n.s.
	# not met	56	57	113	75%	
Phosphorus	# met	67	71	138	92%	n.s.
	# not met	6	6	12	8%	
Potassium	# met	9	13	22	15%	n.s.
	# not met	64	64	128	85%	
Selenium	# met	70	74	144	96%	n.s.
	# not met	3	3	6	4%	
Sodium	# met	69	73	142	95%	n.s.
	# not met	4	4	8	5%	
Zinc	# met	42	46	88	59%	n.s.
	# not met	31	31	62	41%	

n.s. - not significant

Discussion

Due to health consequences related to inadequate micronutrient intake and the understanding that the general population not only fails to meet the majority of micronutrient recommendations but is also overweight, hypotheses were one, young adults are not consuming adequate levels of micronutrients and two, inadequate micronutrient intake correlates with BMI. No EAR threshold for any individual micronutrient was met by 100% of the participants in this study and no participant in this study met the EAR threshold for all of the nutrients which supports the first hypothesis. The second hypothesis, inadequate micronutrient intake correlates with BMI, was only supported in sodium, vitamin C, and vitamin K.

The only relationship seen between BMI held as a continuous variable and individual nutrient intake held as a continuous variable, was a positive relationship with sodium. Poor intake of individual nutrients based on EAR thresholds was not associated with BMI category except in the cases of vitamin K and vitamin C. Overall, participants in this study had poor intake of micronutrients. This study used the EAR as the threshold to categorize nutrient intake as met or not met for each participant. Inadequate consumption of micronutrients by this sample is not a novelty in the US. NHANES 2007-2010 data reflect an overall underconsumption of micronutrients by the US population (Drake, 2017). In the United States, the obesity rate is 39.8% in adults over 20 years of age according NHANES data in 2015-2016 (Drake, 2017; Fryar et al., 2018). In general, individuals who are obese consume a diet scarce in fruits, vegetables, whole grains, and low-fat dairy products, foods that are good sources of micronutrients (Centers for Disease Control, 2017). This led researchers to believe obesity, or a high BMI, could be associated with lower micronutrient intake (García et al., 2009).

The nutrients of concern listed by the Dietary Guidelines for Americans were also under-consumed nutrients in the present study. Less than 40% of participants in this study met the EAR threshold for seven of the eight nutrients of concern. Vitamin A, the remaining nutrient of concern, was only slightly better with 46% of participants meeting the EAR threshold. It is important to reiterate that the EAR is the level at which half of the population's needs are estimated to be met (Food and Nutrition Board, 2015). Therefore, just meeting the EAR is not adequate to meet half of the population's micronutrient needs and intake levels below the EAR satisfies the needs of even fewer individuals. The main takeaway from this study is that most participants failed to meet the EAR threshold for a majority of micronutrients.

Inadequate micronutrient intake can have negative effects on health and well-being with common symptoms such as increased fatigue, decreased cognitive function, and decreased immunity, but not to the point where they are showing deficiency symptoms and are frankly deficient (Pascual et al., 2019). Over time, insufficient consumption of micronutrients can lead to metabolic disruption, accelerated mitochondrial decay, neural decline, and increased risk of developing cancer, cardiovascular disease, type 2 diabetes, and osteoporosis (Ames, 2006; Pascual et al., 2019). Low micronutrient intake is related to poor diet quality and obesity (Pascual et al., 2019). Obesity is not only a chronic disease itself, but it is also linked to the development and exacerbation of other chronic diseases, which lead to further healthcare costs. In 2008 dollars, the healthcare costs of obesity were estimated at $147 billion (Centers for Disease Control, 2017). Obesity related to poor diet is linked to insufficient consumption of micronutrients and a host of negative health effects including some chronic effects. It is important to consume adequate micronutrient levels to maintain proper body function and decrease the risk of developing chronic disease (Bird et al., 2017; Pascual et al., 2019). This

study and future studies on the relationship between diet, obesity, and health are important due to the high costs of healthcare associated with obesity and the overall well-being of the population.

The majority of participants in this study were full-time or part-time students. On college campuses, the accessibility and the likelihood of selecting nutrient dense foods such as fruits, vegetables, whole grains, and low-fat dairy products is low due to barriers such as taste, value, convenience, and cost (Roy et al., 2019; Tam et al., 2017). Many students, especially students who live in the dorms, rely on campus dining for the bulk of their meals because they either do not have a kitchen readily available to them, they do not have transportation, or they do not have the skills needed to prepare healthful foods (Dhillon et al., 2019). Even students who live off campus experience some of those same barriers to healthful eating. In addition to the barriers, the convenience of being able to grab lunch on campus instead of planning ahead to pack a lunch can have an influence on dietary choices. In addition to poor micronutrient consumption, an increase in caloric intake is also often seen on college campuses, especially by students who eat most of their meals at buffet style dining halls (Sogari et al., 2018). The food environment on a college campus has a major effect on what students consume. Participants in this study may be at higher risk for micronutrient inadequacy due to their occupation as students on a college campus. A study by Dhillon et al looked at how the personal processes of decisional balance and agency interact with four dimensions of the perceived food environment, affordability, acceptability, accessibility, and adequacy, in addition to subjective norms influenced the food choices of students (Dhillon et al., 2019). Participants in that study noted they felt internal conflict when deciding between healthful and less healthful foods due to the four dimensions of perceived food environment. There are many factors that go into food choices, but food environment is a major player in that decision.

This study was strengthened by the use of five 24-hour dietary recalls taken on variable days throughout the week and on two consecutive days because it increased the comprehensiveness of participant intake information (Jerome et al., 2017; World Health Organization, 1998; Yuan et al., 2018). However, 35% of participants failed to complete all five dietary recalls which somewhat decreased the likelihood of getting an estimate that is reflective of actual intake. This study was also limited by a small sample size of 150 participants, a low number of male participants, and no collection of biochemical measures. A major limitation of this study is that no data were collected on habitual supplement use. Participants in the parent study were asked to abstain from consuming supplements during the 31-day study period therefore, participants did not include supplement use in their dietary recalls. However, if a participant regularly consumed a multivitamin and mineral supplement, their normal nutrient intake may be greater than what this study revealed. Individuals in this study could have failed to meet nutrient thresholds by dietary intake over the course of the study, but regularly meet the thresholds with their normal supplementation practices in addition to dietary intake. This study did show a negative correlation between micronutrient intake and BMI category for vitamin C and vitamin K, and a positive relationship between sodium intake and BMI. Perhaps this study failed to revel more correlations due to many participants failing to meet the EAR threshold which caused a narrow range of intake levels for each nutrient. A larger sample size with more participants meeting and exceeding the EAR thresholds may reveal correlations with more micronutrients because there would be greater differentiation within the range of participant intake.

This study could be repeated with a larger sample size and with micronutrient levels assessed via biochemical measures through blood draws. Future studies in this area could address

how BMI correlates with overall micronutrient intake, not just compared to individual micronutrients. Additionally, perhaps in place of thresholds, nutrient intake could be scored by the Healthy Eating Index.

Conclusion

While this study only reveled a correlation between BMI and the following nutrients, vitamin K, vitamin C, and sodium, this study did reveal that many participants failed to meet the EAR thresholds. Overall, participants in this study failed to consume adequate levels of micronutrients regardless of their BMI, similar to the US population (Dietary Guidelines Advisory et al., 2015; Drake, 2017; Kim et al., 2019). This is significant because there is a burden associated with micronutrient inadequacy both financially and in health. This burden is significant and preventable, with simple solutions available. On an individual basis, solutions may include increasing the nutrient density of foods they consume by increasing fruit, vegetable, whole grain, and low-fat dairy intake or consuming a daily multivitamin and mineral supplement. Additionally, nutrition education programs regarding the importance of consuming adequate micronutrients via nutrient dense dietary patterns could be beneficial to the population. These programs, such as Cooking Matters and Food Corps lead initiatives, could be implemented in the workplace and in schools to increase knowledge of nutrition.

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Appendices

Script for Initial contact and Study Screening

Hello, my name is ___ and I am a research assistant with the Multivitamin-Mineral Supplementation study at the University of Arkansas. Is now a good time to talk and give you some information about the study? (If yes, say thank you and continue on. If no, then ask if there is a better time to call back).

Thank you very much for your interest in our study. First, I would like to tell you a little about the study and if you are interested then ask you a few questions to determine if you are eligible to participate.

This research study is looking at the effects of multivitamin-mineral supplementation on mood and overall well-being. Participants in this study will be asked to take a daily multivitamin supplement or placebo for 30 days and complete online questionnaires asking about mood, physical health and diet, and weight-related health. Your participation would last approximately 32 days and you would be compensated $100 for participating.

Are you still interested? (*If they are not interested in participating:* Thank you for your time and interest in the study.)

If yes: Great! We are happy to hear you are interested in participating. We have a few screening questions that we would like to ask to determine your eligibility in the study. These questions ask your basic information and if you have any health-related diagnoses that could possibly impair the effectiveness of the multivitamin supplementation. Do I have your permission to ask these questions?
Note to research assistants: Please go through the entire screening questionnaire even if they are disqualified half way through.

Screening Questionnaire

1. What is your name?
2. What is your phone number and email address?
3. What is your preferred method of contact?
4. What is your height?
5. What is your current weight?
6. BMI?
7. Are you between 18 and 24 years old?
   Yes No

8. Are you pregnant or planning to become pregnant? (If male, skip this question)
   Yes No N/A
9. Are you going to school or working at least part-time?
   Yes No
10. Have you ever been diagnosed with malabsorption, or any related gastrointestinal diagnoses for example, Chron's disease or inflammatory bowel syndrome?
   Yes No
11. Have you ever received a diagnosis related to impaired liver or renal function?
   Yes No
12. Do you have iron deficiency anemia?
   Yes No
13. Have you ever been diagnosed with a mental health disorder, for example, general anxiety, depression, bipolar disorder or an eating disorder?
   Yes No
14. Are you currently taking any prescription medications for a mental health diagnosis?
   Yes No
15. Are you willing to abstain from taking any other supplements during the study and abstain from taking any drugs, including marijuana?
   Yes No
16. Are you extremely uncomfortable or unable to swallow pills?
   Yes No

NOTE: People responding *YES* to questions 7, 9, 10, 11, 12, 13, and 15 or a *NO* to question 14 are not eligible for the study.

For those not eligible to participate (answering yes to any of the above disqualifies the person from participating): I am sorry to inform you that unfortunately you are not eligible to participate in the Multivitamin-Mineral Supplementation study. Thank you very much for you interest in participating.

For those eligible to participate: You are eligible to participate in our study! Next, we would like for you to come to our study laboratory so that we can obtain your informed consent, explain the study instructions, and get some further background information from you. Our study laboratory is located on the 2nd floor of the Home Economic building in office 205D on the University of Arkansas campus. When would be a good time for you to come in? (Schedule a date and time).
We appreciate your interest in the multivitamin-mineral supplementation study and we look forward to meeting you on (date) and (time). If you have any questions or trouble locating our lab, please do not hesitate to contact me at _____.

Multivitamin-Mineral Supplementation & Mood Study
Consent to Participate in a Research Study
Principal Researcher: Jennifer Becnel, PhD & Sabrina Trudo, PhD, RD

INVITATION TO PARTICIPATE

You are invited to participate in a research study investigating the effects of multivitamin-mineral supplementation on your health. You are being asked to participate in this study because you are between the ages of 18 and 24 years old, going to school or working at least part-time, and have no gastrointestinal or mental health diagnoses. Please take time to review the following form, ask questions, and decide whether you wish to participate or not.

WHAT YOU SHOULD KNOW ABOUT THE RESEARCH STUDY

Who are the Principal Researchers?
This study is being conducted by Jennifer Becnel, PhD and Sabrina Trudo, PhD, RD of the School of Human Environmental Sciences at the University of Arkansas. Dr. Becnel can be reached by phone at 479-575-2358 or by email at becnel@uark.edu. Dr. Trudo can be reached by phone at 479-575-4863 or by email at trudo@uark.edu.

What is the purpose of this research study?
Poor health and mood have been associated with micronutrient deficiencies. The purpose of this study is to examine the effects of multivitamin-mineral supplementation on mood, health, and weight-related satisfaction in young adults.

Who will participate in this study?
This study will include 140 young adult men and women. To participate, you must be the ages of 18-24, going to school or working at least part-time, have no malabsorption or related gastrointestinal diagnosis, no mental health diagnosis, and not taking prescription medications. You must be willing to take only the provided multivitamin-mineral supplement for 30 days.

What am I being asked to do?
During your first visit to the study laboratory, study staff will explain the study and address any questions or concerns you may have. If you agree to participate, study staff will take your height and weight and outline a detailed schedule for your participation in the study. You will also fill out a short questionnaire asking basic questions about yourself. At this time, we ask that you discontinue use of dietary/herbal supplements (including all vitamins and teas).

Participation in this study will last 31 days. You will be randomly assigned to take two pills daily for a month of either a multivitamin-mineral supplement or placebo (not containing any vitamins or minerals). You will not know if you are assigned to take the multivitamin-mineral supplement or the placebo. During the 31 days, you will be asked to visit the study laboratory weekly (every 7 days) to pick up the multivitamin-mineral supplements or placebo. The multivitamin-mineral supplement or placebo is to be taken every morning at approximately the same time.

Additionally, you are asked to complete two online questionnaires on five assessment days: Day 1, Day 3, Day 4, Day 15, and Day 30. The first online questionnaire will ask questions about psychological functioning, health, and weight-related satisfaction. The second online questionnaire will ask about your dietary intake in the previous 24 hours. The questionnaires should take approximately one hour to complete, total. On the last day of the study, you will be asked to return to the study laboratory to have your height and weight taken again. Below is an outline of the study schedule.

Study Schedule

Day 0:	Return to the study laboratory to pick up the supplements/placebo. You will be given 7 days' worth of the supplement/placebo.
Day 1:	Begin taking the supplement/placebo in the morning and complete the online assessments within 3 hours of taking the supplement/placebo.
Day 3:	Complete the online assessments within 3 hours of taking the supplement/placebo.
Day 4:	Complete online assessment *before* taking the supplement/placebo.
Day 7:	Return to the study laboratory for another week's supply of the supplement/placebo.
Day 14:	Return to the study laboratory for another week's supply of the supplement/placebo.
Day 15:	Complete the online assessments within 3 hours of taking the supplement/placebo.
Day 21:	Return to the study laboratory for another week's supply of the supplement/placebo.
Day 30:	Complete the online assessments within 3 hours of taking the supplement/placebo.
Day 31:	Return to the study laboratory to finish out the study and have your height and weight taken.

What are the possible risks or discomforts?

You may feel uncomfortable answering some of the questions in the online questionnaire. If you feel any discomfort, you can omit an answer to a question or terminate your involvement in the study. You will not be penalized for omitting answers or terminating the questionnaires early. There may be discomfort from swallowing the supplement/placebo pills if you are not accustomed to swallowing pills. If you find that you cannot tolerate swallowing pills, you do not have to complete the study. The amounts of the vitamins and minerals in the supplement are similar to supplements that are available for purchase at stores.

What are the possible benefits of this study?

There are no benefits to participating in the study.

Will I receive compensation for my time and inconvenience if I choose to participate in this study?

You will receive a total of $100 in cash for completing the study, distributed as each assessment day is completed. Compensation is received for each day the online questionnaires are completed. Amounts increase for each questionnaire day (Day 1 = $10, Day 3 = $15, Day 4 =

$20, Day 15 = $25, Day 31 = $30). To minimize the number of times you need to visit the laboratory, compensation will be dispersed on Day 7, Day 21, and Day 31.

Will I have to pay for anything?
There will be no cost associated with your participation in this study.

What are the options if I do not want to be in the study?
If you do not want to be in this study, you may refuse to participate. Also, you may refuse to participate at any time during the study. Your standing and relationship with the University of Arkansas will not be affected in any way if you refuse to participate or drop out of the study.

How will my confidentiality be protected?
All information will be kept confidential to the extent allowed by applicable State and Federal law. Participants in this study will be assigned an ID number to ensure confidentiality. A master list linking participant's names to ID numbers and all participant data will be kept on a secure server that only the study staff will have access to.

Will I know the results of the study?
At the conclusion of the study you will have the right to request feedback about the results. You may contact the Principal Researcher, Jennifer Becnel at becnel@uark.edu or 479.575.2358. You will receive a copy of this form for your files.

What do I do if I have questions about the research study?
You have the right to contact the Principal Researcher as listed below for any concerns that you may have.

Jennifer Becnel, PhD
Assistant Professor of Human Development and Family Sciences
Human Environmental Sciences
HOEC 118
1 University of Arkansas
Fayetteville, AR 72701
479.575.2358
Becnel@uark.edu

Sabrina Trudo, PhD, RD
Associate Professor of Nutrition
21st Century Endowed Chair in Human Environmental Sciences
HOEC 118
1 University of Arkansas
Fayetteville, AR 72701
Tel: 479.575.4863
trudo@uark.edu

You may also contact the University of Arkansas Research Compliance office listed below if you have questions about your rights as a participant, or to discuss any concerns about, or problems with the research.

Ro Windwalker, CIP
Institutional Review Board Coordinator
Research Compliance
University of Arkansas
109 MLKG Building
Fayetteville, AR 72701-1201
479-575-2208
irb@uark.edu

STATEMENT OF CONSENT

I have read the above statement and have been able to ask questions and express concerns, which have been satisfactorily responded to by the investigator. I understand the purpose of the study as well as the potential benefits and risks that are involved. I understand that participation is voluntary. I understand that no rights have been waived by signing the consent form. I have been given a copy of the consent form.

Name of Participant: _____

Signature of Participant: _____

Signature of Investigator: _____

Date: _____

Multivitamin-Mineral Supplementation & Mood Study

Participant Instruction Booklet

For questions about any part of the study, please contact your study coordinator.
Study Coordinator: Sharon Chang
Laboratory: HOEC 205D
Research Coordinator: _____
Coordinator Phone Number: _____
Emergencies—Dr. Becnel
(480) 276-2955
Email
Yc031@uark.edu

Please stop taking all medications and dietary/herbal supplements (including all vitamins and teas) beginning one week before the study period.

Stop on:_____

Purpose of the Study

The primary purpose of this study is to examine the effects of a multivitamin-mineral supplement (MVM) on psychological functioning, health, and weight-related satisfaction among young adult college students.

Study Procedures and Time Commitment

This is a research study looking at the effects of Multivitamin-Mineral Supplementation on mood and overall well-being. The total timeline for the project is two years, during which we will conduct a randomized controlled trial at the University of Arkansas, Fayetteville. However, you are required to participate in the study only for 31-days.

You may qualify for the study if you are/have:

- 18 – 24 years old;
- Going to school or working at least part-time;
- No diagnosis of malabsorption or related gastrointestinal diagnoses (e.g., Crohn's disease, inflammatory bowel disease);
- No diagnosis related to impaired liver or renal function;
- No mental health diagnosis (e.g., general anxiety disorder, depression, bipolar-related diagnoses);
- Not taking prescription medications for mental health diagnoses;
- And willing to not take any other supplements during the study.

After the screening interview over the phone, if you qualify, you will be asked to come to the study laboratory to have your height and weight taken, fill out a one-time demographic questionnaire, and be given the study instructions and activities. At this time, we will randomly assign you to either the MVM supplement or placebo group. The following week, you will return to the study laboratory to receive a week's supply of the supplement or placebo pills and will be instructed to take two pills at approximately the same time every morning. You will return to the study laboratory once a week for another week's supply of the supplement or placebo pills and to return any pills that you did not take during the previous week.

You will also be asked to complete the following two questionnaires on each of the five assessment days: Consent Day, Day 3, Day 4, Day 15, and Day 31. They are,

1. **Questionnaire- I:** A self-administered online questionnaire to assess your psychosocial functioning, health indicators, and weight related satisfaction. It is a set of questionnaires that will be presented in a random order each time through Qualtrics software.

2. **Questionnaire- II**: A self-administered online questionnaire, ASA24®, to assess your dietary intake in the previous 24 hours. ASA24® is completed separately using a website and confidential login from the National Cancer Institute.

You will be instructed to complete the questionnaires within three hours after taking the supplement or placebo on Day--3, Day 15, and Day 31. However, on Day 4 you will be required

to complete the questionnaires **before** taking the supplement. Links to the questionnaires will be provided to you and you will be reminded to complete the questionnaires via text, email, or phone calls.

Coming to HOEC

The Home Economics (HOEC) building is located on the University of Arkansas, Fayetteville campus. The study office is located on the 3rd floor of HOEC in 205D.

Supplement

The Multivitamin-Mineral Supplement that we are using in this study was formulated to contain selective nutrients such as B vitamins, vitamin C, calcium, magnesium, and zinc and no additional compounds such as herbals. The composition of MVM supplement is given in the table below. We will randomly assign you either to an MVM supplement group or a placebo group. You will be asked to take two pills at a time each day. For research purposes, we will make both the supplement and placebo pills look exactly the same and you will not know whether you are taking MVM pills or placebo pills.

Supplement packets can be picked up from the study laboratory every Tuesday. Please bring back the empty supplement packs from the week prior when you pick up the new pack for the next week.

Vitamin/Mineral	Amount in Supplement	RDA	%RDA
B1 = Thiamin	15 mg	1.1 – 1.2 mg	1364
B2 = Riboflavin	15 mg	1.1 – 1.3 mg	1364
B3 = Nicotinamide	50 mg	14 – 16 mg	357
B5 = Pantothenic Acid	23 mg	5 mg	460
B6	10 mg	1.3 mg	769
B12	10 µg	2.4 µg	416
C	500 mg	75 – 90 µg	667
H = Biotin	150 µg	30 µg	500
Folic Acid	400 µg	400 µg	100
Calcium	100 mg	1,000 mg	10
Magnesium	100 mg	310 – 400 mg	32
Zinc	10 mg	8 – 11 mg	125

Questionnaires

You will be asked to complete questionnaire-I and questionnaire-II on each of the five assessment days. In addition, you will be asked to complete one time questionnaires on demographics and alcohol consumption at the start of the study.

Demographics:
A demographic questionnaire will ask about age, gender/sex, year and full or part time in college, socioeconomic status and work status, geographic location (urban vs. rural), food insecurity, Greek life engagement, general eating behaviors, and sleep behaviors.

Alcohol Use:
Participants will complete 6 questions from National Institute on Alcohol Abuse and Alcoholism (NIAAA) on frequency of drinking and binge drinking behaviors.

Questionnaire-I:
Questionnaire-I is a compilation of several mini questionnaires to assess psychological functioning, weight related functioning and health measures.

1). Psychological Functioning Measures:

BAI (Beck Anxiety Inventory): The BAI evaluates physiological and cognitive symptoms of anxiety.

Center for Epidemiologic Studies Depression Scale (CES-D): The CES-D is a brief assessment measuring attitudes and symptoms of depression.

Self-Esteem: A single item measures self-esteem or your feelings about yourself.

ADI (Abbreviated Dysregulation Inventory): The ADI evaluates ability to control thoughts, feelings, and behavior.

PSS (Perceived Stress Scale): The PSS assesses feelings and thoughts related to stress and coping.

2). Weight-Related Functioning Measures:

IWQOL-Lite (Impact of Weight on Quality of Life-Lite): The IWQOL-Lite assesses the impact of obesity on quality of life in areas of physical functioning, self-esteem, public distress, and work.

BSQ (Body Shape Questionnaire): The BSQ measures individuals' self-perception of their body shape and body satisfaction/dissatisfaction.

3). Health Measures:

HRQOL (CDC Health Related Quality of Life-14 Measure): The HRQOL is a measure developed by the Centers for Disease Control to assess health related to physical, emotional, and social functioning.

IPAQ (International Physical Activity Questionnaire): The IPAQ measures health-related physical activity.

Questionnaire-II:

ASA24® (Automated Self-Administered 24-Hour Dietary Assessment Tool): The ASA24® was developed by the National Cancer Institute and assesses what was eaten over the previous 24-hour period.

Detailed Schedule of Study Activities

Day	Date	Instructions	Complete
Consent		**Agree to participate in study; measurements taken; complete questionnaires**	**Questionnaire I Questionnaire II**
Day 0		**Pick up supplements from study lab**	
Day 1		**Begin taking the supplement in the morning**	
Day 3		**Complete the online questionnaires within 3 hours of taking the supplement**	**Questionnaire I Questionnaire II**
Day 4		**Complete the online questionnaires *before* taking the supplement**	**Questionnaire I Questionnaire II**
Day 7		**Return to the study lab for another week's supply of the supplement & return any unused supplements**	
Day 14		**Return to the study lab for another week's supply of the supplement & return any unused supplements**	
Day 15		**Complete the online questionnaires within 3 hours of taking the supplement**	**Questionnaire I Questionnaire II**
Day 21		**Return to the study lab for another week's supply of the supplement & return any unused supplements**	
Day 30		**Complete the online questionnaires within 3 hours of taking the supplement**	**Questionnaire I Questionnaire II**
Day 31		**Return to the study lab to finish out the study & return any unused supplements**	

- Take 2 pills at a time every day throughout the study period
- Avoid herbal supplements, herbal teas and other vitamin-mineral supplements during the study period

Things to Avoid During the Study

You will be asked not to take any other vitamin, mineral and herbal supplements and teas as well as herbal teas during the study. You should let us know if a medication is started for a mental or physical health-related diagnosis any time during the study.

Compensation

Thank you for your interest in participating in the Multivitamin-Mineral Supplementation & Mood Study. You will receive a total of $100 in cash as a stipend to compensate you for your time, effort, and inconvenience related to completing the study. This stipend will be distributed incrementally as assessments are completed. Cash is received for each day the online questionnaires are completed. Amounts increase for each questionnaire day (Day 1 = $10, Day 3 = $15, Day 4 = $20, Day 15 = $25, Day 31 = $30). Stipends can be picked up from the study laboratory on Day 7, Day 21, and Day 31.

Questions and Contact Information

If you have any questions at any time, you can contact the study coordinator, Ryan Grant at 479-575-7538. The researchers conducting this study are Jen Becnel, PhD and Sabrina Trudo, PhD, RD. If you have any questions for them, you can contact Dr. Becnel at 479-575-2358 and Dr. Trudo at 479-575-4863. If you have any questions or concerns about your rights as a research participant, then you are encouraged to contact Ro Windwalker at 479-575-2208.

Services Available for Discomfort Experienced during the Questionnaire

The online questionnaires that you are asked to take ask questions regarding depression, anxiety, and how you feel about yourself. If you experience any discomfort while answering these questions, please do not hesitate to contact Counseling and Psychological Services (CAPS) here on campus at 479.575.5276.

MVM Demographic Survey

Start of Block: Introduction

Q19 Welcome to the Multivitamin-Mineral Supplementation study!

This study is investigating multivitamin-mineral supplementation and mood. We would appreciate you taking about 15 minutes to complete the following survey. Be assured that all answers you provide will be kept in the strictest confidentiality. Any personal information obtained is for linking participants across surveys and will not be shared. Please click the red arrow button to begin.

End of Block: Introduction

Start of Block: Name

Q21 What is your first and last name?

_____

End of Block: Name

Start of Block: Demographics

Q3 What is your age in years?

_____

Skip To: End of Survey If Condition: What is your age in years? Is Greater Than 25. Skip To: End of Survey.

Skip To: End of Survey If Condition: What is your age in years? Is Less Than 18. Skip To: End of Survey.

Q5 What is your gender?

- Male (1)
- Female (2)
- Other (3)

Q9 Are you a full-time or part-time student?

- Full-time (1)
- Part-time (2)
- Not a student (3)

Skip To: Q11 If Are you a full-time or part-time student? = Not a student

Q7 What year are you in college?

- Freshman (1)
- Sophomore (2)
- Junior (3)
- Senior (4)
- Graduate Student (5)
- Not a college student (6)

Q11 What is your highest level of education completed?

- Some high school (1)
- High school (2)
- Some college (3)
- Associate's degree (4)
- Bachelor's degree (5)
- Post graduate degree (6)

Q13 What is your employment status?

- Full-time (1)
- Part-time (2)
- Unemployed (3)

Q15 What is your geographic living location?

- Urban (1)
- Rural (2)

Q17 Are you currently or were you ever involved in Greek life?

- Yes (1)
- No (2)

End of Block: Demographics

Start of Block: parent edcuation

Q12 What is the highest level of education your mother completed?

- 8th grade or less (1)
- Some high school (2)
- High school degree (3)
- Completed vocational/technical training (4)
- Some college (5)
- College degree (bachelor's) (6)
- Some graduate school (7)
- Completed master's or doctoral degree (8)

Q14 What is the highest level of education your father completed?

- 8th grade or less (1)
- Some high school (2)
- High school degree (3)
- Completed vocational/technical training (4)
- Some college (5)
- College degree (bachelor's) (6)
- Some graduate school (7)
- Completed master's or doctoral degree (8)

End of Block: parent edcuation

Start of Block: food insecurity

Q16 In the last 12 months, the food that I/we bought just didn't last, and I/we didn't have money to get more.

- ○ Often True (1)
- ○ Sometimes True (2)
- ○ Never True (3)
- ○ Don't Know (4)

Q18 In the last 12 months, I/We couldn't afford to eat balanced meals.

- ○ Often True (1)
- ○ Sometimes True (2)
- ○ Never True (3)
- ○ Don't know (4)

Q22 In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money for food?

- ○ Yes (1)
- ○ No (2)
- ○ Don't know (3)

Q20 In the last 12 months, were you ever hungry but didn't eat because there wasn't enough money for food?

- ○ Yes (1)
- ○ No (2)
- ○ Don't know (3)

Q21 In the last 12 months, did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?

- ○ Yes (1)
- ○ No (2)
- ○ Don't know (3)

Skip To: End of Block If In the last 12 months, did you or other adults in your household ever cut the size of your meals... = No

Skip To: End of Block If In the last 12 months, did you or other adults in your household ever cut the size of your meals... = Don't know

Q23 How often in the last 12 months did you or other adults in your household ever cut the size of your meals or skip meals because there wasn't enough money for food?

- ○ Almost every month (1)
- ○ Some months but not every month (2)
- ○ Only 1 or 2 months (3)
- ○ Don't know (4)

End of Block: food insecurity

Start of Block: sleep

Q61 During the past month when have you usually gone to bed?

_____

Q62 During the past month how long (in minutes) has it taken you to fall asleep each night?

▼ 5 minutes (2) ... 60 minutes or more (13)

Q63 During the past month, what time have you usually gotten up in the morning?

_____

Q64 The following questions relate to your usual sleep habits during the past month only. Please indicate the most accurate reply for the majority of days and night in the past month.

○ How many hours of actual sleep did you get at night? (1)
_____

○ How many hours were you in bed? (2)
_____

End of Block: sleep

Start of Block: sleep

Q65
During the past month, how often have you had trouble sleeping because you:

	Not during the past month (1)	Less than once a week (2)	Once or twice a week (3)	Three or more times a week (4)
Cannot get to sleep within 30 minutes (2)	○	○	○	○
Wake up in the middle of the night or early morning (3)	○	○	○	○
Have to get up to use the bathroom (4)	○	○	○	○
Cannot breathe comfortably (5)	○	○	○	○
Cough or snore loudly (6)	○	○	○	○
Feel too cold (7)	○	○	○	○
Feel too hot (8)	○	○	○	○
Have bad dreams (9)	○	○	○	○
Have pain (10)	○	○	○	○
Other reason (11)	○	○	○	○

Q66 During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?

- ○ Not during the past month (1)
- ○ Less than once a week (2)
- ○ Once or twice a week (3)
- ○ Three or more times a week (4)

Q67 During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

- Not during the past month (1)
- Less than once a week (2)
- Once or twice a week (3)
- Three or more times a week (4)

Q68 During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?

- Not during the past month (1)
- Less than once a week (2)
- Once or twice a week (3)
- Three or more times a week (4)

Q69 During the past month, how would you rate your sleep quality overall?

- Very good (1)
- Fairly good (2)
- Fairly bad (3)
- Very bad (4)

End of Block: sleep

Start of Block: Alcohol

Q20 During the last 12 months, how often did you usually have any kind of drink containing alcohol? **By a drink we mean half an ounce of absolute alcohol (e.g. a 12oz can or glass of beer or cooler, a 5oz glass of wine, or a drink containing 1 shot of liquor).** Choose only one.

- ○ Every day (1)
- ○ 5 to 6 times a week (2)
- ○ 3 to 4 times a week (3)
- ○ Twice a week (4)
- ○ Once a week (5)
- ○ 2 to 3 times a month (6)
- ○ Once a month (7)
- ○ 3 to 11 times in the past year (8)
- ○ 1 or 2 times in the past year (9)
- ○ I did not drink any alcohol in the past year, but I did drink in the past (10)
- ○ I have never drank any alcohol in my life (11)

Skip To: Q22 If During the last 12 months, how often did you usually have any kind of drink containing alcohol? B... = I did not drink any alcohol in the past year, but I did drink in the past

Skip To: Q24 If During the last 12 months, how often did you usually have any kind of drink containing alcohol? B... = I have never drank any alcohol in my life

Q26 During the last 12 months, how many alcoholic drinks did you have on a typical day when you drank alcohol?

- ○ 25 or more drinks (1)
- ○ 19 to 24 drinks (2)
- ○ 16 to 18 drinks (3)
- ○ 12 to 15 drinks (4)
- ○ 9 to 11 drinks (5)
- ○ 7 to 8 drinks (6)
- ○ 5 to 6 drinks (7)
- ○ 3 to 4 drinks (8)
- ○ 2 drinks (9)
- ○ 1 drink (10)

Q28 During the last 12 months, what is the largest number of drinks containing alcohol that you drank within a 24-hour period?

- ○ 36 drinks or more (1)
- ○ 24 to 35 drinks (2)
- ○ 18 to 23 drinks (3)
- ○ 12 to 17 drinks (4)
- ○ 8 to 11 drinks (5)
- ○ 5 to 7 drinks (6)
- ○ 4 drinks (7)
- ○ 3 drinks (8)
- ○ 2 drinks (9)
- ○ 1 drink (10)

Q30 During the last 12 months, how often did you drink this largest number of drinks? Choose only one.

- ○ Every day (1)
- ○ 5 to 6 times a week (2)
- ○ 3 to 4 times a week (3)
- ○ Twice a week (4)
- ○ Once a week (5)
- ○ 2 to 3 times a month (6)
- ○ Once a month (7)
- ○ 3 to 11 times in the past year (8)
- ○ 1 or 2 times in the past year (9)

Q32 During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks containing any kind of alcohol within a two-hour period? (That would be the equivalent of at least 5 (4) 12oz cans or bottles of beer, 5 (4) 5oz glasses of wine, 5 (4) drinks each containing once shot of liquor or spirits.) Choose only one response.

- ○ Every day (1)
- ○ 5 to 6 days a week (2)
- ○ 3 to 4 days a week (3)
- ○ Two days a week (4)
- ○ One day a week (5)
- ○ 2 to 3 days a month (6)
- ○ One day a month (7)
- ○ 3 to 11 days in the past year (8)
- ○ 1 or 2 days in the past year (9)

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = Every day

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = 5 to 6 days a week

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = 3 to 4 days a week

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = Two days a week

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = One day a week

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = 2 to 3 days a month

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = One day a month

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = 3 to 11 days in the past year

Skip To: End of Block If During the last 12 months, how often did you have 5 or more (males) or 4 or more (females) drinks... = 1 or 2 days in the past year

Q24 So you have never had a drink containing alcohol in your entire life.

- ○ Correct, I have never drank (1)
- ○ No, I did drink (2)

Skip To: Q22 If So you have never had a drink containing alcohol in your entire life. = No, I did drink

Skip To: End of Block If So you have never had a drink containing alcohol in your entire life. = Correct, I have never drank

Q22 During your lifetime, what is the maximum number of drinks containing alcohol that you drank within a 24-hour period?

- ○ 36 drinks or more (1)
- ○ 24 to 35 drinks (2)
- ○ 18 to 23 drinks (3)
- ○ 12 to 17 drinks (4)
- ○ 8 to 11 drinks (5)
- ○ 5 to 7 drinks (6)
- ○ 4 drinks (7)
- ○ 3 drinks (8)
- ○ 2 drinks (9)
- ○ 1 drink (10)

End of Block: Alcohol

Start of Block: eating behaviors

Q29 During the past 6 months, have you had times when you eat continuously during the day or parts of the day without planning what and how much you would eat?

- ○ Yes (1)
- ○ No (2)

Skip To: Q27 If During the past 6 months, have you had times when you eat continuously during the day or parts of... = Yes

Skip To: Q39 If During the past 6 months, have you had times when you eat continuously during the day or parts of... = No

Q27 Did you experience a loss of control, that is, you felt like you could not control your eating?

- ○ Yes (1)
- ○ No (2)

Q39 In the past 3 months, have you had any episodes of binge eating?

- ○ Yes (1)
- ○ Maybe (2)
- ○ No (3)

Q38 During the past 3 months, how often did you keep eating a meal even though you were not hungry anymore?

- ○ Never (1)
- ○ Rarely (one per month or less) (2)
- ○ Occasionally (once per week) (3)
- ○ Most of the time (multiple times per week) (4)

Q31 In the past 3 months, how often did you keep eating a meal even though you felt full?

- Never (1)
- Rarely (once per month or less) (2)
- Occasionally (once per week or more) (3)
- Most of the time (multiple times per week) (4)

Q33 During the past 3 months, how much of your daily food intake did you consume after suppertime?

- 0 (none) (1)
- 1-25% (up to a quarter) (2)
- 26-50% (about half) (3)
- 51-75% (more than half) (4)
- 76-100% (almost all) (5)

Q35 During the past 3 months, how often did you get up (at least once) in the middle of the night other than [having] to use the bathroom?

- Never (1)
- Less than once a week (2)
- About once a week (3)
- More than once a week (4)
- Every night (5)

Q37 During the past 3 months, how often would you have a snack in the middle of the night?

- Never (1)
- Sometimes (2)
- About half the time (3)
- Usually (4)
- Always (5)

End of Block: eating behaviors

Start of Block: anxiety

Q41 Below is a list of common symptoms of anxiety. Please carefully read each item in the list. Indicate how much you have been bothered by that symptom during the past week, including today.

	Not at all (1)	Mildly, but it didn't bother me much (2)	Moderately- it wasn't pleasant at times (3)	Severely- it bothered me a lot (4)
Numbness or Tingling (1)	○	○	○	○
Feeling hot (2)	○	○	○	○
Wobbliness in legs (3)	○	○	○	○
Unable to Relax (4)	○	○	○	○
Fear of worst happening (5)	○	○	○	○
Dizzy or lightheaded (6)	○	○	○	○
Heart pounding/racing (7)	○	○	○	○
Unsteady (8)	○	○	○	○
Terrified or afraid (9)	○	○	○	○
Nervous (10)	○	○	○	○
Feeling of choking (11)	○	○	○	○
Hands trembling (12)	○	○	○	○
Shaky/unsteady (13)	○	○	○	○
Fear of losing control (14)	○	○	○	○
Difficulty in breathing (15)	○	○	○	○

Fear of dying (16)	○	○	○	○
Scared (17)	○	○	○	○
Indigestion (18)	○	○	○	○
Faint/lightheaded (19)	○	○	○	○
Face flushed (20)	○	○	○	○
Hot/cold sweats (21)	○	○	○	○

End of Block: anxiety

Start of Block: depression

Q43 Below is a list of ways you might have felt or behaved. Please indicate how often you have felt this way during the last week.

	Rarely or none of the time (less than 1 day) (1)	Some or a little of the time (1-2 days) (2)	Occasionally or a moderate amount of time (3-4 days) (3)	All of the time (5-7 days) (4)
I was bothered by things that usually don't bother me. (1)	○	○	○	○
I had trouble keeping my mind on what I was doing. (2)	○	○	○	○
I felt depressed. (3)	○	○	○	○
I felt that everything I did was an effort. (4)	○	○	○	○
I felt hopeful about the future. (5)	○	○	○	○
I felt fearful. (6)	○	○	○	○
My sleep was restless. (7)	○	○	○	○
I was happy. (8)	○	○	○	○
I felt lonely. (9)	○	○	○	○
I could not "get going." (10)	○	○	○	○

End of Block: depression

Start of Block: self-esteem

Q45 I have high self-esteem

- Strongly Agree (1)
- Agree (2)
- Neutral (3)
- Disagree (4)
- Strongly disagree (5)

End of Block: self-esteem

Start of Block: dysregulation

Q47 Below is a series of statements. Indicate how often they are true of you by choosing the option that best describes you.

	Never true (1)	Occasionally true (2)	Mostly true (3)	Always true (4)
I have difficulty remaining seated at school or at home during dinner. (1)	○	○	○	○
I get very fidgety after a few minutes if I am supposed to sit still. (2)	○	○	○	○
I have difficulty keeping attention on tasks. (3)	○	○	○	○
I get into arguments when people disagree with me. (4)	○	○	○	○
Little things or distractions throw me off. (5)	○	○	○	○
I can’t seem to stop moving. (6)	○	○	○	○
Most of the time I don't pay attention to what I am doing. (7)	○	○	○	○
I get bored easily. (8)	○	○	○	○
I am easily distracted. (9)	○	○	○	○
I spend money without thinking about it first. (10)	○	○	○	○

End of Block: dysregulation

Start of Block: dysregulation

Q49 Below is a series of statements. Indicate how often they are true of you by choosing the option that best describes you.

	Never true (1)	Occasionally true (2)	Mostly true (3)	Always true (4)
I develop a plan for all my important goals. (1)	○	○	○	○
I put my plans into action. (2)	○	○	○	○
I think about the future consequences of my actions. (3)	○	○	○	○
Once I have a goal I make a plan to reach it. (4)	○	○	○	○
As soon as I see things are not working, I do something about it. (5)	○	○	○	○
I consider what will happen before I make a plan. (6)	○	○	○	○
I think about my mistakes to make sure they don't happen again. (7)	○	○	○	○
I spend time thinking about how to reach my goals. (8)	○	○	○	○
Failure at a task or in school makes me work harder. (9)	○	○	○	○
I stick to a task until it is finished. (10)	○	○	○	○

End of Block: dysregulation

Start of Block: dysregulation

Q51 Below is a series of statements. Indicate how often they are true of you by choosing the option that best describes you.

	Never True (1)	Occasionally True (2)	Mostly True (3)	Always True (4)
I have trouble controlling my temper. (1)	○	○	○	○
I lose sleep because I worry. (2)	○	○	○	○
When I am angry I lose control over my actions. (3)	○	○	○	○
I get so frustrated that I often feel like a "bomb ready to explode." (4)	○	○	○	○
I "fly off the handle" for no good reason. (5)	○	○	○	○
There are days when I'm "on edge" all the time. (6)	○	○	○	○
I easily become emotionally upset when I am tired. (7)	○	○	○	○
Often I am afraid I will lose control of my feelings. (8)	○	○	○	○
I slam doors when I am mad. (9)	○	○	○	○
My mood goes up and down without reason. (10)	○	○	○	○

End of Block: dysregulation

Start of Block: stress

Q52 The questions in this scale ask you about your feelings and thoughts during the last week. In each case, you will be asked to indicate how often you felt or thought a certain way.

	Never (1)	Almost Never (2)	Sometimes (3)	Fairly Often (4)	Very Often (5)
How often have you been upset because of something that happened unexpectedly? (1)	○	○	○	○	○
How often have you felt that you were unable to control the important things in your life? (2)	○	○	○	○	○
How often have you felt nervous and “stressed”? (3)	○	○	○	○	○
How often have you felt confident about your ability to handle your personal problems? (4)	○	○	○	○	○
How often have you felt that things were going your way? (5)	○	○	○	○	○
How often have you found that you could not cope with all the things that you had to do? (6)	○	○	○	○	○
How often have you been able to control irritations in your life? (7)	○	○	○	○	○

How often have you felt that you were on top of things? (8)	○	○	○	○	○
How often have you been angered because of things that were outside of your control? (9)	○	○	○	○	○
How often have you felt difficulties were piling up so high that you could not overcome them? (10)	○	○	○	○	○

End of Block: stress

Start of Block: Health Related QOL

Q54 Would you say that in general your health is

- ○ Excellent (1)
- ○ Very good (2)
- ○ Good (3)
- ○ Fair (4)
- ○ Poor (5)
- ○ Don't know/Not sure (6)

Q56 Now thinking about your physical health, which includes physical illness and injury, for how many days during the past 30 days was your physical health not good?

0 3 6 9 12 15 18 21 24 27 30

Number of days ()	

Q58 Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?

0 3 6 9 12 15 18 21 24 27 30

Number of days ()	

Q60 During the past 30 days, for about how many days did poor physical or mental health keep you from doing your usual activities, such as self-care, work, or recreation?

0 3 6 9 12 15 18 21 24 27 30

Number of days ()	

Q62 Are you LIMITED in any way in any activities because of any impairment or health problem?

- ○ Yes (1)
- ○ No (2)
- ○ Don't know/Not sure (3)

Skip To: End of Block If Are you LIMITED in any way in any activities because of any impairment or health problem? = No

Q64 For HOW LONG have your activities been limited because of your major impairment or health problem?

- ○ Days (1)
- ○ Weeks (2)
- ○ Months (3)
- ○ Years (4)
- ○ Don't know/not sure (5)

Q66 Because of any impairment or health problem, do you need the help of other persons with your PERSONAL CARE needs, such as eating, bathing, dressing, or getting around the house?

- Yes (1)
- No (2)
- Don't know/not sure (3)

Q68 Because of any impairment or health problem, do you need the help of other persons in handling your ROUTINE needs, such as everyday household chores, doing necessary business, shopping, or getting around for other purposes?

- Yes (1)
- No (2)
- Don't know/not sure (3)

End of Block: Health Related QOL

Start of Block: weight related WOL

Q70 Over the last week, how true are the following statements:

	Never true (1)	Rarely true (2)	Occasionally true (3)	Often true (4)	Always true (5)
Because of my weight, I have trouble picking up objects. (1)	○	○	○	○	○
Because of my weight, I have trouble tying my shoes. (2)	○	○	○	○	○
Because of my weight, I have difficulty getting up from chairs. (3)	○	○	○	○	○
Because of my weight, I have trouble using stairs. (4)	○	○	○	○	○
Because of my weight, I have difficulty putting on or taking off my clothing. (5)	○	○	○	○	○
Because of my weight, I have trouble with mobility. (6)	○	○	○	○	○
Because of my weight, I have trouble crossing my legs. (7)	○	○	○	○	○
I feel short of breath with only mild exertion. (8)	○	○	○	○	○
I am troubled by painful or stiff joints. (9)	○	○	○	○	○

My ankles and lower legs are swollen at the end of the day. (10)	○	○	○	○	○
I am worried about my health. (11)	○	○	○	○	○

End of Block: weight related WOL

Start of Block: weight related QOL

Q72 Over the last week, how true are the following statements:

	Never true (1)	Rarely true (2)	Occasionally true (3)	Often true (4)	Always true (5)
Because of my weight, I am self-conscious. (1)	○	○	○	○	○
Because of my weight, my self-esteem is not what it could be. (2)	○	○	○	○	○
Because of my weight, I feel unsure of myself. (3)	○	○	○	○	○
Because of my weight, I don't like myself. (4)	○	○	○	○	○
Because of my weight, I am afraid of being rejected. (5)	○	○	○	○	○
Because of my weight, I avoid looking in mirrors or seeing myself in photographs. (6)	○	○	○	○	○
Because of my weight, I am embarrassed to be seen in public places. (7)	○	○	○	○	○
Because of my weight, I do not enjoy sexual activity. (8)	○	○	○	○	○

Because of my weight, I have little or no sexual desire. (9)	○	○	○	○	○
Because of my weight, I have difficulty with sexual performance. (10)	○	○	○	○	○
Because of my weight, I avoid sexual encounters whenever possible. (11)	○	○	○	○	○

End of Block: weight related QOL

Start of Block: Block 17

Q74 Over the last week, how true are the following statements:

	Never true (1)	Rarely true (2)	Occasionally true (3)	Usually true (4)	Always true (5)
Because of my weight, I worry about fitting into seats in public places (e.g., theaters, restaurants, cars, airplanes). (1)	○	○	○	○	○
Because of my weight, I worry about fitting through aisles or turnstiles. (2)	○	○	○	○	○
Because of my weight, I worry about finding chairs that are strong enough to hold my weight. (3)	○	○	○	○	○
Because of my weight, I experience ridicule, teasing, or unwanted attention. (4)	○	○	○	○	○
Because of my weight, I experience discrimination by others. (5)	○	○	○	○	○
Because of my weight, I have trouble getting things accomplished or meeting my responsibilities. (6)	○	○	○	○	○

Because of my weight, I am less productive than I could be. (7)	○	○	○	○	○
Because of my weight, I don't receive appropriate raises, promotions, or recognition at work. (8)	○	○	○	○	○
Because of my weight, I am afraid to go on job interviews (9)	○	○	○	○	○

End of Block: Block 17

Start of Block: body dissatisfaction

Q76 Over the past **FOUR WEEKS:**

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Very Often (5)	Always (6)
Has feeling bored made you worry or agonize about your shape? (1)	○	○	○	○	○	○
Have you thought that your thighs, hips or bottom are too large for the rest of you? (2)	○	○	○	○	○	○
Have you felt so bad about your shape that you have cried? (3)	○	○	○	○	○	○
Have you avoided running because your flesh might wobble? (4)	○	○	○	○	○	○
Has being with thin people made you feel self-conscious about your shape? (5)	○	○	○	○	○	○
Have you worried about your thighs spreading out when sitting down? (6)	○	○	○	○	○	○

Has eating sweets, cakes, or other high calorie food made you feel fat? (7)	○	○	○	○	○	○
Has worry about your shape made you feel you ought to exercise? (8)	○	○	○	○	○	○

End of Block: body dissatisfaction

Start of Block: physical activity

Q78 During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?

▼ 0 (1) ... 7 (8)

Q80 How much time did you usually spend doing vigorous physical activities on one of those days?

○ Hours per day (1) _____

○ Minutes per day (2) _____

Q82 During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

▼ 0 (1) ... 7 (8)

Q84 How much time did you usually spend doing moderate physical activities on one of those days?

○ Hours per day (1) _____

○ Minutes per day (2) _____

Q86 During the last 7 days, on how many days did you walk for at least 10 minutes at a time?

▼ 0 (1) ... 7 (8)

Q88 How much time did you usually spend walking on one of those days?

- Hours per day (1) _____
- Minutes per day (2) _____

Q90 During the last 7 days, how much time did you spend sitting on a week day?

- Hours per day (1) _____
- Minutes per day (2) _____

End of Block: physical activity