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CEREAL GRAIN BELLY? AN EXPLORATION OF HOW GRAIN SOURCE VERSUS PRODUCE SOURCE DIETARY FIBER IS ASSOCIATED WITH CARDIOMETABOLIC RISK

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ABSTRACT

Introduction

Obesity and its associated chronic diseases are persistent and growing problems in the United States. Dietary fiber can ameliorate risk through several physiological processes, though little research defines fiber types or sources that most efficiently control waistlines. Our investigation sought to understand whether higher ratios of grain fiber consumption frequency to produce fiber consumption frequency were associated with increased cardiometabolic risk, as measured by increased waist circumference.

Methods

We used the Dietary Screener Questionnaire and other relevant NHANES 2009-10 data sets to create a grain fiber source to produce fiber source ratio. Based on metabolic syndrome criteria, we generated a dichotomous outcome indicating cardiometabolic risk. We regressed this risk measure with the fiber source ratio and all relevant covariates.

Results

The ratio of grain to fruit and vegetable source frequency did not significantly alter odds of cardiometabolic risk when all covariates were controlled {OR=1.0513(0.953 - 1.161)}. Those of older age {OR=1.0377(1.0317 - 1.0437)} and higher sedentary activity {OR=1.0120(1.0072 - 1.0712)} had significantly greater odds of cardiometabolic risk when compared to those of lower age and sedentary activity. Males had significantly lower odds than did females {OR=0.3876(0.3291 - 0.4563)}; those identifying as other race had lower odds than did non-Hispanic whites {OR=0.5362(0.3686 - 7801)}; and college graduates had lower odds than did high school graduates {OR=0.5702(0.4515 - 0.7201)}.

Discussion

Significant differences between racial, ethnic, and income categories may be explained by health opportunities corresponding to low- and high-SES neighborhoods. The insignificant primary regression suggests that fiber source ratio has no influence on cardiometabolic risks, and invites further exploration of fiber source proportions in the diet.

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Chapter 1: Introduction

Adult obesity and disease risk

Overweight and obesity are growing concerns among U.S. adult populations. In 2012, United States obesity rates reached 37.2%, twice those observed in 1980 and three times those of 1950[1]. Data show overweight and obesity increasing across most adult groups, with some populations disproportionately affected. Non-Hispanic blacks (47.8%) and Hispanics (42.5%) in the US have particularly high prevalence of obesity[2], as do adults aged 40 to 64 (39.5%) compared those aged 20 to 29 (30.4%)[1].

Obesity is cause for concern because of its association with various health conditions. Those classified as overweight or obese are at increased risk for heart disease, high blood pressure, unfavorable blood lipid distributions, certain cancers, arthritis, respiratory conditions, psychosocial conditions, and type 2 diabetes[3]. These chronic ailments can result in low quality of life[4], loss in productivity[5], and substantial healthcare costs for both the individual and the community[6].

Waist circumference as an indicator of risk

Not all obesity is related to significant health risks. In fact, most obesity-related conditions are strongly associated with “android” obesity, in which excess fat accumulates in and around metabolically vital organs (such as the liver and pancreas)[7]. Its accumulation is thought to impede organ function and increase potential for metabolic disorders, such as diabetes and cardiovascular disease[8]. Where android obesity is characterized by harmful fat distribution in

visceral areas, “gynoid” obesity involves fat distribution around the hips, buttocks, and thighs. Gynoid obesity does not impact the vital organs and has not been found to increase disease risk[7].

The commonly used body mass index (BMI; calculated as kg/m^2) measure does not distinguish between android and gynoid obesity. Due to this lack of distinction, many doubt the usefulness of BMI in determining health risks[9], and support the use of other body measures which account for harmful fat distribution. One simple and telling measure is waist circumference. A high measure of waist circumference can indicate fat deposition around the vital organs and distinguish an individual’s risk for metabolic diseases[9].

The American Journal of Clinical Nutrition has defined waist circumference cutoff points that predict risk for obesity, metabolic syndrome, and cardiovascular problems. These “cardiometabolic risk” points are 35 inches for women and 40 inches for men[10].

Fiber and weight

BMI, waist circumference, and disease risk are strongly associated with diet, and especially with certain dietary components such as fiber[11]. Fiber is the non-digestible carbohydrate complex found naturally in plants, or extracted and added to other foods, that produces beneficial effects in the human body. While present in nearly all plant-derived foods, fiber is particularly abundant in fruits, vegetables, grains (such as wheat, rye, and oats), and legumes (such as edible seeds, beans, and nuts)[12]. Fiber is minimally present in animal products (such as milk, eggs, and meat).

Fiber’s beneficial effects in the body are diverse and far-reaching. Fiber can lower blood cholesterol by trapping dietary cholesterol before its intestinal absorption[13]. Fiber intake slows intestinal rates of sugar absorption and has been identified as protective against high blood sugar

and the development of type 2 diabetes mellitus[14]. Within the digestive tract, fiber can retain water and increase fecal bulk to prevent constipation. Dietary fiber has many benefits in addition to those listed, though its influence on BMI and waist circumference is among the most studied.

The positive relationship between fiber intake and a healthy BMI is well documented. One Canadian cross-sectional study compared the diets of individuals categorized as lean (BMI<27), moderately obese (BMI between 27 and 40), and severely obese (BMI>40). After adjusting for gender, age, income levels, and education, the study indicated significantly higher fiber intake in the lean individuals than in each of the other groups[15]. Many case-control studies have confirmed this positive relationship. A review of 22 studies comparing high-fiber treatment diets with low-fiber control diets noted that 20 resulted in net weight loss for the treatment group[17].

Fiber and waist circumference have been loosely linked in a number of studies. The American Journal of Clinical Nutrition found in a study of dietary patterns that individuals consuming high-fiber diets rich with fruit, vegetables, and whole grains had low gains in waist circumference compared with groups eating diets lower in fiber[11]. Another study of European Prospective Investigation into Cancer and Nutrition (EPIC) data concluded that low visceral adiposity was recorded most frequently in participants consuming diets high in fiber[18].

The Academy of Nutrition and Dietetics (formerly known as the American Dietetic Association) has long recognized the weight moderating effects of fiber and has set adequate intake recommendations at 25 grams per day for women and 38 grams per day for men[19]. (The higher recommendation for men accounts for greater caloric intake for larger frames and body mass.)

Physiological mechanisms of fiber weight moderation

Fiber can help individuals maintain healthy body weights in a number of ways. The first is *early satiety induction*[20]. In early satiety induction, non-digestible dietary fibers fill the stomach without contributing caloric value to the meal. The stomach sends volume-based fullness signals to the brain "satiety center" regardless of a meal's caloric content[21]. An individual may feel full and stop eating, possibly before consuming excess energy, if satiated early with a fiber-rich meal. Over time, low caloric density at satiation can prevent weight gain.

Early satiation through stomach distension is a straightforward effect of dietary fiber, and researchers are now exploring more complicated fiber interactions that moderate weight. One such interaction is *bacterial modification*. Bacterial modification involves fiber acting as a food source for colonic bacteria, whose activity may in turn influence satiety and energy harvest[22]. After a meal, dietary fiber travels through the digestive tract until reaching bacterial colonies of the large intestine. There, hundreds of species of gut bacteria ferment the fibers in a process thought to enhance secretion of colon satiety signals[23]. Eating high-fiber foods can help these beneficial bacteria proliferate, and in turn allow for increased fullness signaling. In a more roundabout process than simple satiety induction, bacterial modification also facilitates cessation of meals.

While underdeveloped, comparison of gut bacteria in healthy versus obese individuals is an intriguing point in the fiber-weight relationship. Multiple studies have found gut bacteria differences between populations of healthy body weight and obese or overweight populations. Obese individuals are likely to host bacteria with high energy harvesting capacity and poor fiber fermentation capacity[24], meaning that their species have both limited ability to consume fiber and

enhanced ability to increase net calories from food. While more research is necessary to fully understand weight as a bacterial indicator, fiber clearly relates to bacterial populations and their energy balance influence.

Association of fiber and diet patterns

Where fiber exerts many minute weight-moderating processes, it may also reduce weight gain through its broader association with "whole" foods. Fiber content is typically greater in whole foods, such as fruit and oats, than in their processed counterparts, such as fruit juice and breakfast cereals[25]. Whole foods also happen to have higher concentrations of essential vitamins and minerals, and lower concentration of caloric additives such as tropical oils and corn syrup, than do processed foods. Fiber may be protective against weight gain simply because of its association with healthful foods.

In a step beyond individual whole foods, fiber may influences weight as part of a healthful dietary pattern. The American Journal of Clinical Nutrition identifies dietary patterns high in fiber, such as the Mediterranean Diet, as protective against weight gain, and several low-fiber patterns, such as the Western diet, as risk factors for weight gain[26]. Studies of dietary pattern show that fiber exerts its diverse and multifaceted effects when combined with other foods in typical lifestyles.

Types of fiber

Just as the mechanisms for fiber's weight moderation are numerous, so, too, are the types and activities of the fiber itself. The properties of fiber are highly variable with respect to solubility,

viscosity, fermentability, and chemical stability. These varied properties influence fibers' reactivity in the digestive tract and subsequent effects on hormones, satiety, and bacterial populations[27]. Insoluble and non-fermentable fiber found in foods such as wheat bran would differ in physiological effect from the soluble and fermentable fiber found in oats and legumes, and so on. One logical question in the complexities of fiber type is: which types of fiber are most effective in maintaining weight?

So far, studies have not been able to identify specific fiber types that consistently outperform others. One study reviewed 44 fiber dose treatments and their effects on immediate human satiety. The review concluded that 61% of the fiber treatments did not significantly increase satiety; the 39% of treatments that did increase satiety varied greatly in their fermentability, solubility, and other properties, leaving researchers puzzled as to whether or not physical properties were influencing fullness[12]. Another study clinically tested the hormonal satiety responses of rats fed a number of distinct fibers. Rats fed highly viscous, insoluble fibers had higher levels of satiety hormones than those fed other fiber types[28]. However, significant response variation occurred with certain fiber pairings (viscous and insoluble versus viscous and soluble) and also with varied states of feeding or fasting. Each of these studies, though conclusive in some ways, highlights questions left to answer in fiber and weight moderation.

(It is important to note that, while the relationship between fiber type and weight is unclear, the relationship between fiber solubility and *other physiological benefits* is clear. Soluble fibers, found mostly in grains, legumes, and the insides of fruit, are known for their ability to "soak up" cholesterol, other lipids, and glucose during gastrointestinal transit, reducing blood cholesterol and blood glucose[19]. Insoluble fibers, found mostly in vegetables, wheat bran, and the skin of fruits are known for their laxative properties.)

Many researchers have speculated that because soluble fibers interfere with sugar and lipid absorption, soluble fiber sources would have a greater impact on weight management than insoluble fibers. Some studies, though, have found the opposite to be true. One long-term investigation that added either soluble or insoluble fiber to the diets of obesity-prone mice showed that mice eating extra soluble fiber actually gained more weight than those eating insoluble fiber[29]. The research team deduced that soluble fiber, though beneficial in sugar and cholesterol management, also increases bacterial energy harvest. For the mice in this study, increased colonic digestion of soluble fibers resulted in weight gain.

In humans, investigations into the effect of soluble and insoluble fiber on weight have not yielded pronounced results. A study of humans who consumed 0.6 gram of either soluble or insoluble fiber supplements for a period of three weeks failed to produce significant differences in energy intake, weight gain, or fat percentages[30]. Neither soluble nor insoluble fiber was shown in this study to influence weight more than the other.

While many benefits of fiber can be attributed to certain fiber types, weight loss and maintenance have puzzling relationships with fibers and their various properties. All fiber types, no matter their sources or types, are of great interest to individual and population health.

Grain fiber in popular literature

A final factor clouds our understanding of fiber type and its influence on body weight. Where research illuminates the complicated relationship between fiber and weight in the academic community, popular literature oversimplifies and dramatizes this relationship. Many popular works have pointed fingers particularly at wheat and other grains as nutritional culprits for

obesity and cardiometabolic risk. *Wheat Belly*, a *New York Times* #1 bestseller in 2012, criticizes wheat and cereal grains as principle fiber source contributors to weight and cardiometabolic problems at the individual and population level[31]. Though many laud the book as a groundbreaking piece that could initiate worldwide nutritional modifications, others note that its essential claims lack conclusive scientific support. In an analysis of *Wheat Belly* released by the American Association for Cereal Chemists, writer Julie Jones notes that some of the book's claims are consistent with scientific research, while others take advantage of conflicting conclusions in fiber source studies or jump to unsupported conclusions where little research exists[32]. As scientific literature illuminates the breadth of research potential in this field, other literature incorrectly summarizes it with unsubstantial generalizations.

Wheat Belly and its weakly verified claims are symbolic of general confusion in the fiber-weight relationship. Refining scientific understanding of fiber source weight moderation will allow medical professionals and the food industry to better recommend healthful diets for weight loss or maintenance. Specifically refining the understanding of grain source fiber versus produce source fiber will prevent further exploitation of inconclusive research.

The purpose of this study is to determine if, at a population level, eating a higher ratio of grain fiber sources to fruit and vegetable fiber sources has an influence on waist circumference and cardiometabolic risk. To our knowledge, no published research has used national data to determine how fiber intake from grain sources versus produce sources is associated with body fat. The study uses a cross-sectional comparison of predominant dietary fiber source and waist circumference.

Chapter 2: Methods

Data

For this investigation, we combined six National Health and Nutrition Examination Survey (NHANES) 2009-10 data sets. The sets, titled “Demographic Variables,” “Dietary Screener Questionnaire,” “Total Nutrient Intakes,” “Body Measures,” “Physical Activity,” and “Income” include complete health and demographic data from 5,000 Americans up to the age of 80[33]. NHANES survey participants are selected to represent the general American population.

Selection and exclusion criteria

Adult participants aged 18 and 69 year were included in the analysis. Those aged 70 to 80 (n = 1052) were not sampled in the Dietary Screener Questionnaire, and could not be assessed. Pregnant and breastfeeding women (n = 68), whose waist circumferences were not representative of their health status[34], were excluded. We removed those eating fewer than 1000 or greater than 5000 calories in the recorded day (n=1834)[35], as well as other nutritional outliers whose intakes of protein (n = 4), fat (n = 23), or fiber (n = 49) were less or greater than three times the interquartile range between the first and third quartiles, respectively[36]. A total of 3,492 participants met all criteria and fell within normal nutrient intake ranges.

Waist circumference measurements

NHANES technicians measured waist circumference, the outcome of interest, by fitting a tape measure across each respondent's trunk just above the ilium bones and across the back[37]. Waist circumference measures were reported to the nearest tenth of a centimeter[38].

We converted this measure to inches for ease of analysis, then generated a dichotomous measure of cardiometabolic waist circumference risk. We assigned risk status to females with waist circumferences measuring 35 inches or more and to males with waist circumferences measuring 40 inches or more[10].

Exposure variables

Our central independent variable was the ratio of fiber-rich grain consumption frequency to fiber-rich fruit and vegetable consumption frequency. We developed this variable first by identifying which of the 25 food items included in the NHANES Dietary Screener Questionnaire were also included in the AND's fiber-rich food recommendation list[19]. Ten foods were represented in both the questionnaire and the AND list (see Appendix A).

The dietary screener questionnaire, conducted in phone interviews by trained NHANES examiners, provided each participant's self-reported daily, weekly, and monthly consumption of foods or food types. This questionnaire type assesses typical eating patterns without identifying quantities consumed. Tests have shown that frequency questionnaires are valid and reproducible assessments of individual nutrient intakes[39]. Because we were concerned with predominant dietary fiber sources, and not absolute amounts of fiber consumed, the data were appropriate.

The 10 foods which fit the requirements were categorized as either *grain sources of fiber* or *fruit and vegetable sources of fiber* (two phrases henceforth shortened to "grain source" and "fruit and vegetable source" or "produce source"). In the grain source category were: hot or cold cereal, whole grain bread, cooked whole grains, and popcorn. In the fruit and vegetable source category were: fruit, leafy greens, fried potatoes, non-fried potatoes, beans, and other vegetables.

We summed each participant's grain source frequency per month and produce source frequency per month, then created a ratio variable of grain source frequencies to produce source frequencies. As an example: if a respondent reported eating cereal 10 times, whole grain bread 20 times, cooked whole grains 5 times, and popcorn 5 times in one month for a grain source sum of 40; and reported eating fruit 25 times, salad greens 15 times, and potatoes 20 times in one month for a produce source total of 60; then his ratio would be 40 / 60, or 0.667.

Covariates

We identified several secondary variables that might affect the primary relationship between fiber source ratio and waist circumference. Our model included caloric intake, as high calorie diets can facilitate proportionally high intake of fiber while also raising waist circumference. We included BMI for the same reason, as high BMI can also allow for a high-calorie and proportionally high-fiber maintenance diet. Sedentary lifestyle can induce high waist circumference independent of fiber intake[40]. Body fat varies with hormones, mobility, and comfort in advancing age[41]. We controlled for caloric intake, BMI, minutes of sedentary activity per day, and age as continuous covariates.

Higher levels of education and income are associated with lower body fat, and vice-a-versa[42, 43]. Variable waist circumferences have also been found across racial groups[44] and gender[45], with men typically presenting higher waist circumference than women but women presenting higher overall body fat than men. We controlled for the categorical variables of education (less than 9th grade, 9th-11th grade, high school grad/GED or equivalent, some college or AA degree, college graduate or above; reference group = high school grad/GED or equivalent), income (monthly poverty level index <= 1.30, 1.30 < monthly poverty level index <= 1.85, monthly poverty level index >1.85; referent group = monthly poverty level index >1.85), race/ethnicity (Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, other race— including biracial and Asian; reference group = non-Hispanic white), and gender (referent group = female).

Data analyses

We used STATA version 12.0 (College Station, TX) to analyze the NHANES data. We first defined the medians of the grain source to fruit and vegetable source ratio. This median allowed us to create dichotomous variables categorizing study participants as either above or below the sample fiftieth percentile. In independent t-tests, we studied whether covariate influences on the dichotomous outcome differed significantly from zero (see Appendix B for code). After weighting data with NHANES design variables from the Dietary Screener Questionnaire, we ran a logistic regression including the continuous fiber source ratio and all covariates.

Research Role

I personally defined this investigation's research question and design. I selected and acquired NHANES data sets, which were publicly available through the Center for Disease Control and Prevention prior to the study initiation. Under the guidance of Health Policy and Administration faculty and PhD candidates, I edited my question and wrote all STATA code. I led decision-making in all phases of this project, including the running and interpretation of statistical analyses.

Chapter 3: Results

Sample Characteristics

Participant characteristics by mean ratios of grain to produce source frequencies are summarized in Table 1. The median ratio of grain source to fruit and vegetable source frequency across the sample was 0.5436, and significant differences existed across subpopulations. Males, non-Hispanic whites, non-Hispanic blacks, and those living above 130% of the federal poverty level fell, on average, above the median ratio. In other words, members of these groups were more likely than members of others to have higher ratios of grain fiber sources to fruit and vegetable fiber sources. Females, Mexicans, other Hispanics, other races, those living within 130% of the federal poverty level, and those who attained at least a high school graduation or equivalent fell below the median ratio. That is, their consumption ratios of grain fiber source to produce fiber source were lower than the total sample midpoint.

Cardiometabolic risk outcomes

Our logistic regression model results are summarized in Table 2. The primary exposure variable, ratio of grain to produce source frequency, had no significant association with cardiometabolic risk, all covariates controlled {OR=1.0513(0.953 - 1.161)}.

Other continuous variables significantly affected outcome odds. For every one year increase in age, sample respondents were 4% more likely to fall into the high-risk category {OR=1.0377(1.0317 - 1.0437)}. Odds for high-risk categorization also increased by 1% for every additional self-reported hour spent in daily sedentary activity {OR=1.0120(1.0072 - 1.0712)}.

Males were, on average, 61% less likely to fall into the high-risk category than sampled females {OR=0.3876(0.3291 - 0.4563)}. Those categorized as other race were 46% less likely to fall into the high-risk category than the white reference group {OR=0.5362(0.3686 - 7801)}. Sample respondents who had graduated from college were 43% less likely than the referent high school graduate group to be categorized as high-risk {OR=0.5702(0.4515 - 0.7201)}.

We found insignificant odds ratio differences based on caloric intake; Mexican, other Latino, and non-Hispanic black racial ethnic categorization (referent group = non-Hispanic white); educational attainment below high school graduation (referent group = high school graduates); and income less than 130% of the federal poverty level or above 185% of the federal poverty level (referent group = 130-185% of federal poverty level).

Table 1: Ratio of Grains Consumption to Fruit and Vegetable Consumption by Demographic Group in NHANES 2009-10

		Mean Ratio of Grain Fiber Source to Fruit and Vegetables Fiber Source Frequency	% Below Median Ratio	% Above Median Ratio	P-value
All		0.5436	50%	50%	
Gender					0.0480*
	Female	0.4992	50.46	47.61	
	Male	0.5862	48.59	51.41	
Race					0.000***
	Mexican	0.4658	56.98	43.02	
	Other Hispanic	0.5912	55.45	45.55	
	White	0.5062	47.95	52.05	
	Non-Hispanic black	0.7259	42.54	57.46	
	Other, including biracial	0.4506	56.55	43.46	
Educational attainment					0.0020**
	Less than 9th grade	0.4465	60.75	39.25	
	9th-11th grade	0.6508	52.14	47.86	
	High school/GED/equivalent	0.5684	49.93	50.07	
	Some college/AA degree	0.5247	48.06	51.94	
	College graduate or above	0.4729	49.21	50.79	
Income					0.0365*
	Monthly poverty level index <= 1.30	0.6233	50.87	49.13	
	1.30 < Monthly poverty level index <= 1.85	0.5009	47.58	52.42	
	Monthly poverty level index >= 1.85	0.4989	49.72	50.28	

Source: NHANES 2009-10 Demographic Data, Physical Activity Data, Income Data, Dietary Screener Questionnaire Data, and Total Nutrient Intakes Data

** $p < 0.05$, significant values different from reference categories for all explanatory variables in the model*

*** $p < 0.01$, significant values different from reference categories for all explanatory variables in the model*

**** $p < 0.001$, significant values different from reference categories for all explanatory variables in the model*

Table 2. Logistic Regression Model: Cardiometabolic Risk Moderators, Measured by Waist Circumference, in NHANES 2009-10

Variable		Odds Ratio	Standard Error	Confidence Interval	P-value
Continuous					
	Grain source to fruit and vegetable source ratio	1.0513	0.0527	0.9529 - 1.1610	0.3180
	Age	1.0377	0.0031	1.0317 - 1.0437	0.000***
	Caloric intake per day	1.0000	0.0001	0.0001 - 0.0002	0.2840
	Hours sedentary per day	1.0120	0.0025	1.0072 - 1.0172	0.000***
Gender					
	Female	Reference group	-	-	-
	Male	0.3876	0.0323	0.3291 - 0.4563	0.000***
Race/Ethnicity					
	Mexican	1.1602	0.1439	0.9100 - 1.4794	0.2310
	Other Latino	0.8606	0.1174	0.6586 - 1.1245	0.2710
	White	Reference group	-	-	-
	Black	1.1936	0.1336	0.9585 - 1.4864	0.1140
	Other race, including biracial	0.5362	0.1026	0.3686 - 0.7801	0.001**
Education					
	Less than 9th grade education	1.0330	0.1732	0.7436 - 1.4350	0.8460
	9th-11th grade education	1.0644	0.1433	0.8175 - 1.3857	0.6430
	High school/GED/equivalent	Reference group	-	-	-
	Some college/AA degree	1.0524	0.1138	0.8514 - 1.3009	0.6360
	College graduate or above	0.5702	0.0679	0.4515 - 0.7201	0.000***
Income					
	Monthly poverty level index <= 1.30	1.1523	0.1411	0.9065 - 1.4647	0.2470
	1.30 < Monthly poverty level index <= 1.85	Reference group	-	-	-
	Monthly poverty level index >= 1.85	0.9582	0.1156	0.7563 - 1.2139	0.7230

Source: NHANES 2009-10 Demographic Data, Physical Activity Data, Income Data, Dietary Screener Questionnaire Data, and Total Nutrient Intakes Data

** p < 0.05, significant values different from reference categories for all explanatory variables in the model*

*** p < 0.01, significant values different from reference categories for all explanatory variables in the model*

**** p < 0.001, significant values different from reference categories for all explanatory variables in the model*

Chapter 4: Discussion

Significant findings

Significance tests revealed lower ratios of grain to produce source fiber consumption in females ($p<0.05$), Mexicans ($p<0.001$), other Hispanics ($p<0.001$), and other races ($p<0.001$; referent group = non-Hispanic white). A central explanation for these lower ratios could be ethnic dietary tendency to emphasize low-fiber grains, including white rice, tortillas, and baked goods, before high-fiber grains. Literature supports the claim that many Asian and Latino groups, and particularly females in these groups, consume higher percentages of daily calories from refined grain sources than do white and black groups[46].

Significant ethnic differences may intersect with significant differences for those living within 130% of the federal poverty level (referent group = 130% to 185% of federal poverty level). This group's low relative ratio of grain source to produce source may relate to its high proportion of ethnic minorities[47]. Ethnic dietary tendencies, detailed above, combined with limited healthful grain options in low SES neighborhoods, may have caused low ratios of grain source to produce source consumption[48].

Where low SES contributed to low ratios in some groups, high SES produced similarly low ratios in other groups. The high school graduate group's low relative ratios can probably be attributed to superior produce access and consumption in their high-SES neighborhoods[49]. Unlike low-SES groups, for whom low ratios were driven by low grain source intake, this group's low ratios were likely driven by high produce intake.

Results of the regression analysis suggest that ratios of grain source to produce source consumption have an insignificant effect on cardiometabolic risk as measured by waist

circumference, all covariates controlled. Increased odds of cardiometabolic risk did occur through other continuous moderators, including increased age and increased sedentary activity. These results are likely interrelated: energy needs and physical activity typically decline with age, causing waist circumference gains[11]. Significantly increased odds of cardiometabolic risk with older age and greater sedentary hours were probably linked.

Our regression yielded many significant differences in waist circumference between categorical groups. Lower odds of cardiometabolic risk among males compared with females were consistent with some studies of Japanese[50], Caucasian, and black populations[51], which found both higher measures of waist circumference and higher prevalence of metabolic disorders such as diabetes in females than in males. Lower odds for those categorized as other race (referent group = non-Hispanic whites) likely relate to the high prevalence of Asian ethnicities in this category. On average, Asians have lower weight and waist circumference than do non-Hispanic whites, because of genetic and environmental differences[52,53]. Their reduced odds of meeting risk thresholds were consistent with studies of race- and ethnicity-linked body measures[53].

Sample respondents who had completed college had significantly lower odds of risk than did referent group respondents (referent group = high school graduate or equivalent). This finding is consistent with some pure studies of educational attainment and waist circumference[54]. Many studies attribute lower risk in high SES groups to healthy environmental influences, especially neighborhood features promoting nutritional choice, physical activity, and social and healthcare support.

Limitations

Readers should note that the available NHANES data sets, and particularly the NHANES Dietary Screener Questionnaire, did not allow us to understand specific fiber sources and their amounts in sample diets. While the validity and reproducibility in this data collection method are confirmed[36,39], the data format prevented us from quantifying fiber content and potentially noting thresholds and cutoff points related to cardiometabolic risk.

Other accessed NHANES sets limited our research in some ways. The Physical Activity set did not include a variable quantifying physical activity for adults. By instead using a variable of daily sedentary time, our results followed a trend in research but will be less easily compared with similar studies.

The race and ethnicity variable did not include codes to identify Asian nationality or other sub-groups within race categories which may have shown differences. This lack of specificity prevents us from comparing our race variable results to some other research.

Finally, the cross sectional, retrospective nature of this investigation prevented us from discerning causality between fiber source and waist circumference.

Strengths

Despite study limitations, this analysis is among the first to create a ratio of fiber source frequency and investigate its influence on cardiometabolic risk. In the context of popular debate about fiber source health, the investigation's nationally representative analysis does not find evidence to support the *Wheat Belly* claim that wheat and other grain fiber sources create cardiometabolic risk. Questioning claims such as those antagonizing grains is a vital step in the

pursuit of accurate and useful dietary information. This analysis can supplement critical reviews[32] and other fiber investigations[12] to demonstrate a need for further fiber source research.

This analysis' statistically significant findings in multiple directions illuminate the topic's complexity, introducing environmental, educational, cultural, and life course considerations into questions of fiber source influence. The results challenge trendy nutrition with the support of a broad sample and results generalizable across American populations.

Future Research

As speculation continues around fiber source influence on health risks, our research supports further exploration of fiber source pairings and proportions in the diet. Our investigation used a representative sample and aggregated fiber sources of no defined quality; future studies should seek to narrow populations, and also to define and narrow fiber sources while including assessments of environmental influence and SES.

Appendix A: Dietary Screener Questionnaire Questions

The following questions and variable labels were used to assess frequency of fiber-rich grain consumption:

- DTD010Q - How often eat cold or hot cereal?
- DTD200Q - How often eat whole grain bread?
- DTD210Q - How often eat cooked whole grains?
- DTD260Q - How often eat popcorn?

The following questions and variable labels were used to assess frequency of fiber-rich fruit and vegetable consumption:

- DTD080Q - How often eat fruit?
- DTD090Q - How often eat leafy/lettuce salad?
- DTD100Q - How often eat fried potatoes?
- DTD110Q - How often eat non-fried potatoes?
- DTD120Q - How often eat beans?
- DTD130Q - How often eat other vegetables?

Appendix B: STATA Code

```
use "Z:\EBoretz\Stata files\Complete3.DTA", clear

*Keeping necessary variables
keep seqn indfmmpc RIDRETH1 DMDEDUC2 ridageyr riagendr PAD680 bmxbmi bmxwaist ridexprg sdmvpsu
sdmvstra DR2TKCAL DR2TPROT DR2TTFAT DR2TCARB DR2TFIBE WTMEC2YR DR2DRSTZ  DR2_300 DTD010Q DTQ010U
DTD080Q DTQ080U DTD090Q DTQ090U DTD100Q DTQ100U DTD110Q DTQ110U DTD120Q DTQ120U DTD130Q DTQ130U
DTD200Q DTQ200U DTD210Q DTQ210U DTD260Q DTQ260U
*kept: BMI, waist circumference, weights, kcal, protein, fat, carb, fiber, weight, questionnaire
vars, age, gender, ethnicity, education, pregnancy, sedentary minutes, income level
*_____________________________________________________________________________

**SAMPLING FRAME**

*Keeping only adults.
keep if ridageyr>=18
*Only adults age 69 and younger were included in the dietary frequency questionnaire.

*Keeping non-pregnant adults.
keep if ridexprg>=2

*Labeling gender variable
label define male 1 "male" 2 "female"
label values riagendr male

*Keeping normal caloric intake.
keep if DR2TKCAL>=1000
keep if DR2TKCAL<=5000

*Dropping missing values from physical activity and poverty level variables.
replace PAD680=. if PAD680==9999
replace indfmmpc=. if indfmmpc==7
replace indfmmpc=. if indfmmpc==9

*Replacing missing values in FFQ participants who answered "none" for first question. These
answers were missing by design because they were not applicable. Skip pattern.
replace DTQ010U=0 if DTD010Q==0 & DTQ010U==.
**Repeat for each questionnaire variable.
replace DTQ080U=0 if DTD080Q==0 & DTQ080U==.
replace DTQ090U=0 if DTD090Q==0 & DTQ090U==.
replace DTQ100U=0 if DTD100Q==0 & DTQ100U==.
replace DTQ110U=0 if DTD110Q==0 & DTQ110U==.
replace DTQ120U=0 if DTD120Q==0 & DTQ120U==.
replace DTQ130U=0 if DTD130Q==0 & DTQ130U==.
replace DTQ200U=0 if DTD200Q==0 & DTQ200U==.
replace DTQ210U=0 if DTD210Q==0 & DTQ210U==.
replace DTQ260U=0 if DTD260Q==0 & DTQ260U==.

*Looking at percent missing for each variable
mdesc
*22.75% of sample did not answer any FFQ questions. Dropping them.
drop if DTD010Q==. & DTQ010U==. & DTD080Q==. & DTQ080U==. & DTD090Q==. & DTQ090U==. & DTD100Q==.
& DTQ100U==. & DTD110Q==. & DTQ110U==. & DTD120Q==. & DTQ120U==. & DTD130Q==. & DTQ130U==. &
DTD200Q==. & DTQ200U==. & DTD210Q==. & DTQ210U==. & DTD260Q==. & DTQ260U==.
*1052 were deleted. Checking missing again.
mdesc
*Less than 0.12% missing for all FFQ variables now.

*Dropping missing from DTQ.
drop if DTD010Q==.
drop if DTQ010U==.
drop if DTD080Q==.
drop if DTQ080U==.
drop if DTD090Q==.
drop if DTQ090U==.
```

```
drop if DTD100Q==.
drop if DTQ100U==.
drop if DTD110Q==.
drop if DTQ110U==.
drop if DTD120Q==.
drop if DTQ120U==.
drop if DTD130Q==.
drop if DTQ130U==.
drop if DTD200Q==.
drop if DTQ200U==.
drop if DTD210Q==.
drop if DTQ210U==.
drop if DTD260Q==.
drop if DTQ260U==.

*Excluding outliers less or greater than three times the IQR between the Q1 & Q3 for CHO, PRO,
fat, and fiber.
*Starting with carbs
summarize DR2TCARB, detail
drop if DR2TCARB<61.71
drop if DR2TCARB>976.59
*no outliers for carbs
*Summarizing protein
summarize DR2TPROT, detail
drop if DR2TPROT<19.148
drop if DR2TPROT>315.015
*Summarizing fat
summarize DR2TTFAT, detail
drop if DR2TTFAT<16.517
drop if DR2TTFAT>296.16
*Summarizing fiber
summarize DR2TFIBE, detail
drop if DR2TFIBE<3.53
drop if DR2TFIBE>66.6

*_____________________________________________________________________________

*GENERATING USABLE VARIABLES
*Generating frequency variables that represent number of times per month each FFQ item is
consumed.
*Fiber grain sources are: cereal, bread, cooked grains, popcorn
*Fiber fruit and veg sources: fruit, leafy greens, fried/non-fried potatoes, other veg

**Grain fiber sources: cereal, bread, cooked grains, popcorn
*Hot or cold cereal:
gen DTQ010Unew = .
replace DTQ010Unew=30 if (DTQ010U<=1)
replace DTQ010Unew=4.29 if (DTQ010U==2)
replace DTQ010Unew=1 if (DTQ010U==3)

*Whole-grain bread:
gen DTQ200Unew = .
replace DTQ200Unew=30 if (DTQ200U<=1)
replace DTQ200Unew=4.29 if (DTQ200U==2)
replace DTQ200Unew=1 if (DTQ200U==3)

*Cooked whole grains:
gen DTQ210Unew = .
replace DTQ210Unew=30 if (DTQ210U<=1)
replace DTQ210Unew=4.29 if (DTQ210U==2)
replace DTQ210Unew=1 if (DTQ210U==3)

*Popcorn:
gen DTQ260Unew = .
replace DTQ260Unew=30 if (DTQ260U<=1)
replace DTQ260Unew=4.29 if (DTQ260U==2)
replace DTQ260Unew=1 if (DTQ260U==3)
```

```
*Fruit and veg sources: fruit, leafy greens, fried/non-fried potatoes, other veg
*Fruit:
gen DTQ080Unew = .
replace DTQ080Unew=30 if (DTQ080U<=1)
replace DTQ080Unew=4.29 if (DTQ080U==2)
replace DTQ080Unew=1 if (DTQ080U==3)

*Leafy/lettuce salad:
gen DTQ090Unew = .
replace DTQ090Unew=30 if (DTQ090U<=1)
replace DTQ090Unew=4.29 if (DTQ090U==2)
replace DTQ090Unew=1 if (DTQ090U==3)

*Fried potatoes:
gen DTQ100Unew = .
replace DTQ100Unew=30 if (DTQ100U<=1)
replace DTQ100Unew=4.29 if (DTQ100U==2)
replace DTQ100Unew=1 if (DTQ100U==3)

*Non-fried potatoes:
gen DTQ110Unew = .
replace DTQ110Unew=30 if (DTQ110U<=1)
replace DTQ110Unew=4.29 if (DTQ110U==2)
replace DTQ110Unew=1 if (DTQ110U==3)

*Beans:
gen DTQ120Unew = .
replace DTQ120Unew=30 if (DTQ120U<=1)
replace DTQ120Unew=4.29 if (DTQ120U==2)
replace DTQ120Unew=1 if (DTQ120U==3)

*Other vegetables:
gen DTQ130Unew = .
replace DTQ130Unew=30 if (DTQ130U<=1)
replace DTQ130Unew=4.29 if (DTQ130U==2)
replace DTQ130Unew=1 if (DTQ130U==3)

*Coding missing values in FFQ questions.
replace DTD010Q = . if DTD010>=777
replace DTD080Q = . if DTD080>=777
replace DTD090Q = . if DTD090>=777
replace DTD100Q = . if DTD100>=777
replace DTD110Q = . if DTD110>=777
replace DTD120Q = . if DTD120>=777
replace DTD130Q = . if DTD130>=777
replace DTD200Q = . if DTD200>=777
replace DTD210Q = . if DTD210>=777
replace DTD260Q = . if DTD260>=777

*Generating variables that represent # times eat item per month
gen DTQcereal = .
replace DTQcereal = (DTQ010Unew*DTD010Q)
label variable DTQcereal "How many times per month eat hot or cold cereal? "

gen DTQfruit = .
replace DTQfruit = (DTQ080Unew*DTD080Q)
label variable DTQfruit "How many times per month eat fruit? "

gen DTQleaves = .
replace DTQleaves = (DTQ090Unew*DTD090Q)
label variable DTQleaves "How many times per month eat leafy/lettuce salad? "

gen DTQfries = .
replace DTQfries = (DTQ100Unew*DTD100Q)
```

```
*Potatoes are a major source of fiber, but I worry that fried potatoes will mess things up as
disproportionate caloric contibutors to weight? Should I make one fruit&veg variable with and one
without?
label variable DTQfries "How many times per month eat fried potatoes? "

sum DTQfries
*Fried potatoes are eaten at a mean frequency 7.02 times/month. That's ~10% of the 71 times per
month for fruitandveg total.

gen DTQpotatoes = .
replace DTQpotatoes = (DTQ110Unew*DTD110Q)
label variable DTQpotatoes "How many times per month eat non-fried potatoes? "

gen DTQbeans= .
replace DTQbeans = (DTQ120Unew*DTD120Q)
label variable DTQbeans "How many times per month eat beans? "

gen DTQveg = .
replace DTQveg = (DTQ130Unew*DTD130Q)
label variable DTQveg "How many times per month eat other vegetables? "

gen DTQwgbread = .
replace DTQwgbread = (DTQ200Unew*DTD200Q)
label variable DTQwgbread "How many times per month eat whole grain bread? "

gen DTQwgrains = .
replace DTQwgrains = (DTQ210Unew*DTD210Q)
label variable DTQwgrains "How many times per month eat other whole grains? "

gen DTQpopcorn = .
replace DTQpopcorn = (DTQ260Unew*DTD260Q)
label variable DTQpopcorn "How many times per month eat popcorn? "

*Checking to make sure that no means for monthly frequency are alarming.
sum DTQcereal DTQfruit DTQleaves DTQfries DTQpotatoes DTQbeans DTQveg DTQwgbread DTQwgrains
DTQpopcorn
*No mean is greater than 23, meaning that no group was eaten, on average, more than once a day.
Sounds right.

*Summing total # of times per month ate fruit or vegetable.
gen fruitandveg = .
replace fruitandveg = (DTQfruit + DTQleaves + DTQfries + DTQpotatoes + DTQbeans + DTQveg)
label variable fruitandveg "How many times per month eat fruit or vegetables? "

*Summing total # of times per month ate fruit or vegetable, minus FRIED potatoes.
gen fandvsomepo = .
replace fandvsomepo = (DTQfruit + DTQleaves + DTQbeans + DTQveg + DTQpotatoes)
label variable fandvsomepo "How many times per month eat fruit or vegetables NOT fried po? "

*Summing total # of times per month ate fruit or vegetable, minus all potatoes.
gen fandvnopo = .
replace fandvnopo = (DTQfruit + DTQleaves + DTQbeans + DTQveg)
label variable fandvnopo "How many times per month eat fruit or vegetables NOT any potatoes? "

*Summing total # of times per month ate grains.
gen grains = .
replace grains = (DTQcereal + DTQwgbread + DTQwgrains + DTQpopcorn)
label variable grains "How many times per month eat grains? "

sum fruitandveg fandvnopo fandvsomepo grains, detail
*Median fruitandveg frequency = 63
*Median fandvsomepo frequency = 56.175
*Median fandvnopo frequency = 50
*Median grain frequency = 24.45

*Creating Ratio of # grains / month to # fruit and vegetable / month.
gen moregrains = .
```

```
replace moregrains = (grains/fruitandveg)

gen moregrains1 = .
replace moregrains1 = (grains/fandvsomepo)

gen moregrains2 = .
replace moregrains2 = (grains/fandvnopo)

sum moregrains moregrains1 moregrains2, detail
*Median of moregrains is .375. The graph is skewed positively, with some ratios as high as 9.
*Median of moregrains1 is .4137931. The graph is skewed positively, with some ratios as high as
9.
*Median of moregrains2 is .4597367. The graph is skewed positively, with fewer high ratios.

*Creating dummies for "More Grains Than Fruit and Veg Servings"
gen moregrainsdummy1=0
replace moregrainsdummy1=1 if (moregrains>=.375)
replace moregrainsdummy1=. if missing(moregrains)

gen moregrainsdummy11=0
replace moregrainsdummy11=1 if (moregrains1>=.4137931)
replace moregrainsdummy11=. if missing(moregrains1)

gen moregrainsdummy2=0
replace moregrainsdummy2=1 if (moregrains2>=.4597367)
replace moregrainsdummy2=. if missing(moregrains2)

*Labeling ratio dummy variable
label define grainratio 1 "highergrains" 0 "higherfandv"
label values moregrainsdummy1 grainratio

label define grainratio1 1 "highergrains" 0 "higherfandv"
label values moregrainsdummy11 grainratio1

label define grainratio2 1 "highergrains" 0 "higherfandv"
label values moregrainsdummy2 grainratio2

*Checking that the dummy divides the group in two.
tab moregrainsdummy1
tab moregrainsdummy11
tab moregrainsdummy2
*_____________________________________________________________________________

**OTHER CLEANING
*Replacing missing values in Education Level Variable
replace DMDEDUC2=. if (DMDEDUC2>=7) & DMDEDUC2<=30

*Turning Waist Circumference into inches
gen circuminch=.
replace circuminch=(bmxwaist*0.393701)

*Generating Waist Circumference Risk Dummy Var
gen circumdum=.
replace circumdum=1 if riagendr==1 & circuminch>=40 | riagendr==2 & circuminch>=35
replace circumdum=0 if riagendr==1 & circuminch<=40 | riagendr==2 & circuminch<=35

*Turning Minutes sedentary into hours
gen sedent=.
replace sedent=(PAD680/12)

*Creating dummy variables for gender
gen maledum1=.
replace maledum1=1 if riagendr==1
replace maledum1=0 if riagendr==2 & riagendr<=10

*Creating dummy variables for race
*Referent group: 3 (non-Hispanic white)
```

```
gen racedum1=.
replace racedum1=1 if RIDRETH1==1
replace racedum1=0 if RIDRETH1>=2 & RIDRETH1<=10

gen racedum2=.
replace racedum2=1 if RIDRETH1==2
replace racedum2=0 if RIDRETH1==1 |  RIDRETH1==3 |  RIDRETH1==4 |  RIDRETH1==5

gen racedum4=.
replace racedum4=1 if RIDRETH1==4
replace racedum4=0 if RIDRETH1==1 |  RIDRETH1==2 |  RIDRETH1==3 |  RIDRETH1==5

gen racedum5=.
replace racedum5=1 if RIDRETH1==5
replace racedum5=0 if RIDRETH1==1 |  RIDRETH1==2 |  RIDRETH1==3 |  RIDRETH1==4

*Creating dummy variables for education
*Referent group: 3 (High School Grad/GED or Equivalent)
gen eddummy1=1 if DMDEDUC2==1
replace eddummy1=0 if DMDEDUC2>=2 & DMDEDUC2<=10

gen eddummy2=1 if DMDEDUC2==2
replace eddummy2=0 if DMDEDUC2==1 | DMDEDUC2==3 | DMDEDUC2==4 | DMDEDUC2==5

gen eddummy4=1 if DMDEDUC2==4
replace eddummy4=0 if DMDEDUC2==1 | DMDEDUC2==2 | DMDEDUC2==3 | DMDEDUC2==5

gen eddummy5=1 if DMDEDUC2==5
replace eddummy5=0 if DMDEDUC2==1 | DMDEDUC2==2 | DMDEDUC2==3 | DMDEDUC2==4

*Creating dummy variables for income
*Referent group: 3 (Monthly poverty level index > 1.85)
gen incdum1=1 if indfmmpc==1
replace incdum1=0 if indfmmpc>=2 & indfmmpc<=10

gen incdum3=1 if indfmmpc==3
replace incdum3=0 if indfmmpc==1 | indfmmpc==2

*_____________________________________________________________________________

*Descriptives
ttest bmxbmi , by(moregrainsdummy1)
*BMI difference between groups is insignificant.
ttest ridageyr , by(moregrainsdummy1)
*Age difference between groups is insignificant.
tabulate riagendr moregrainsdummy1, column chi
*Gender differences are significant. 59.91% of males were above the median for grain/(fruit and
veg) intake, while only 40.09% of women were.
ttest DR2TKCAL , by(moregrainsdummy1)
*Kcal differences by group are significant.

*Descriptives
ttest bmxbmi , by(moregrainsdummy11)
*BMI difference between groups is insignificant.
ttest ridageyr , by(moregrainsdummy11)
*Age difference between groups is insignificant.
tabulate riagendr moregrainsdummy11, column chi
*Gender differences are significant. More males above the median for grain/(fruit and veg)
intake, fewer females.
ttest DR2TKCAL , by(moregrainsdummy11)
*Kcal differences by group are significant.

*Descriptives
ttest bmxbmi , by(moregrainsdummy2)
*BMI difference between groups is insignificant.
ttest ridageyr , by(moregrainsdummy2)
*Age difference between groups is insignificant.
```

```
tabulate riagendr moregrainsdummy2, column chi
*Gender differences are significant. 54.17% of males were above the median for grain/(fruit and
veg) intake, while only 45.83% of women were.
ttest DR2TKCAL , by(moregrainsdummy2)
*Kcal differences by group are significant.
*_____________________________________________________________________________

*Analyzing bias between missing and non-missing.
summarize if moregrains==. , detail
summarize if moregrains1==. , detail
summarize if moregrains2==. , detail
*About 11 people for each, not a big deal!

*Add in weight. Code from Sohye:
svyset [w=WTMEC2YR], psu(sdmvpsu) strata(sdmvstra)

*Determining mean ratios by pop characteristics.
summarize moregrains if riagendr==1
summarize moregrains if riagendr==2
summarize moregrains if racedum1==1
tab racedum1 moregrainsdummy1, column chi

summarize moregrains if racedum2==1
summarize moregrains if RIDRETH1==3
summarize moregrains if racedum4==1
summarize moregrains if racedum5==1
summarize moregrains if eddummy1==1
summarize moregrains if eddummy2==1
summarize moregrains if DMDEDUC2==3
summarize moregrains if eddummy4==1
summarize moregrains if eddummy5==1
summarize moregrains if incdum1==1
summarize moregrains if incdum3==1
summarize moregrains if indfmmpc==3

tabulate riagendr moregrainsdummy1, column chi
tabulate racedum1 moregrainsdummy1, column chi
tabulate RIDRETH1 moregrainsdummy1, column chi
tabulate racedum2 moregrainsdummy1, column chi
tabulate racedum4 moregrainsdummy1, column chi
tabulate racedum5 moregrainsdummy1, column chi
tabulate eddummy1 moregrainsdummy1, column chi
tabulate eddummy2 moregrainsdummy1, column chi
tabulate DMDEDUC2 moregrainsdummy1, column chi
tabulate eddummy4 moregrainsdummy1, column chi
tabulate eddummy5 moregrainsdummy1, column chi
tabulate incdum1 moregrainsdummy1, column chi
tabulate incdum3 moregrainsdummy1, column chi

*Primary linear regression between moregrains and circuminch
logistic circumdum moregrains ridageyr DR2TKCAL sedent maledum1 racedum1 racedum2 racedum4
racedum5 eddummy1 eddummy2 eddummy4 eddummy5 incdum1 incdum3 sdmvpsu sdmvstra
```

Appendix C: NHANES Variables

SEQN - Respondent sequence number

Variable Name: SEQN
SAS Label: Respondent sequence number
English Text: Respondent sequence number.
Target: Both males and females 0 YEARS - 150 YEARS

RIAGENDR - Gender

Variable Name: RIAGENDR
SAS Label: Gender
English Text: Gender of the sample person
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Male	5225	5225	
2	Female	5312	10537	
.	Missing	0	10537	

RIDAGEYR - Age at Screening Adjudicated - Recode

Variable Name: RIDAGEYR
SAS Label: Age at Screening Adjudicated - Recode
English Text: Best age in years of the sample person at time of HH screening. Individuals 80 and over are topcoded at 80 years of age.
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 79	Range of Values	10112	10112	
80	>= 80 years of age	425	10537	
.	Missing	0	10537	

RIDRETH1 - Race/Ethnicity - Recode

Variable Name: RIDRETH1
SAS Label: Race/Ethnicity - Recode
English Text: Recode of reported race and ethnicity information.
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Mexican American	2384	2384	
2	Other Hispanic	1133	3517	
3	Non-Hispanic White	4420	7937	

Code or Value	Value Description	Count	Cumulative	Skip to Item
4	Non-Hispanic Black	1957	9894	
5	Other Race	643	10537	
.	Missing	0	10537	

DMDEDUC2 - Education Level - Adults 20+

Variable Name: DMDEDUC2
SAS Label: Education Level - Adults 20+
English Text: (SP Interview Version) What is the highest grade or level of school {you have/SP has} completed or the highest degree {you have/s/he has} received?
English Instructions: HAND CARD DMQ1 READ HAND CARD CATEGORIES IF NECESSARY ENTER HIGHEST LEVEL OF SCHOOL
Target: Both males and females 20 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Less Than 9th Grade	771	771	
2	9-11th Grade (Includes 12th grade with no diploma)	1005	1776	
3	High School Grad/GED or Equivalent	1426	3202	
4	Some College or AA degree	1742	4944	
5	College Graduate or above	1259	6203	
7	Refused	5	6208	
9	Don't Know	10	6218	
.	Missing	4319	10537	

RIDEXPRG - Pregnancy Status at Exam - Recode

Variable Name: RIDEXPRG
SAS Label: Pregnancy Status at Exam - Recode
English Text: Pregnancy status for females between 20 and 44 years of age at the time of MEC exam.
Target: Females only 20 YEARS - 44 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Yes, positive lab pregnancy test or self-reported pregnant at exam	68	68	
2	SP not pregnant at exam	1266	1334	
3	Cannot ascertain if SP is pregnant at exam	71	1405	
.	Missing	9132	10537	

INDFMMPC - Family monthly poverty level category

Variable Name: INDFMMPC
SAS Label: Family monthly poverty level category
English Text: Family monthly poverty level index categories.
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Monthly poverty level index <= 1.30	4296	4296	
2	1.30 < Monthly poverty level index <= 1.85	1415	5711	
3	Monthly poverty level index > 1.85	4142	9853	
7	Refused	60	9913	
9	Don't Know	116	10029	
.	Missing	508	10537	

PAD680 - Minutes sedentary activity

Variable Name: PAD680
SAS Label: Minutes sedentary activity
English Text: The following question is about sitting at work, at home, getting to and from places, or with friends, including time spent sitting at a desk, traveling in a car or bus, reading, playing cards, watching television, or using a computer. Do not include time spent sleeping. How much time {do you/does SP} usually spend sitting on a typical day?
English Instructions: (SP interview version) SOFT EDIT: >17 HOURS. HARD EDIT: >24 HOURS. ENTER NUMBER OF MINUTES OR HOURS (MEC interview version) SOFT EDIT: 18 hours or more. Error Message: Please verify times of 18 hours or more. HARD EDIT: 24 hours or more. Error Message: The time should be less than 24 hours. ENTER NUMBER (OF MINUTES OR HOURS)
Target: Both males and females 12 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 1200	Range of Values	7476	7476	
7777	Refused	0	7476	
9999	Don't know	18	7494	
.	Missing	2277	9771	

BMXBMI - Body Mass Index (kg/m**2)

Variable Name: BMXBMI
SAS Label: Body Mass Index (kg/m**2)
English Text: Body Mass Index (kg/m**2)
Target: Both males and females 2 YEARS - 150 YEARS

Code or Value Value Description Count Cumulative Skip to Item

Code or Value	Value Description	Count	Cumulative	Skip to Item
12.58 to 84.87	Range of Values	9412	9412	
.	Missing	841	10253	

BMXWAIST - Waist Circumference (cm)

Variable Name: BMXWAIST
SAS Label: Waist Circumference (cm)
English Text: Waist Circumference (cm)
Target: Both males and females 2 YEARS - 150 YEARS
Hard Edits: 0.0000 to 200.0000

Code or Value	Value Description	Count	Cumulative	Skip to Item
40.7 to 179	Range of Values	8973	8973	
.	Missing	1280	10253	

WTDRD1 - Dietary day one sample weight

Variable Name: WTDRD1
SAS Label: Dietary day one sample weight
English Text: Dietary day one sample weight
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
2098.5262571 to 280175.99397	Range of Values	9754	9754	
.	Missing	499	10253	

DR2TKCAL - Energy (kcal)

Variable Name: DR2TKCAL
SAS Label: Energy (kcal)
English Text: Energy (kcal)
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 8976	Range of Values	8288	8288	
.	Missing	1965	10253	

DR2TPROT - Protein (gm)

Variable Name: DR2TPROT
SAS Label: Protein (gm)
English Text: Protein (gm)
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 555.67	Range of Values	8288	8288	
.	Missing	1965	10253	

DR2TCARB - Carbohydrate (gm)

Variable Name: DR2TCARB
SAS Label: Carbohydrate (gm)
English Text: Carbohydrate (gm)
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 1252.51	Range of Values	8288	8288	
.	Missing	1965	10253	

DR2TFIBE - Dietary fiber (gm)

Variable Name: DR2TFIBE
SAS Label: Dietary fiber (gm)
English Text: Dietary fiber (gm)
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 109.6	Range of Values	8288	8288	
.	Missing	1965	10253	

DR2TTFAT - Total fat (gm)

Variable Name: DR2TTFAT
SAS Label: Total fat (gm)
English Text: Total fat (gm)
Target: Both males and females 0 YEARS - 150 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 400.11	Range of Values	8288	8288	
.	Missing	1965	10253	

DTD010Q - How often eat cold or hot cereal?

Variable Name: DTD010Q
SAS Label: How often eat cold or hot cereal?

English Text: During the past month, how often did {you/SP} eat hot or cold cereals? You can tell me per day, per week or per month.
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS.
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 63	Range of Values	7850	7850	
777	Refused	2	7852	
999	Don't know	9	7861	
.	Missing	680	8541	

DTQ010U - How often eat cold or hot cereal?

Variable Name: DTQ010U
SAS Label: How often eat cold or hot cereal?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	1585	1585	
2	Week	2359	3944	
3	Month	2468	6412	
7	Refused	1	6413	
9	Don't know	1	6414	
.	Missing	2127	8541	

DTD080Q - How often eat fruit?

Variable Name: DTD080Q
SAS Label: How often eat fruit?
English Text: [During the past month], how often did {you/SP} eat fruit? Include fresh, frozen or canned fruit. Do not include juices. [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 90	Range of Values	7849	7849	
777	Refused	3	7852	
999	Don't know	7	7859	
.	Missing	682	8541	

DTQ080U - How often eat fruit?

Variable Name: DTQ080U
SAS Label: How often eat fruit?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	2790	2790	
2	Week	2135	4925	
3	Month	2333	7258	
7	Refused	3	7261	
9	Don't know	7	7268	
.	Missing	1273	8541	

DTD090Q - How often eat leafy/lettuce salad?

Variable Name: DTD090Q
SAS Label: How often eat leafy/lettuce salad?
English Text: [During the past month], how often did {you/SP} eat a green leafy or lettuce salad, with or without other vegetables? [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 45	Range of Values	7850	7850	
777	Refused	3	7853	
999	Don't know	6	7859	
.	Missing	682	8541	

DTQ090U - How often eat leafy/lettuce salad?

Variable Name: DTQ090U
SAS Label: How often eat leafy/lettuce salad?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	733	733	
2	Week	2601	3334	
3	Month	2684	6018	
7	Refused	3	6021	
9	Don't know	6	6027	
.	Missing	2514	8541	

DTD100Q - How often eat fried potatoes?

Variable Name: DTD100Q
SAS Label: How often eat fried potatoes?
English Text: [During the past month], how often did {you/SP} eat any kind of fried potatoes, including french fries, home fries, or hash brown potatoes? [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 45	Range of Values	7849	7849	
777	Refused	3	7852	
999	Don't know	6	7858	
.	Missing	683	8541	

DTQ100U - How often eat fried potatoes?

Variable Name: DTQ100U
SAS Label: How often eat fried potatoes?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	204	204	
2	Week	2368	2572	
3	Month	3959	6531	
7	Refused	3	6534	
9	Don't know	6	6540	
.	Missing	2001	8541	

DTD110Q - How often eat non-fried potatoes?

Variable Name: DTD110Q
SAS Label: How often eat non-fried potatoes?
English Text: [During the past month], how often did {you/SP} eat any other kind of potatoes, such as baked, boiled, mashed potatoes, sweet potatoes, or potato salad? [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 30	Range of Values	7846	7846	
777	Refused	3	7849	
999	Don't know	9	7858	
.	Missing	683	8541	

DTQ110U - How often eat non-fried potatoes?

Variable Name: DTQ110U
SAS Label: How often eat non-fried potatoes?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	160	160	
2	Week	2261	2421	
3	Month	3768	6189	
7	Refused	3	6192	
9	Don't know	9	6201	
.	Missing	2340	8541	

DTD120Q - How often eat beans?

Variable Name: DTD120Q
SAS Label: How often eat beans?
English Text: [During the past month], how often did {you/SP} eat refried beans, baked beans, beans in soup, pork and beans or any other type of cooked dried beans? Do not include green beans. [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 45	Range of Values	7849	7849	
777	Refused	3	7852	
999	Don't know	6	7858	

Code or Value	Value Description	Count	Cumulative	Skip to Item
.	Missing	683	8541	

DTQ120U - How often eat beans?

Variable Name: DTQ120U
SAS Label: How often eat beans?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	451	451	
2	Week	1944	2395	
3	Month	3329	5724	
7	Refused	3	5727	
9	Don't know	6	5733	
.	Missing	2808	8541	

DTD130Q - How often eat other vegetables?

Variable Name: DTD130Q
SAS Label: How often eat other vegetables?
English Text: [During the past month], not including what you just told me about [lettuce salads, potatoes, cooked dried beans], how often did {you/SP} eat other vegetables? [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 60	Range of Values	7845	7845	
777	Refused	3	7848	
999	Don't know	8	7856	
.	Missing	685	8541	

DTQ130U - How often eat other vegetables?

Variable Name: DTQ130U
SAS Label: How often eat other vegetables?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	2189	2189	
2	Week	2560	4749	
3	Month	2472	7221	
7	Refused	3	7224	
9	Don't know	8	7232	
.	Missing	1309	8541	

DTD200Q - How often eat whole grain bread?

Variable Name: DTD200Q
SAS Label: How often eat whole grain bread?
English Text: [During the past month], how often did {you/SP} eat whole grain bread including toast, rolls and in sandwiches? Whole grain breads include whole wheat, rye, oatmeal and pumpernickel. Do not include white bread. [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 70	Range of Values	7842	7842	
777	Refused	3	7845	
999	Don't know	10	7855	
.	Missing	686	8541	

DTQ200U - How often eat whole grain bread?

Variable Name: DTQ200U
SAS Label: How often eat whole grain bread?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	1424	1424	
2	Week	2005	3429	
3	Month	2359	5788	
7	Refused	3	5791	
9	Don't know	10	5801	
.	Missing	2740	8541	

DTD210Q - How often eat cooked whole grains?

Variable Name: DTD210Q
SAS Label: How often eat cooked whole grains?
English Text: [During the past month], how often did {you/SP} eat brown rice or other cooked whole grains, such as bulgur, cracked wheat, or millet? Do not include white rice. [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 30	Range of Values	7846	7846	
777	Refused	4	7850	
999	Don't know	7	7857	
.	Missing	684	8541	

DTQ210U - How often eat cooked whole grains?

Variable Name: DTQ210U
SAS Label: How often eat cooked whole grains?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	94	94	
2	Week	895	989	
3	Month	1875	2864	
7	Refused	4	2868	
9	Don't know	7	2875	
.	Missing	5666	8541	

DTD260Q - How often eat popcorn?

Variable Name: DTD260Q
SAS Label: How often eat popcorn?
English Text: [During the past month], how often did {you/SP} eat popcorn? [You can tell me per day, per week or per month.]
English Instructions: ENTER QUANTITY IN DAYS, WEEKS, OR MONTHS
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
0 to 30	Range of Values	7849	7849	
777	Refused	3	7852	
999	Don't know	2	7854	

Code or Value	Value Description	Count	Cumulative	Skip to Item
.	Missing	687	8541	

DTQ260U - How often eat popcorn?

Variable Name: DTQ260U
SAS Label: How often eat popcorn?
English Text: UNIT OF MEASURE
English Instructions: ENTER UNIT
Target: Both males and females 2 YEARS - 69 YEARS

Code or Value	Value Description	Count	Cumulative	Skip to Item
1	Day	87	87	
2	Week	923	1010	
3	Month	3097	4107	
7	Refused	3	4110	
9	Don't know	2	4112	
.	Missing	4429	8541	

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Academic Vita

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Education

The Pennsylvania State University, University Park, PA — **Expected May 2015**
Schreyer Honors College
Candidate for Bachelor of Science in Nutritional Sciences
Minor in Health Policy and Administration

Nutrition Experience

Amir Project at Camp Ramah in the Berkshires — **Wingdale, NY**
Garden and Food Educator — **May 2014-August 2015**

- Taught campers aged ten to sixteen the principles of growing, cooking, and consuming healthy produce through age-appropriate activities in garden and kitchen
- Developed teaching and lesson planning skills for the experiential learning environment
- Explored my interest in environmentally responsible eating and food production by teaching several lessons per week on food and water systems

Slow Food California — **Redlands, CA**
Food Policy Summer Intern — **May 2013-August 2013**

- Organized and promoted activities of Slow Food California's Policy Action Committee
- Coordinated formation of a local food policy council through the Slow Food Redlands chapter and its community partners
- Developed an understanding of the region's nutritional and agricultural challenges through engagement with community stakeholders

Introduction to Nutrition — **University Park, PA**
Teaching Assistant — **January 2013- May 2013**

- Provided counseling-style feedback for students' personal nutrition plans in an online forum
- Facilitated group review sessions in the concepts of basic nutrition

Penn State Food Science Sensory Lab — **University Park, PA**
Lab Assistant — **January 2012- May 2013**

- Prepared laboratory materials, ran tests, and performed other support tasks under the supervision of a graduate student in Sensory Food Science
- Developed an understanding of individual food preference, food industry product manipulation, and food industry health objectives throughout scientific process

Leadership

Student Programming Association, Lecture Committee Chair — **Spring 2014-present**

- Coordinate motivational and educational lecture events catered to the campus community
- Guide committee to serve community interests through outreach and partnerships

Penn State Service Trips Team, Executive Director — **Spring 2013-present**

- Oversee planning of various weeklong service opportunities
- Learn and teach principles of peer leadership, social justice, logistics planning, and risk management

Skills

Proficient in Spanish (Mexican and American dialects)
Graduate-level practice and thesis experience with SAS and STATA analysis
Trained in coordinating peer committees, childhood education, and community programing

Other Experience

Brit Shalom Religious School — **August 2012-present**
Teach two sixth grade Hebrew classes and one second grade Jewish studies class weekly

Honors

NASA Space Grant Recipient, Women in Science and Engineering Research (WISER)
Student Leader Scholarship, Office of Student Activities
College of Health and Human Development Academic Excellence Scholarship