Plant-based diets and risk of erectile dysfunction in young men

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Accessibility
Plant-Based Diets and Risk of Erectile Dysfunction in Young Men

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A Thesis in the Field of Biology
for the Degree of Master of Liberal Arts in Extension Studies

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Erectile dysfunction (ED) is the most common medical issue associated with ageing. Beyond the obvious impact on sexual quality of life, data suggests that ED may be an early indicator cardiometabolic disease, especially in younger men. In fact, research in the past few decades has reported that ED, vascular dysfunction, and metabolic diseases share common pathoetiologies. Interestingly, multiple studies have noted that lifestyle factors associated with cardiovascular disease risk are also associated with ED risk. Recently, healthy dietary patterns have been associated with a reduced risk for erectile dysfunction in middle-aged and older men. However, the extent to which findings on the relationship between diet and ED (and more generally the relationship between modifiable lifestyle factors with ED) among middle-aged men is generalizable to younger men is uncertain. I hypothesized that greater adherence to a plant-based diet was correlated with lower risk of ED in young men, similar to that of men over 40. To test this hypothesis, I used data from 1,964 men, aged 18 to 31, participating in the Growing Up Today Study (GUTS) – an ongoing prospective cohort study. Plant-based diet adherence was scored according frequency and consumption of foods reported in a food frequency questionnaire. ED was self-reported after a 2-year follow-up using the validated International Index of Erectile Function-5 (IIEF-5). Of the 1,964 men, 4.7% (N=92) reported moderate or severe ED (Score=5-16), and 19.5% (N=382) reported ED of any severity (Score=5-21). Men in the highest quartile of plant-based diet adherence had 26% lower risk of ED (RR=0.74; 95%CI, 0.52 to 1.06; \( P \) trend=0.04) compared to
the lowest quartile after adjustment. Results were similar in analyses using moderate to severe ED as the study outcome. These data suggest that greater adherence to a plant-based diet may be associated with lower risk of ED in young men. Given the novelty of these findings, it is important that additional studies evaluate this relation again. Should these results be replicated, clinical recommendations to prevent or treat erectile dysfunction should include plant-based dietary adherence.
Dedication

I dedicate this work to my sisters. Five people who are, in their own right, survivors, warriors, listeners, spiritual gurus, and passionate leaders. You each work tirelessly to make this world a better place – for me, for your children, and for anyone you touch. I would never have been able to accomplish my dreams without you. Thank you.
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Chapter I.
Introduction

Erectile Dysfunction in Middle-Aged and Older Men

Prevalence and Etiology

Erectile dysfunction (ED) is often viewed as an inevitable consequence of aging. Although ED is not considered critical, quality of life, interpersonal relationships, and self-esteem are all negatively affected by the condition. Additionally, recent data suggests that erectile issues may be an early indication of cardiometabolic disease (Uddin et al., 2018). Nearly half of the adult male population is burdened by erectile dysfunction, reaching more than 70% in men 70 years and older (Feldman, Goldstein, Hatzichristou, Krane, & McKinlay, 1994). ED affects approximately 18 million men in the United States, and nearly 322 million worldwide (Selvin, Burnett, & Platz, 2007). Although a large portion of the male population experience sexual problems, nearly 90% of men in the US never seek medical care (McKinlay, 2000). Treatment options primarily include phosphodiesterase type 5 (PDE5) inhibitors and are currently the most common and effective treatment for ED. Despite the prevailing belief that PDE5 inhibitors are the solution to erectile issues, studies suggest that they are only effective in half of the population who take them _ad libitum_, and 35-70% of men reportedly abandon this form of treatment (Klotz, T., Mathers, Klotz, R., & Sommer, 2005). Although PDE5 inhibitors are effective for a substantial portion of the population, they are designed to temporarily
treat the symptoms of a chronic condition with varying etiologies. Consequently, there are large populations of men with ED who go untreated and whose treatment options are limited.

The physiology of healthy erectile function is the result of complex neurological, endocrinological, and vascular interactions (Andersson, 2011). The penis is a highly vascularized organ, innervated by arterial blood supply derived from the internal iliac artery (Figure 1) (Rojas-Gomez et al., 2017).

Figure 1. Afferent vasculature to the gonadal organs.

A digital representation of the iliac arteries, which feed the internal pudendal and helicine arteries to the corpus cavernosa of the penis (Rojas-Gomez et al., 2017).

The iliac artery is a branch of the abdominal aorta, which feeds the internal pudendal artery (Yafi et al., 2016). The pudendal arteries give to the cavernosal arteries and helicine arteries innervating the corpus cavernosa of the penis. The corpora are two
cylindrical tubes running dorsal-lateral down the shaft of the penis and are comprised of a matrix of smooth muscle cells, connective tissue, and sinusoid. Sinusoidal tissue is made up of vascular channels lined with a monolayer of endothelial cells, which are vital for proper vascular function. During erectile tumescence, a psychogenic stimulus triggers the release of neurotransmitters, which in-turn, activate oxytocinergic neurons to increase calcium (Ca$^{2+}$) influx (Andersson, 2011; Uddin et al., 2018; Yafi et al., 2016). Successively, Ca$^{2+}$ activates nitric oxide synthase (NOS) enzymes that synthesize nitric oxide (NO) produced by endothelial cells lining the sinusoid. NO acts in a positive feedback fashion, activating additional neurons, but also targets guanylyl cyclases (GCs) within the neurons innervating the corpus cavernosa. In a flaccid state, the smooth muscle of the corpora remains contracted, limiting blood flow. When GCs are activated, they convert guanosine triphosphate (GTP) into cyclic guanosine monophosphate (cGMP), relaxing smooth muscle, allowing engorgement. (Figure 2) (Yafi et al., 2016). In detumescence, the PDE5 enzyme immediately begins to degrade cGMP (Andersson, 2011; Uddin et al., 2018; Yafi et al., 2016). The complexity of healthy erectile function contributes to many etiological perturbations when dysfunction occurs.

There are three commonly reported etiologies of erectile dysfunction: endocrine disorders, commonly associated with low testosterone; neurological disorders, including psychological stress and depression, as well as anatomical abnormalities; and vascular disorders, which includes peripheral, cerebrovascular, and coronary diseases (Uddin et al., 2018; Yafi et al., 2017). It is now widely accepted that ED is primarily a vascular disorder in older men. Yafi et al. (2017) suggests that ED is vascular in nearly 80% of cases in men over 40 years of age.
Figure 2. Penile anatomy in a flaccid and tumescent state.

*a. Tonic smooth muscular contraction in a flaccid state allows minimal blood flow through cavernosa and helicine arteries and unrestricted venous return. b. Dilation of the afferent arteries and cGMP activation results in smooth muscle relaxation, causing expansion of the sinusoid, venous occlusion, and tumescence (Yafi et al., 2016).*

Multiple studies show a strong correlation between ED and most vascular and metabolic disorders (Vlachopoulos, Terentes-Printzios, Ioakeimidis, Aznaouridis, & Stefanadis, 2013). In fact, it has been elucidated that cardiometabolic disease and erectile dysfunction share similar pathoetiologies (Blick, Ritchie, & Sullivan, 2016).

Cardiometabolic Disease

Cardiovascular disease (CVD) is a broad term to define diseases of the vasculature. CVD includes diseased vessels of the heart and any aspect of the peripheral vasculature, including cerebrovascular disease and stroke (LaRocca, Martens, & Seals, 2017). Nearly half of the population in the United States who are over 20 years of age have CVD, where approximately one person dies every 36 seconds of a vascular-related death (Benjamin et al., 2019; Virani et al., 2020). Atherosclerosis is the most common
cause of CVD, defined as the narrowing of arteries due to the formation of lipid-filled plaques (Zhu et al., 2018). Ischemia, due to thickening or sclerotic blockage, or infarction, due to thrombus or embolus, lead to atherosclerotic related cardiac events and mortality. High quantities of circulating blood lipids (hyperlipidemia), especially composed of low-density lipoprotein (LDL) is predominately associated with atherosclerotic plaque buildup within the vasculature.

It was once thought that LDL was simply retained in the vasculature (Rhoads & Major, 2018). Evidence in the last few decades has determined that LDL is a complex molecule containing cholesterol, phospholipids, and triglycerides, which undergo conformation prior to plaque formation and the process involves both innate and adaptive inflammatory mediators. Reactive oxygen species (ROS), heme iron, and other free radicals contribute to endothelial damage and LDL oxidation (oxLDL) (de Valk & Marx, 1999; Incalza et al., 2018; Rhoads & Major, 2018). OxLDL is a hazardous molecule that contributes heavily to atherosclerotic plaque formation: 1) by recruiting inflammatory mediators, exacerbating local inflammation; 2) by increasing the formation of ROS, which trigger inflammation and foam cell formation; 3) by contributing to the upregulation of adhesion molecules within the vascular endothelium, increasing plaque adhesion; and 4) inciting matrix degradation, contributing to plaque destabilization (Figure 3) (Hansson, Robertson, & Soderberg-Naucler, 2006; Pirillo, Norata, & Catapano, 2013). Foam cells are lipid-filled inflammatory macrophages, termed foam cells because of the foamy appearance of their cytoplasm (Hansson et al., 2006). Foam cells dominate visible fatty streaks and atheromas within the vascular endothelium and can contribute to plaque rupture. In a healthy individual, ROS are important reactive
intermediaries, synthesized as a byproduct of cellular metabolism; they are typically buffered by an anti-oxidant defense system (Incalza et al., 2018; Mittal, Siddiqui, Tran, Reddy, & Malik, 2014; Tavakoli & Asmis, 2012). When ROS are in excess, either by increased production or decreased buffering capacity, they can contribute to oxLDL and foam cell formation, leading to atherosclerosis and endothelial dysfunction.

Figure 3. Mediators and physiology of atherosclerotic lesions and thrombosis.

Endothelial dysfunction is also a significantly linked to vascular disease and type 2 diabetes. The vascular endothelium is a monolayer of endothelial cells that line the
entire vasculature and perform a multitude of vital functions (Rajendran et al., 2013; Stern et al., 1991). The endothelium is responsible for fluid filtration, blood vessel tone, endocrine trafficking and inflammatory recruitment, though its primary function is to facilitate the flow of blood, plasma, and cellular constituents throughout the vasculature. NO is a gaseous molecule synthesized in the endothelium responsible for vascular tone and homeostasis (Rajendran et al., 2013; Stern et al., 1991). In a disease state ROS can damage endothelial cells, reducing NO bioavailability, thereby impairing vascular tone and causing endothelial dysfunction. Other common contributors to CVD and measures of disease severity include the following: 1) coronary artery calcification (CAC), described by calcified lesions associated with arterial stiffness (Liu et al., 2015); 2) carotid intima-media thickening (CIMT), thickening of the intimal-medial layers of the vasculature including the smooth muscle (Nakahara, et al., 2017); and 3) C-reactive protein (CRP), an inflammatory protein synthesized in the liver, smooth muscle cells, inflammatory cells, endothelial cells, and adipocytes (Sproston & Ashworth, 2018).

Metabolic diseases encompass any disorder that disrupts normal metabolism but are typically used to describe the two most common metabolic disorders: type 2 diabetes and metabolic syndrome (MetS). In 2018 there were approximately 30.5-32.5 million people in the United States with diagnosed type 2 diabetes and approximately 88 million with prediabetes (CDC Diabetes, 2020). Type 2 diabetes is a non-communicable disease, which results from the inability of tissues to respond appropriately to insulin or defective insulin secretion by pancreatic β-cells, resulting in high levels of glucose in the blood stream (hyperglycemia) (Galicia-Garcia et al., 2020; Stumvoll, Goldstein, & van Haeften, 2005; Weyer, Bogardus, Mott, & Pratley, 1999). Plethoric glucose in the blood stream is
highly damaging to vascular endothelium through cellular apoptosis and increased expression of adhesion molecules (Cohen, Riahi, Alpert, Gruzman, & Sasson, 2007; Lorenzi, Caliero, & Toledo, 1985; Stenina, 2005). Injured endothelium attracts inflammatory mediators, increases smooth muscle cell proliferation, and produces ROS. Chronic inflammation and oxidative stress contribute to inflammation of β-cell containing islets in the pancreas (Christensen & Gannon, 2019; Halban et al., 2014; Galicia-Garcia et al., 2020). Although type 2 diabetes and CVD are disparate diseases, they are similar in pathoetiology and have many common risk factors. Patients with type-2 diabetes are most likely to die from cardiovascular associated events (Galicia-Garcia et al., 2020; Gaede et al., 2003).

MetS, more common than type 2 diabetes, is a metabolic disease that describes a cluster of conditions. Patients with synchronous high blood pressure (hypertension), hyperglycemia, excess visceral abdominal fat, and abnormal cholesterol levels (hypercholesterolemia) are classified as MetS patients (Samson & Garber, 2014). MetS symptoms together infer an especially high risk for type 2 diabetes, CVD and all-cause mortality. In 2017, cardiac and metabolic diseases accounted for nearly one million deaths in the United States (Shah et al., 2019). Cardiometabolic diseases have reach critical pandemic levels and confer a considerable economic, social, and health burden on nearly half of the US population.

ED and Cardiometabolic Disease Share Similar Pathoetiologies

It is well established that erectile issues are primarily vascular in older men. A meta-analysis of 92,757 men with erectile dysfunction had a 44% higher risk of CV events (95%CI, 1.25 to 1.63), 19% higher risk of CV mortality (95%CI, 0.97 to 1.46),
62% higher risk of MI (95%CI, 1.34 to 1.96), 39% risk of cerebrovascular events (95%CI, 1.23 to 1.57), and 25% risk of all-cause mortality (95%CI, 1.12 to 1.39) (Vlachopoulos et al., 2013). Vlachopoulos et al. (2013) suggested that ED is not only a manifestation of obstructive vascular disease but also inflammation and pro-thrombotic activation. Endothelial dysfunction also contributes to ED with the disruption of bioavailable NO (Blick et al., 2016). Reduction in NO availability induces atherosclerosis, impairs vascular tone, as well as smooth muscle contractility needed for proper erectile function.

In the past two decades, researchers were unclear how erectile issues were related to cardiometabolic conditions. Were erectile issues a clinical manifestation of disease or was ED a harbinger of forthcoming vascular and metabolic disorders? Researchers have verified both hypotheses: ED is a risk factor for cardiometabolic disease and cardiometabolic disease is a risk factor for ED (Nguyen, Gabrielson & Hellstrom, 2017). The significance of these findings being that men with ED who are otherwise seemingly healthy may, in fact, have comorbid clinically silent cardiometabolic disease and at may be at significant risk for future cardiovascular events. Miner et al. (2012) suggest that ED can be a better predictor for future cardiovascular disease risk than family history of MI or smoking. Various studies indicate that ED symptoms precede vascular symptoms by a number of years, for instance Baumhakel & Bohm (2007) reported that ED preceded CV events by 3.04 years (SD, ±7.24) (N=192). A meta-analysis of twelve prospective cohort studies involving 36,744 participants, reported that ‘healthy’ men with ED experienced a 48% increase risk for CVD, 46% for coronary heart disease (CHD), 35% for stroke, and 19% risk for all-cause mortality compared to men with normal erectile function (Dong,
Zhang, & Qin, 2011). Similarly, Eleid et al. (2010) published that CIMT and atherosclerotic plaque was observed in 38% of patients with low cardiovascular disease risk after carotid ultrasound. Men presenting with ED are also at higher risk for type 2 diabetes and MetS (Besiroglu, Otunctemur, & Ozbek, 2015; Selvin et al., 2007). Skeldon, Detsky, Goldenberg, and Law (2015) reported that seemingly healthy men with ED had more than double the odds of undiagnosed diabetes (OR=2.20; 95%CI, 1.10 to 4.37). If ED presents as a harbinger of forthcoming disease as reported, early identification, treatment and possible prevention of ED is considerably important for public health.

Diet is a Risk Factor for Cardiometabolic Disease

Prevention or reversal of cardiometabolic disease is possible with healthier diet adherence, increased physical activity, and other interventions such as smoking or alcohol cessation, and weight loss (Arackal & Benegal, 2007; Esselstyn, Gendy, Doyle, Golubic, & Roizen, 2014; Hsiao et al., 2012; Wen, Rissel, Cheng, Richters, & de Visser, 2017). Multiple studies have shown the cardiometabolic benefits of plant-focused diets. Increased consumption of plant-based foods is associated with lower risk of type 2 diabetes (Satija et al., 2016), cardiovascular disease (Kim et al., 2019), CHD (Satija et al., 2017), CVD mortality (Kim et al., 2019), and all-cause mortality (Kim et al., 2019; Martinez-Gonzalez et al., 2014) in both men and women ($P$ trend $<0.05$ for all). Additionally, animal-based foods have been correlated with increased risk in CVD, CHD, type 2 diabetes, and all-cause mortality (De Biase, Fernandes, Gianini, & Duarte, 2007; Qi, van Dam, Rexrode, & Hu, 2007; Riserus, Willett, & Hu, 2009; Teixeria, Molina, Zandonade, & Mill, 2007).
Animal-based foods have proved to be high in saturated fat, cholesterol, triglycerides, heme iron, and other harmful components that contribute to both vascular and metabolic disease. Animal consumption increases plasma levels of cholesterol, saturated fat, and triglycerides, inducing endothelial dysfunction via oxidative stress, resulting in disruption of NO bioavailability (Dharmashankar & Widlansky, 2010; Incalza et al., 2018). Lian et al. (2020) reported a study where LDL receptor knock out mice were fed a Mediterranean-type diet, high in plant-based foods and low in animal-based foods, for 4 weeks. In this version of the Mediterranean Diet, saturated fat was replaced with olive oil and nuts. Results showed significant decrease in plasma saturated fat, triglycerides, and cholesterol resulting in a marked reduction of inflammatory cytokines, oxLDL levels, and atherosclerotic plaque adhesion ($P<0.05$ for all). A meta-analysis of 112 randomized control trials compared plant protein as a substitution for animal protein (Li et al., 2017). In the plant protein substitution group, LDL plasma concentration decreased by 0.16 mmol/L (95%CI, -0.20 to -0.12; $P < 0.00001$) after a 3 or more week follow-up. A prospective study reported that only a one-unit increase in plasma total cholesterol (TC) to high-density cholesterol (HDL) ratio confers a 53% increase in CVD risk (95%CI, 0.26 to 0.85) (Stampfer et al., 1991).

Aside from saturated fat and cholesterol content in animal-based foods, heme iron is also high in meat, poultry, and seafood, derived from hemoglobin consumption (Haider, Schwinsackl, Hoffman, & Ekmekcioglu, 2018). Heme iron is a potential pro-oxidant and may contribute to the development of atherosclerosis by catalyzing production of free radicals and systemic oxLDL concentrations (de Valk & Marx, 1999). A meta-analysis of 131,533 participants indicated that higher heme iron intake was
associated with a 31% increased risk of CHD compared to those with lower heme intake (RR=1.31; 95%CI, 1.04 to 1.67) (Yang et al., 2014). Animal-prominent diets have also shown to increase gut microbial populations that produce trimethylamine N-oxide (TMAO) associated with endothelial cell and vascular inflammation (Zhang, Wang, Ke, & Du, 2021). As animal-foods contain elements attributed to disease risk; plant foods contain elements that are said to have a protective effect.

Plant-based foods are high in fiber, contain mono and polyunsaturated fats, are high in polyphenols, and contribute to a healthier microbiome than animal-based foods (Figure 6) (Satija & Hu, 2018). Reducing inflammatory saturated fat and replacing it with plant sourced mono and polyunsaturated fats can have a significant protective effect against cardiovascular disease (Willett, 2012). Fiber has been shown in numerous studies to improve plasma LDL cholesterol (Story, Furumoto, & Buhman, 1997), inflammatory CRP (Ma et al., 2006), and insulin sensitivity (Weickert & Pfeiffer, 2008). Two studies suggest that adding 10g of daily dietary fiber decreases risk of CHD-related mortality by 17-27% (Periera et al., 2004; Streppel, Ocke, Boshuizen, Kok, & Kromhut, 2008).

Continually, polyphenols are plant-derived micronutrients that are highly beneficial in disease prevention, particularly in regards to endothelial function, anti-inflammatory effects, anti-oxidant effects, and glycemic homeostasis (Gonzalez et al., 2011). Plant-based diets are also highly beneficial in promoting gut microbial diversity. Firmicutes, for example, metabolize plant polysaccharides and have been shown to improve inflammation and insulin sensitivity (Chakraborti, 2015).

Dietary patterns in cohort and intervention studies have been increasingly utilized as an accurate method of assessing risk of disease (Shan et al., 2020). Individual
components of food work synergistically in the body and are therefore a more accurate representation of dietary consequences. Various dietary patterns are utilized to determine the effects of modification on cardiometabolic risk. The Mediterranean Diet, the Dietary Approaches to Stop Hypertension (DASH) diet, the Healthy Eating Index (HEI), the Alternative Healthy Eating Index (AHEI), various plant-based dietary patterns, and pro-vegetarian dietary patterns are just some of the few currently recommended diets by various clinical and national guidelines. Many dietary patterns are highly similar, emphasizing increased consumption of plant-based foods, such as grains, vegetables, fruit, nuts and legumes, while decreasing consumption of animal-based foods, such as dairy, eggs, and meat. Variations between these diets exist primarily with the inclusion or exclusion of certain foods, such as oils, full fat or low-fat dairy, eggs, refined grains, or sugary beverages. A study by Shan et al. (2020) compared four healthy eating patterns: 1) the Healthy Eating Index (HEI)-2015, 2) the Alternative Mediterranean Diet (AMD) 3) the Healthful Plant-Based Diet Index, and 4) the Alternative Healthy Eating Index (AHEI). In this study 209,133 men and women were assessed for cardiovascular risk as part of the Nurses’ Health Study (NHS) I and II and the Health Professionals Follow-up Study (HPFS). In pooled multivariable analyses it was observed that every recommended dietary pattern was associated with decreased risk for fatal and nonfatal CHD and stroke ($P$ trend $<0.001$ for all), with only minor risk differences between dietary patterns.

In the 1970’s it was observed that the Mediterranean Diet was possibly cardioprotective when researcher Ancel Keys conducted the Seven Countries Study (Menotti & Puddu, 2015). Adherence to the Mediterranean dietary pattern includes high intake of olive oil, fruit, vegetables, nuts, and cereals; a moderate intake of fish and
poultry; low intake of dairy products, red meat, processed meats, and sweets; and moderate consumption of wine (Willett et al., 1995). Notably, a Mediterranean Diet was utilized in the PREvencion con DIeta MEDiteranea (PREDIMED) to compare a low-fat control diet with two versions of the Mediterranean Diet, one supplemented with olive oil and one with mixed nuts (Estruch et al., 2018). Both Mediterranean Diet arms were correlated with reduced risk of major cardiovascular events compared to the control diet; in the olive oil supplemented diet, a 31% risk reduction (95% CI, 0.53 to 0.91), and in the nut-supplemented diet, a 28% risk reduction (95% CI, 0.54 to 0.95). Adherence to the Mediterranean Diet has demonstrated repeated correlation with reduced risk of many cardiometabolic diseases, as well as all-cause mortality. While Mediterranean Diet adherence is effective in reducing risk of cardiometabolic diseases, components of this dietary pattern contain saturated fat and cholesterol, which have been shown to increase risk of vascular and metabolic disease (Dharmashankar & Widlansky, 2010; Incalza et al., 2018). While moderation of these less healthy foods are recommended, moderation is subjective and therefore may be less protective in some cases. A study by Barnard et al. (2021) reported that a low-fat vegan diet showed greater improvement in some cardiometabolic biomarkers than a Mediterranean Diet after a 16-week randomized crossover trial. In this study, no changes in post-prandial insulin sensitivity tests were seen; blood pressures declined, more so in the Mediterranean Diet arm of the study. Their findings also showed that participants who adhered to the low-fat vegan diet had greater reduction in body weight ($P<0.001$), improved $\beta$-cell function and insulin resistance ($P=0.21$), improved insulin sensitivity ($P=0.003$) and lower LDL cholesterol ($P=0.001$) compared to Mediterranean Diet controls.
The Healthy Eating Index (HEI) is a dietary pattern created by the Department of Health and Human Services as part of the 2015-2020 Guidelines for Americans (USDA, 2015). These recommendations have been modified since their first inception, and now include: fruit, vegetables, low-fat for fat free dairy and or soy products, a variety protein-rich foods, such as seafood, lean meat and poultry, eggs, legumes, nuts or seeds, while limiting saturated fats, trans fats, sugar, and sodium. The Alternative Healthy Eating Index (AHEI) was created by researchers at the Harvard T.H. Chan School of Public Health as an alternative to the HEI to better distinguish between quality of grains, to emphasize the reduction in saturated fat consumption, and acknowledge the health benefits of unsaturated oils (McCullough & Willett, 2006). Although adherence to both dietary patterns have been associated with reduced cardiovascular risk, the AHEI was associated with a greater risk reduction in all major scored chronic diseases of 105,886 men and women from the NHS and HPFS cohorts.

Plant-based dietary patterns in research are relatively new, though plant-focused eating has demonstrated health benefits for centuries. Various methodologies are utilized to assess adherence to plant-based foods. The healthful plant-based diet index (hPDI) has been utilized in a multitude of studies to demonstrate cardiovascular protectiveness (Figure 4) (Satija & Hu, 2018). Similar patterns include the Whole Foods Plant-Based (WFPD) diet, vegan/vegetarian diets, and the Eco-Atkins Diet. Essentially, plant-based diets emphasize an overall trend toward plant foods and trend away from animal foods.

It is important to note that dietary patterns may provide conflicting results, often because intake of plant foods must significantly outweigh restriction of animal foods enough to see cardiometabolic benefits; this is especially important in cohort studies with
no control group. Plant-based dietary patterns, specifically, are beneficial in cohort studies, where dichotomizing beneficial and harmful foods may be more statistically sound and easier to interpret. For example, the Mediterranean Diet suggests some animal foods are to be consumed in moderation. Physiologically, the harm of moderately consumed animal-based foods may be outweighed by the benefits of increased plant consumption, though empirically, moderation is difficult to measure and interpret. Furthermore, the balance between harmful and beneficial food consumption is different for every individual. There are a multitude of dietary patterns that have shown to reduce risk of cardiometabolic maladies. The most effective dietary patterns have incorporated plant-based foods, which are high in fiber, mono and polyunsaturated fats, polyphenols, and other beneficial micronutrients, while simultaneously discounting animal-based foods that are high in saturated fat, cholesterol, and inflammatory byproducts. Dietary assessment through association studies is highly valuable, although assessment of dietary patterns in large population cohorts is challenging due to the homogeneity of most diets within the United States. The resulting intake of any given macronutrient or micronutrient lies predominantly within one or two standard deviations of the mean. Therefore a combination of research methodologies, physiological assessments of food components, and clinical data together provides strong evidence for the utilization of a plant-based dietary pattern in assessing cardiometabolic risk.
Various components of healthful plant-based diets contribute to protective effects of biological mediators against cardiometabolic diseases (Satija & Hu, 2018). Healthful plant-based diets include fruit, vegetables, whole grains, nuts, and legumes.

Diet as a Possible Risk Factor for ED

It has long been established that healthy dietary patterns are associated with reduced risk of disease. New data suggests that erectile dysfunction may also improve by with healthier diet adherence. Esposito et al. (2006) studied 65 men diagnosed with MetS and concomitant ED. After 2 years, 35 men who followed a Mediterranean Diet, composed of less than 10% saturated fat, reported improved erectile function ($P=0.015$), as well as endothelial function, blood glucose and insulin, LDL cholesterol, triglycerides, blood pressure, and serum CRP ($P<0.05$) compared to controls ($N=30$). A new cohort study by Bauer et al. (2020) found significant association between diet and erectile dysfunction, independent of comorbid disease. In this pioneer study, men who most adhered to a Mediterranean Diet had the lowest risk of erectile dysfunction, especially for the youngest age group. Men aged 40-60 years old in the highest quintile of diet adherence had a 22% lower risk of ED compared to the lowest adherence group.
(HR=0.78; 95% CI, 0.66-0.92; P trend <0.002). These studies together have significant implications; they strengthen the evidence that erectile issues are primarily vascular etiologies and suggest that erectile dysfunction may be modifiable, similar to vascular and metabolic diseases.

Erectile Dysfunction in Young Men

Cardiometabolic Disease in Young Men

The prevalence of cardiovascular and metabolic diseases in men under 40 is highly underreported. Chronic disease is becoming more common in this age group and even more so in children. Since the 1970’s adolescent obesity has more than tripled (Ruiz, Zuelch, Dimitratos, & Scherr, 2019; Warren, Beck, & Rayburn, 2018). Data collected from the National Health and Nutrition Examination Survey (NHANES) 2015-2016 stated that 18.5% of youth aged 2-19 years were obese (Fryar, Carroll, & Ogden, 2018; Ruiz et al., 2019). A Centers for Disease Control and Prevention (CDC) study of 8,579 children and young adults stated that 46.9% were overweight and 36.4% of those were classified as obese (CDC, 2017). Adolescent obesity, similar to adult obesity, promotes endothelial dysfunction, insulin resistance, oxidative stress, and vascular atherosclerosis (Celemajer, 1992; Expert Panel, 2011; Moran et al., 1999; Sinaiko et al., 2005). This risk group is highly worrisome in that sudden cardiac death from acute MI is more common in men under 40 years of age (Cleveland Clinic, 2019). A study by McGill, et al. (2000) performed autopsies on young victims of accidents, suicides, or homicides to observe possible evidence of sclerotic lesions. Of the 760 young men and
women, 15-34 years of age, approximately 20% of males showed evidence of advanced atherosclerotic lesions. Another autopsy study by Strong et al. (1999), published that of the 2,876 persons aged 15-34 who died from external causes, nearly every patient showed evidence of fatty streaks and aortic lesions. McGill, et al. (2002) suggests that the process of atherosclerosis begins several decades prior to evidence of disease. It is critical to identify young patients with early signs of vascular disease in order to mitigate disease progression.

Factors contributing to obesity and disease risk in young people mirror those in adults. Thomson et al. (2019) suggests that today’s adolescents consume higher levels of saturated fat than mono or polyunsaturated fat. Other studies have reported that adolescents consume inadequate amounts of fruits and vegetables (Lorson, Melgar-Quinonez, & Taylor, 2009). A cross-sectional investigation of 31,420 boys and girls estimated that 39.8% (95% CI, 35.1% to 44.5%) of 2-5 year olds, 52.5% (95% CI, 46.4% to 58.5%) of 6-11 year olds, and 66.6% (95% CI, 61.4% to 71.4%) of 12 to 19 year olds in the United States consume a poor diet (Liu, Rehem, Onopa, & Mozaffarian, 2020). Young adults, today, are more likely to be sedentary, consume suboptimal diets, and present with many of the risk factors associated with chronic disease.

Erectile Dysfunction in Young Men

There is a paucity of data on prevalence and etiology of ED in young men. According to Rastrelli and Maggi (2017), young men who suffer from erectile issues are largely overlooked by the scientific community. Reports have suggested that between 5 and 11% of men under 40 are diagnosed with erectile dysfunction (Ljungman, 2020;
Ponholzer et al., 2012; Selvin et al., 2007). There are three primary challenges in identifying ED in young men. First, defining parameters and diagnostic tools need to be modified and integrated into clinical settings and research methodologies. ED is currently defined by the National Institutes of Health Consensus Panel as: “the inability to attain and/or maintain penile erection sufficient for satisfactory sexual performance” (NIH, 1992). Including the phrase ‘satisfactory sexual performance’ excludes adolescents, young men, and adults who do not currently engage in intercourse. My study found that 24.5% of men aged 18-31 have not engaged in sexual intercourse in the last 12 months. Under the current definition, these sexually inactive young men would have to speculate their performance ability. Non-coital terms, such as ‘weak masturbatory erections’ or ‘less frequent nocturnal erections’ would be beneficial for self-assessment, history and physical examinations, as well as research analyses (Huang et al., 2014). Second, the definition does not include temporal guidelines, meaning any man having undergone one sub-satisfactory event would fall under dysfunctional parameters. Temporal language defining ED as an acute, intermittent or chronic medical condition would elucidate the severity or duration of erectile issues. Lastly, clinicians lack cohesive diagnostic tools to properly assess ED patients. The IIEF is widely used by clinicians and researchers for ED diagnostics (Rosen et al, 1997). The disadvantage of utilizing this self-reported questionnaire is that 19 of the 20 questions (or 4 of 5 abridged IIEF-5) pertain to recent penetrative intercourse. Additionally, the American Academy of Family Physicians (AAFP) reports than physicians are hesitant to discuss erectile issues due to awkwardness with sexual language, fear of insulting patients, and feeling uncomfortable with the topic (Miller, 2000). Consequently, young men are less likely to report their erectile concerns
to their physician and physicians are less likely to inquire about erectile issues. These obstacles result in unidentified or misdiagnosed cases of ED in young men. If assessment tools are improved and standardized, identifying and treating patients with erectile dysfunction would improve.

ED and Cardiometabolic Disease in Young Men

Many medical resources still suggest that ED is primarily explained by psychogenic pathology in men under 40, related to depressive symptoms or performance anxiety (WebMD, 2020; Medical News Today, 2021). The American College of Cardiology stated that assessment for cardiovascular risk in individuals under 40 years of age is difficult and rarely impressively elevated (Greenland et al., 2010). Alternatively, researchers have stressed the importance of identifying this high-risk cohort, addressing cardiometabolic disease prior to major cardiovascular events. Yao et al. (2013) suggested that young men with erectile issues are a currently unidentified risk group and may be showing early signs of silent and aggressive vascular disease. They studied young men, 20-40 years old, with and without erectile dysfunction. Researchers found a significant increase in disease markers: systolic blood pressure, high-sensitivity CRP, inflammatory biomarkers, CIMT, and lower brachial flow mediated dilation in patients with ED versus controls ($P<0.05$). This study was important in that all biomarkers were significantly higher than controls, although indicators of early CVD and metabolic syndromes were within normal limits, suggesting early subclinical disease. A follow-up study by Yao et al. (2018) included similar cardiovascular parameters, as well as fasting blood glucose and testosterone levels in men under 40. Again, all parameters were within normal limits, though statistically distinct from a non-ED control group ($P<0.05$). Huang et al. (2014)
found that similar subclinical biomarkers for early endothelial dysfunction and insulin resistance were significantly higher in men 18-40 with ED. This study was also seminal, such that researchers also identified a risk group with weaker masturbatory erections as an intermediary cohort with mild erectile issues. This cohort presented with significant elevation of subclinical biomarkers versus healthy controls ($P<0.05$).

In congruence with subclinical biomarkers, further difficulties identifying and diagnosing young patients with ED may result from various manifestations of vascular disease. The Artery Size Hypothesis suggests that because hyperlipidemia and inflammation are systemic diseases, that atherosclerotic plaque would be observed in the penile arteries prior to major coronary arteries due to the vascular size differential (Figure 5) (Montorsi et al., 2005). This study suggests that most men with vascular-related ED would show evidence of ischemia to the penile artery prior to larger coronary, carotid, and femoral arteries. Similarly, studies have concluded that ED in younger men is likely psychological due to lack of evidence of ischemia within the penile arteries. Caskurlu et al. (2004) concluded that 85.2% of men under 40 years of age (N=526) had primarily psychogenic erectile dysfunction after psychiatric evaluation, nocturnal penile tumescence RigiScan and penile Doppler ultrasound found little evidence of penile sclerosis (2004). In contrast, a study by Ponholzer et al. (2012) reported that after autopsy, only 12.9% of cases showed evidence of sclerotic lesions to the penile artery. Researchers found that erectile problems were likely due to afferent internal iliac arterial lesions, found in 77.4% of cases (Figure 6). Although erectile symptoms may precede larger artery disease, as presented in the Artery Size Hypothesis, vascular issues often
adversely affect various arteries, similar to cases where cerebrovascular ischemia presents prior to cardiovascular ischemia.

Figure 5. Artery size hypothesis

Montorsi et al. (2005) suggests that because the penile arteries are smaller in diameter it is likely that ED will present as an early manifestation of vascular disease prior to CVD symptoms and ischemia of larger arteries.

Consequently, penile Doppler ultrasound is likely not a sufficient measure of penile sclerosis. ED as a result of vascular ischemia is difficult to diagnosis, especially in young patients who may not present with any other biomarkers for disease. In middle-aged and older men, ED is primarily the result of atherosclerosis, CIMT, hyperlipidemia, CAC, chronic inflammation, hyperglycemia, or a combination thereof (Besiroglu et al., 2015; Raheem, Su, Wilson, & Hsieh, 2017; Rosen et al., 2004; Selvin et al., 2007). Follow-up studies are needed to confirm that ED in younger men is an early manifestation of vascular or metabolic disease. If ED is partially or primarily vascular in young men, it is
likely that this cohort is being misdiagnosed with psychological pathology, and will likely continue on a trajectory toward clinical disease.

Figure 6. Presence of obstructive atherosclerosis in various arteries.

A diagram representing prevalence of sclerotic obstruction post autopsy. Of the 31 men, coronary atherosclerosis was detectable in 87.1% of cases; obstruction of the iliac artery was observed in 77.4% of men, arterial lesions of the penile arterial system were found in 12.9% of men (Ponholzer et al., 2012).

Diet as a Risk Factor for ED in Young Men

Decidedly, ED and vascular diseases are highly interrelated. Lifestyle factors that contribute to the onslaught of cardiometabolic disease are also shared with ED in middle-aged and older men. It is currently unclear if these findings are generalizable to younger men as well. Plant-based dietary patterns have previously shown an association with
lower risk of vascular and metabolic disease, as well as inflammatory mediators. 
Therefore, in this study, I evaluated the relationship between a plant-based dietary pattern and erectile dysfunction in men 18-31 years of age. To my knowledge, this is the first study to determine the impact of diet on erectile dysfunction in young men. We hypothesized that greater adherence to a plant-based diet was correlated with lower risk of ED among men in this study. To test this hypothesis I utilized multivariable regression analyses to assess various models of association between plant-based diet adherence and risk of erectile dysfunction in 1,964 men from the GUTS cohort. There are many significant implications of an observed association between diet and erectile dysfunction in this age group: 1) incorporating healthy dietary patterns could decrease severity and incidence of ED in young men and mollify future erectile issues, 2) erectile function improvement with lifestyle modification may be an advantageous, non-invasive method for diagnostic identification of ED pathology, and 3) prevention, identification, and treatment of ED with plant-based diet adherence could mitigate future risk of metabolic and vascular diseases.
Chapter II.

Materials and Methods

Study Population

The Growing Up Today Study (GUTS) is a prospective study that began in 1996 in succession to the regarded Nurses’ Health Study instituted by researchers at Brigham and Women’s Hospital and Harvard T.H. Chan School of Public Health (GUTS, n.d.). The cohort included 16,882 children between the ages of 9 and 14 and was expanded in 2004, when an additional 10,923 children ages 10 to 17 were added to a second GUTS II cohort. Enrollees completed a variety of demographic, lifestyle, anthropometric, medical, and food-frequency questions biennially. Follow-up for both cohorts was merged in 2011, when participants of both cohorts had reached adulthood and the combined cohort kept the name GUTS. Of the 27,805 potential participants in GUTS, 2,431 males returned questionnaires in 2011 and 2013. Some participants were excluded due to invalid questionnaires leaving 1,964 men aged 18-31 who were included in this analysis. The institutional review boards of Harvard T.H. Chan School of Public Health and Brigham Women’s and Children Hospital approved this study and consent is obtained upon enrollment into the study.
Dietary Pattern Scores

Diet was assessed in 2011 using a previously validated Food Frequency Questionnaire (FFQ). The 2011 FFQ included approximately 178 food, beverage, and supplement frequency questions. Participants were asked to approximate frequency of consumption of a standard serving size of each food and beverage in the questionnaire in categories ranging from never or less than once per month, to greater-than or equal to six servings per day. Blank questions from the 2011 food frequency questionnaire (FFQ) were assigned zeros, assuming the participant does not consume the food or beverage. Following convention from previous studies, participants in this cohort who skipped more than 70 food items and had estimated total energy intakes below 800 or above 4200 kcal/day were excluded, as their responses were considered invalid (Rimm et al., 1992; Yuan et al., 2019). For the purposes of this study I utilized an overall plant-based dietary approach to exclude saturated fat or cholesterol that may contribute to vascular disease processes. Plant-based dietary pattern scores were calculated similarly to previously reported methods (Kim et al., 2019; Martinez-Gonzalez et al., 2014; Satija et al., 2016; Satija et al., 2017) where food frequencies were converted to servings per day and grouped into categories based on primary components: animal fat, eggs, dairy, meat, seafood, fruit juice, refined grains, potatoes, sugar-sweetened beverages, sugar-based foods, hydrogenated oils, whole grains, fruit, vegetables, nuts, legumes, non-hydrogenated oils, coffee and tea (Table 1). Each category was then ranked into quintiles based on lowest-to-highest intake of each category. Foods that are primarily composed of animal-based products received descending scores (5 to 1), such that low intake of animal-based foods received higher scores and high intake received lower scores. Plant-
Based food quintiles received ascending scores (1 to 5), where low intake of plant-based foods received low scores and higher intake received higher scores. Animal-based food quintiles received descending scores (5 to 1), where low intake of animal-based foods received low scores and higher intake received higher scores. Each individual was assigned a total score according to adherence of plant-based diet intake.
Table 1. Servings and scores attributed to food categories.

<table>
<thead>
<tr>
<th>Category</th>
<th>Food items</th>
<th>Servings per day, range</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Q1</td>
<td>Q5</td>
</tr>
<tr>
<td>ANIMAL FOODS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal fat</td>
<td>Butter, spreadable butter, lard for cooking</td>
<td>0.00 - 0.00</td>
<td>0.43 - 4.57</td>
</tr>
<tr>
<td>Eggs</td>
<td>Eggs, egg whites, light mayonnaise, mayonnaise</td>
<td>0.00 - 0.08</td>
<td>0.84 - 8.50</td>
</tr>
<tr>
<td>Dairy</td>
<td>Milk, chocolate milk, whipped cream, frozen yogurt, yogurt, pudding, ice</td>
<td>0.00 - 1.74</td>
<td>4.77 - 14.79</td>
</tr>
<tr>
<td></td>
<td>cream, ice cream, cheese, pizza, chocolate, chowder, dressing, dairy-based</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>meal replacement &amp; coffee drinks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meat</td>
<td>Hotdogs, chicken or turkey dogs, meat sandwiches, meat-based mixed dinnersatte</td>
<td>0.00 - 0.91</td>
<td>2.98 - 17.60</td>
</tr>
<tr>
<td></td>
<td>bacon, hamburgers, liver, meat burritos &amp; pasta dishes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seafood</td>
<td>Canned tuna, fish sticks or cakes, shrimp, fish</td>
<td>0.00 - 0.04</td>
<td>0.42 - 8.08</td>
</tr>
<tr>
<td>Overall animal foods</td>
<td></td>
<td>0.00 - 3.73</td>
<td>8.73 - 30.82</td>
</tr>
<tr>
<td>HEALTHY PLANT FOODS</td>
<td>Popcorn, rye bread, whole meal bread, tortillas, whole grain crackers, oatmeal, cooked breakfast cereals, brown rice, veggie burgers, oat bran, wheat germ, protein bars</td>
<td>0.00 - 0.64</td>
<td>2.78 - 10.64</td>
</tr>
<tr>
<td>Fruit</td>
<td>Raisins, grapes, prunes, bananas, plantains, melons, avocado, apples or</td>
<td>0.00 - 0.42</td>
<td>1.99 - 11.42</td>
</tr>
<tr>
<td></td>
<td>pears, applesauce, citrus, berries, peaches, apricots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetables</td>
<td>Cauliflower, cabbage, Brussels sprouts, carrots, corn, yams, squash, dark</td>
<td>0.00 - 1.18</td>
<td>4.32 - 22.73</td>
</tr>
<tr>
<td></td>
<td>greens, spinach, lettuce, celery, peppers, onions, tomatoes, broccoli,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>garlic, vegetable sandwich, burrito, mixed dish or pasta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nuts &amp; Seeds</td>
<td>Flaxseed, peanut butter, peanuts, walnuts, other nuts or seeds, peanut</td>
<td>0.00 - 0.12</td>
<td>1.14 - 11.71</td>
</tr>
<tr>
<td></td>
<td>butter sandwich</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legumes</td>
<td>String beans, beans, lentils, tofu, soy burger, peas, lima beans, soy</td>
<td>0.00 - 0.07</td>
<td>0.64 - 8.15</td>
</tr>
<tr>
<td></td>
<td>milk, tofu burrito or mixed dish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non hydrogenated oils</td>
<td>Olive oil, vegetable oil, low-calorie salad dressing</td>
<td>0.00 - 0.00</td>
<td>0.43 - 5.08</td>
</tr>
<tr>
<td>Tea &amp; coffee</td>
<td>Tea, decaf tea, coffee, decaf coffee</td>
<td>0.00 - 0.00</td>
<td>2.07 - 14.10</td>
</tr>
<tr>
<td>Overall healthy plant foods</td>
<td></td>
<td>0.08 - 4.24</td>
<td>12.53 - 40.48</td>
</tr>
<tr>
<td>LESS HEALTHY PLANT FOODS</td>
<td>Apple, orange, prune or other fruit juices, smoothies</td>
<td>0.00 - 0.11</td>
<td>1.01 - 8.57</td>
</tr>
<tr>
<td>Refined grains</td>
<td>White bread, crackers, bagels, English muffins, white rice, pasta,</td>
<td>0.00 - 0.60</td>
<td>1.87 - 8.58</td>
</tr>
<tr>
<td></td>
<td>breakfast cereal, pretzels, noodle soup, Pop-Tarts®</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potatoes</td>
<td>French fries, mashed potatoes, potato chips, potato salad</td>
<td>0.00 - 0.20</td>
<td>0.78 - 6.07</td>
</tr>
<tr>
<td>Hydrogenated oils</td>
<td>Margarine, vegetable shortening</td>
<td>0.00 - 0.00</td>
<td>0.29 - 2.50</td>
</tr>
<tr>
<td>SSB</td>
<td>Soda, lemonade, fruit punch, vitamin water, sports drinks, energy drinks</td>
<td>0.00 - 0.28</td>
<td>2.57 - 27.09</td>
</tr>
<tr>
<td>Sugar-based foods</td>
<td>Candy, dark chocolate, fruit snacks, popsicles, jams, honey, ketchup,</td>
<td>0.00 - 0.00</td>
<td>1.68 - 20.00</td>
</tr>
<tr>
<td></td>
<td>sugar, muffins, cakes, pastries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall less healthy plant foods</td>
<td></td>
<td>0.14 - 2.69</td>
<td>7.41 - 30.65</td>
</tr>
</tbody>
</table>

Food items categorized based on primary components. Range of servings/day from 2011 GUTS FFQ. Scores according to overall plant-based diet adherence similar to other studies (Kim et al., 2019; Martinez-Gonzalez et al., 2014; Satija et al., 2016; Satija et al., 2017).
Outcome Assessment

Erectile function was assessed in the 2013 follow-up questionnaire utilizing five self-reported questions that correspond to the International Index of Erectile Function-5 (IIEF-5). The IIEF-5 is an abridged validated series of questions used as a tool for diagnostic assessment of erectile function (Figure 7) (Rosen et al., 1997). The five questions as part of the IIEF-5 quantify ability, confidence, frequency, firmness, and duration of erectile function on a scale of 1-5. The total numerical score is categorized into the following descriptors: a score of 5-7 is interpreted as “severe ED”; 8-11 “moderate ED”; 12-16 “mild to moderate ED”; 17-21 “mild ED;” and 22-25 “no ED.” In this study outcome ED scores were categorized as binary outcomes: 5-21 labeled “any ED” or 5-16 labeled “moderate to severe ED.” Participants who left all erectile function questions blank, and IIEF-5 question one, pertaining to erectile confidence were excluded (N=467). Of the 5 erectile function questions, questions 2-4 pertain to recent intercourse; therefore if questions 2-4 were left blank I matched the missing score to the first question, the only question not pertaining to recent intercourse. If the first IIEF-5 question was left blank, the record was not included.
Figure 7. International Erectile Function-5 (IIEF-5) Scoring System

<table>
<thead>
<tr>
<th>Over the past six months:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>How do you rate your confidence that you can get and keep an</td>
<td>Very low</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>Very high</td>
</tr>
<tr>
<td>erection?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When you had erections with sexual stimulation, how often were</td>
<td>Almost never</td>
<td>Much less</td>
<td>About</td>
<td>Much more</td>
<td>Almost</td>
</tr>
<tr>
<td>your erections hard enough for penetration?</td>
<td>or never</td>
<td>than half</td>
<td>half the</td>
<td>than half</td>
<td>always</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td></td>
</tr>
<tr>
<td>During sexual intercourse how often were you able to maintain</td>
<td>Almost never</td>
<td>Much less</td>
<td>About</td>
<td>Much more</td>
<td>Almost</td>
</tr>
<tr>
<td>your erection after you had penetrated (entered) your partner?</td>
<td>or never</td>
<td>than half</td>
<td>half the</td>
<td>than half</td>
<td>always</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td></td>
</tr>
<tr>
<td>During sexual intercourse how difficult was it to maintain your</td>
<td>Extremely</td>
<td>Very</td>
<td>Difficult</td>
<td>Slightly</td>
<td>Not</td>
</tr>
<tr>
<td>erection to the completion of intercourse?</td>
<td>difficult</td>
<td>difficult</td>
<td>difficult</td>
<td>difficult</td>
<td>difficult</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When you attempted sexual intercourse, how often was it</td>
<td>Almost never</td>
<td>Much less</td>
<td>About</td>
<td>Much more</td>
<td>Almost</td>
</tr>
<tr>
<td>satisfactory for you?</td>
<td>or never</td>
<td>than half</td>
<td>half the</td>
<td>than half</td>
<td>always</td>
</tr>
<tr>
<td></td>
<td>time</td>
<td>time</td>
<td>time</td>
<td>time</td>
<td></td>
</tr>
</tbody>
</table>

The IIEF-5 score is the sum of questions 1 to 5. The lowest score is 5 and the highest score is 25 (Rosen et al., 1997).

Covariate Assessment

Models included covariate assessments based on previously reported health or demographic correlates related to erectile dysfunction (Calzo et al., 2021; Bauer et al., 2020; Kim et al., 2019) or correlates significantly influencing distribution variation (Table 2). Final models were adjusted for: age (years), calories (kcal/day), race/ethnicity (white/other), cigarette smoking at least weekly (yes/no), sexual activity in the past 12 months (yes/no), marital status or living with partner (yes/no), alcohol intake (svg/day), body mass index (BMI kg/m²; <25, ≥25), any previous cardiometabolic disease diagnosis (diabetes, hypertension, high cholesterol and/or high triglycerides) or
associated medication use (insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs) (yes/no), any previous anxiety or depression diagnoses or associated medication use (SSRI’s, minor tranquilizers, other antidepressants) (yes/no), and/or taking any supplements (multivitamin, vitamin A, vitamin D, vitamin B6, vitamin C, potassium, vitamin E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil) (yes/no).

Data Analysis

Baseline characteristics, nutrient intake, and other health correlates were compared across quartiles of adherence to a plant-based diet among 1,964 men (Table 2). Nutrient intake was estimated based on the USDA nutrient composition database as the product of the food item and the corresponding nutrient content (Arvizu et al., 2020; USDA, 2018). I assessed distribution variation via ANOVA for continuous outcomes or chi-squared analyses for dichotomous correlates. Multivariate-adjusted relative risk (RR) and 95% confidence intervals (95% CI) were estimated via binomial regression with the log link function (Skov, Deddens, Petersen, & Endahal, 1998; Wacholder, 1986) by levels of erectile dysfunction according to quartiles of plant-based diet adherence. Furthermore, I conducted sensitivity analyses among related correlates to examine the robustness of my results, as well as evaluating interaction between variables to assess effect modification by age (≥ 25/< 25), sexual activity in the past 12 months (yes/no), and married or living with partner (yes/no). Data was analyzed with SAS® 9.4 and SAS® Viya® 3.5 (SAS, 2021).
Chapter III.

Results

Baseline Demographic and Health Correlates

Baseline demographic and health correlates were reported for the overall cohort and across quartiles of adherence to plant-based diet scores (Table 2). Demographics showed similarity across quartiles. Men in the highest quartiles of adherence to a plant-based diet were more sexually active, more likely to be married or living with a partner, and were less likely to smoke cigarettes compared to the lowest quartile of adherence. As expected, differences in macronutrients were observed across quartiles of plant-based diet adherence. The highest quartile of plant-based diet adherence showed lower cholesterol intake (-115.7±89.9 g/d), saturated fat intake (-6.1±1.1 g/d), as well as higher crude fiber intake (+2.5±0.5 g/d) and carbohydrate intake (+37.1±12.1 g/d) compared to the lowest quartile. Monounsaturated fat intake was slightly lower in the highest quartile of plant-based adherence (-1.1±0.5 g/d) and polyunsaturated fat only slightly higher (+0.4±0.5 g/d). Total energy intake was appreciably more in the highest plant-based adherence quartile compared to the lowest (+826.4±105.3 kcal/d), although BMI was only slightly higher in the highest adherence group (+0.4±0.8 kg/m2). This discrepancy is likely due to an increase in carbohydrate consumption across quartiles (+37.1±12.1 g/d). An increase in history of cardiometabolic disease diagnosis or related medication use was observed across quartiles, which is likely the result of diet modification post diagnosis. Anxiety/depression diagnosis or associated medications were similar across quartiles. In
this study, 19.5% of men (N=382) ages 18-31 self-reported any erectile dysfunction (IIEF-5 score=5-21). Of these men, 4.7% (N=92) reported moderate to severe erectile dysfunction (IIEF-5 score=5-16). A 5.7% reduction in any erectile dysfunction was observed among men in the highest plant-based adherence quartile compared to the lowest adherence quartile.
<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>Quartile 1</th>
<th>Quartile 2</th>
<th>Quartile 3</th>
<th>Quartile 4</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
<td>1,964</td>
<td>453</td>
<td>511</td>
<td>513</td>
<td>487</td>
<td></td>
</tr>
</tbody>
</table>

**Demographic Correlates**

| Age at baseline, years         | 24.7 (3.7) | 25.2 (3.5) | 24.9 (3.6) | 24.5 (3.8) | 24.4 (3.7) | <0.05   |
| White, n (%)                   | 96.3      | 94.7       | 97.3       | 96.5       | 96.7       | 0.18    |
| BMI, kg/m²                      | 25.9 (4.4) | 25.8 (5.1) | 26.2 (4.1) | 25.4 (4.0) | 26.2 (4.3) | 0.65    |
| Sexually active in the last 12 months, n (%) | 75.5 | 73.1       | 70.5       | 77.4       | 81.1       | <0.001  |
| Currently married or living with partner, n (%) | 27.3 | 21.2       | 22.7       | 31.8       | 33.1       | <0.0001 |

**Health Correlates**

| Total energy intake, kcal/d | 2113.7 (815.3) | 1716.5 (704.6) | 1934.6 (700.7) | 2235.1 (797.7) | 2543.2 (809.9) | <0.0001 |
| Taking multivitamin, n (%)   | 39.8       | 36.2       | 38.2       | 40.4       | 44.4       | 0.06    |
| Other supplement, n (%)      | 25.7       | 23.4       | 21.5       | 26.9       | 30.8       | 0.05    |
| Total protein, g/d           | 98.6 (22.3) | 107.8 (27.7) | 98.5 (21.3) | 97.8 (19.8) | 90.8 (16.4) | <0.0001 |
| Animal protein, g/d          | 68.1 (24.3) | 82.7 (28.1) | 69.6 (21.3) | 66.7 (19.9) | 54.5 (19.3) | <0.0001 |
| Vegetable protein, g/d       | 30.6 (9.3)  | 25.5 (7.7)  | 29.2 (7.8)  | 31.2 (7.7)  | 36.2 (10.4) | <0.0001 |
| Total fat, g/d               | 71.5 (13.1) | 75.7 (13.8) | 71.9 (12.6) | 70.5 (12.3) | 68.1 (12.5) | <0.0001 |
| Animal fat, g/d              | 33.7 (10.8) | 40.8 (11.3) | 35.0 (9.3)  | 32.3 (9.1)  | 27.3 (9.0)  | <0.0001 |
| Vegetable fat, g/d           | 37.8 (11.3) | 35.1 (11.4) | 37.0 (10.8) | 38.3 (11.0) | 40.8 (11.4) | <0.0001 |
| Monounsaturated fat, g/d      | 24.9 (5.7)  | 25.6 (5.6)  | 24.9 (5.4)  | 24.7 (5.8)  | 24.5 (6.1)  | 0.02    |
| Polyunsaturated fat, g/d      | 15.4 (3.7)  | 15.3 (3.8)  | 15.3 (4.0)  | 15.4 (3.6)  | 15.7 (3.3)  | 0.35    |
| Saturated fat, g/d            | 25.4 (6.0)  | 28.6 (6.3)  | 26.0 (5.5)  | 24.6 (5.4)  | 22.5 (5.2)  | <0.0001 |
| Carbohydrates, g/d           | 279.8 (45.1) | 259.1 (49.9) | 279.1 (45.0) | 283.2 (39.8) | 296.2 (37.8) | <0.0001 |
| Fiber, crude, g/d            | 5.8 (2.2)   | 4.5 (1.7)   | 5.5 (2.1)   | 6.1 (2.0)   | 7.0 (2.2)   | <0.0001 |
| Cholesterol, g/d             | 261.0 (119.9) | 325.3 (168.4) | 264.2 (98.7) | 249.7 (90.4) | 209.6 (78.5) | <0.0001 |

**Substance Use**

| Smoking, at least weekly, n (%) | 6.6  | 9.7  | 4.9  | 6.0  | 6.2  | 0.02 |
| Alcohol, svg/d                 | 0.5 (0.6) | 0.5 (0.6) | 0.5 (0.6) | 0.5 (0.6) | 0.5 (0.6) | 0.91 |

**Medical Conditions**

| Cardiometabolic diagnosis or medication, n (%) | 12.4 | 9.5  | 9.6  | 15.8 | 14.6 | <0.05 |
| Anxiety/depression diagnosis or medication, n (%) | 14.4 | 14.6 | 14.1 | 13.3 | 15.8 | 0.71 |

Demographic, lifestyle, anthropometric, and medical characteristics among young men in the Growing Up Today Study according to plant-based diet adherence quartiles (N=1,964).

Values derived from 2013 unless otherwise noted. Continuous variables presented as means (SD). 1 Values derived from 2011. 2 Supplements: vit A, vit D, vit B6, vit C, potassium, vit E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil. 3 Cardiometabolic disease diagnosis and/or medication: diabetes, hypertension, high cholesterol, or triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs. 4 Anxiety and/or depression diagnosis and/or regular medication: SSRIs, other antidepressants, minor tranquilizers.

Abbreviations: kg/m², kilograms per meter squared; g/d, grams per day; svg/d, servings per day; vit, vitamin
Main Findings

Figure 8 summarizes the prospective association between adherence to a plant-based diet, modeled in quartiles, and risk of erectile dysfunction. Greater adherence to this diet pattern was associated to a lower risk of any erectile dysfunction across increasing adherence quartiles ($P_{\text{trend}}=0.007$), after adjustment for age (years) and total daily energy intake (kcal/day) (Figure 8). Further adjustment for race/ethnicity, sexual activity, marital status, smoking status, history of cardiometabolic disease diagnosis or medication use did not significantly change associations ($P_{\text{trend}}=0.04$). A 26% lower risk in erectile dysfunction is observed in the highest quartile of adherence to a plant-based diet relative to the lowest quartile of adherence (RR=0.74; 95% CI, 0.52 to 1.06). While the top to bottom quartile comparison failed to reach statistical significance, the linear trend across quartiles of adherence did meet statistically significant criteria ($P_{\text{trend}}=0.04$).
Figure 8. Multivariable-adjusted association of plant-based diet adherence score quartiles with risk of any erectile dysfunction.

Figures demonstrate relative risk (RR) and 95% confidence intervals (CI) of any erectile dysfunction (IIEF-5 score=5-21) among men 18-31 according to plant-based diet adherence score quartiles from the Growing Up Today Study (N=1,964).

a. Age (years) and energy (kcal/day) adjusted. b. Model further adjusted for calories per day (kcal/d); age (continuous); race (white or other); sexual activity in the last 12 months; married or currently living with partner; cigarette smoking at least weekly; cardiometabolic disease diagnosis or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs).
Various Modeling Strategies

Results are consistent when ED is defined with stricter parameters (IIEF-5 score 5-16) (Table 3). A 46% lower risk in ED was observed in the highest quartile compared to the lowest quartile of adherence (RR=0.54; 95% CI, 0.27 to 1.08), after adjusting for age, energy, race, smoking status, sexual activity, cardiometabolic disease diagnosis or medication use, alcohol, supplement intake, anxiety/depression diagnosis or medication use. As was the case in the preliminary analysis, the top to bottom quartile comparison failed to reach conventional levels of statistical significance but the test for linear trend did reach this threshold.

Similar inverse associations were observed between increasing quartiles of adherence to plant-based foods and risk of ED when stratified by age, sexual activity, and marital status (Table 4). Multivariate adjusted $P$ values for trend results were less robust in some strata, although lower risk of ED was observed across quartiles. Interaction terms between strata of age ($P=0.90$), recent sexual activity ($P=0.85$), or living arrangement ($P=0.18$) demonstrated no evidence of effect modification. Models for interaction for covariates with low numbers of observations, such as cardiometabolic disease diagnosis or associated medication use (N=42) or smoking cigarettes at least weekly (N=26), did not converge (data not shown).

Table 5 further confirms consistent inverse linear relationships between moderate or severe erectile dysfunction and plant-based adherence scores after adjustment with multiple modeling strategies. Furthermore, table 6 demonstrates that when omitting men
with mild symptoms of erectile dysfunction (N=290), age and energy-adjusted models, as well multivariate adjusted models still show evidence of linearity. I then used quintiles, rather than quartiles of adherence to evaluate the robustness of the findings to choice of cutoff values. Again, linear relationships were observed for risk of any ED (Table 7), as well as the more severe phenotype (Table 8) when plant-based diet adherence was divided into quintiles after adjusting for age and energy, as well as multivariate adjustment.

When food categories were re-scored as animal-based foods, healthy plant-based foods, and unhealthful plant-based foods, similar to studies published by Kim et al., (2019) and Satija et al. (2016), the overall trends were consistent with previous results, although trend statistics were less significant (Figure 8). A general upward trend in risk of erectile dysfunction was observed in association with animal-based foods after adjustment, though linear trends were not statistically significant ($P_{\text{trend}}=0.69$). Furthermore, healthy plant-based and unhealthy plant-based show inverse linear relationships between risk of erectile dysfunction and healthy or unhealthy plant-based adherence though also not statistically significant ($P_{\text{trend}}= 0.11, 0.05$; respectively).
Table 3. Multivariable-adjusted association of plant-based adherence score quartiles with risk of moderate to severe erectile dysfunction.

<table>
<thead>
<tr>
<th>Plant-Based Diet Index</th>
<th>No. Cases/Total Men</th>
<th>Adjusted for age, energy intake (kcal/d)</th>
<th>Multivariate Adjusted Model 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>28/453</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Q2</td>
<td>29/511</td>
<td>0.90 (0.53 to 1.55)</td>
<td>0.85 (0.49 to 1.49)</td>
</tr>
<tr>
<td>Q3</td>
<td>20/513</td>
<td>0.61 (0.33 to 1.12)</td>
<td>0.64 (0.35 to 1.18)</td>
</tr>
<tr>
<td>Q4</td>
<td>15/487</td>
<td>0.51 (0.26 to 1.01)</td>
<td>0.54 (0.27 to 1.08)</td>
</tr>
</tbody>
</table>

*P for trend* 0.03 0.05

Cell contents are adjusted relative risk (RR) and 95% confidence intervals (CI) of moderate to severe erectile dysfunction (IIEF-5 score=5-16) among men 18-31 according to plant-based diet adherence score quartiles from the Growing Up Today Study (N=1,964).

Multivariate model 1 adjusted for calories per day (kcal/d); age (continuous). Model 2 further adjusted for race (white or other); sexual activity in the last 12 months; married or currently living with partner; cigarette smoking at least weekly; cardiometabolic disease diagnosis or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs).
Table 4. Multivariate-adjusted association of plant-based diet adherence score quartiles with risk of any erectile dysfunction stratified by age, sexual activity, and marital status.

<table>
<thead>
<tr>
<th>Stratified cohort</th>
<th>Cases / Total</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>P Trend</th>
<th>P Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age ≥ 25</td>
<td>157/1016</td>
<td>Ref.</td>
<td>0.97 (0.58 to 1.55)</td>
<td>0.70 (0.42 to 1.23)</td>
<td>0.61 (0.35 to 1.42)</td>
<td>0.04</td>
<td>0.90</td>
</tr>
<tr>
<td>Age &lt; 25</td>
<td>225/948</td>
<td>Ref.</td>
<td>1.01 (0.66 to 1.35)</td>
<td>0.77 (0.81 to 1.01)</td>
<td>0.86 (0.53 to 1.08)</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Sexually active past 12 mo.</td>
<td>192/1483</td>
<td>Ref.</td>
<td>0.88 (0.57 to 1.89)</td>
<td>0.64 (0.41 to 1.43)</td>
<td>0.68 (0.43 to 1.45)</td>
<td>0.06</td>
<td>0.85</td>
</tr>
<tr>
<td>Not sexually active past 12 mo.</td>
<td>190/481</td>
<td>Ref.</td>
<td>1.14 (0.69 to 2.18)</td>
<td>0.82 (0.47 to 1.16)</td>
<td>0.80 (0.44 to 1.16)</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Married or living with partner</td>
<td>41/536</td>
<td>Ref.</td>
<td>0.85 (0.33 to 1.43)</td>
<td>0.46 (0.18 to 1.13)</td>
<td>0.41 (0.14 to 1.19)</td>
<td>0.05</td>
<td>0.18</td>
</tr>
<tr>
<td>Not married or living with partner</td>
<td>341/1428</td>
<td>Ref.</td>
<td>1.02 (0.73 to 6.38)</td>
<td>0.78 (0.54 to 1.92)</td>
<td>0.81 (0.55 to 1.82)</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>

*Cell contents are adjusted relative risk (RR) and 95% confidence intervals (CI) of any erectile dysfunction (IIEF-5 score=5-21) among men 18-31 according to plant-based diet adherence score quartiles from the Growing Up Today Study (N=1,964).*

Multivariable model adjusted for calories per day (kcal/d); age (continuous); race (white or other); sexual activity in the last 12 months; married or currently living with partner; cigarette smoking at least weekly; cardiometabolic disease diagnosis and/or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs). Associations not adjusted for stratified variable.
# Table 5. Multivariable-adjusted association of plant-based adherence score quartiles with risk of any erectile dysfunction

<table>
<thead>
<tr>
<th>Plant-Based Diet Index</th>
<th>No. Cases/Total Men</th>
<th>Adjusted for age (years), energy intake (kcal/d)</th>
<th>Multivariate Adjusted Model 2</th>
<th>Multivariate Adjusted Model 3</th>
<th>Multivariate Adjusted Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>100/453</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Q2</td>
<td>116/511</td>
<td>1.02 (0.75 to 1.38)</td>
<td>0.99 (0.72 to 1.37)</td>
<td>1.00 (0.72 to 1.38)</td>
<td>1.00 (0.72 to 1.38)</td>
</tr>
<tr>
<td>Q3</td>
<td>86/513</td>
<td>0.70 (0.50 to 0.97)</td>
<td>0.73 (0.52 to 1.03)</td>
<td>0.74 (0.52 to 1.05)</td>
<td>0.74 (0.52 to 1.05)</td>
</tr>
<tr>
<td>Q4</td>
<td>80/487</td>
<td>0.69 (0.49 to 0.97)</td>
<td>0.74 (0.52 to 1.06)</td>
<td>0.74 (0.51 to 1.06)</td>
<td>0.74 (0.51 to 1.06)</td>
</tr>
</tbody>
</table>

$P$ for trend 0.007 0.04 0.04 0.04

*Cell contents demonstrate relative risk (RR) and 95% confidence intervals (CI) of any erectile dysfunction (IIEF-5 score=5-21) among men 18-31 according to plant-based diet adherence score quartiles from the Growing Up Today Study (N=1,964).*

Model 2 further adjusted for age (continuous); energy intake (kcal/d); race (white or other); cigarette smoking at least weekly; sexual activity in the last 12 months; married or currently living with partner, cardiometabolic disease diagnosis and/or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs).

Model 3 further adjusted for alcohol intake at baseline (svg/d); taking any supplements (multivitamin, vitamin A, vitamin D, vitamin B6, vitamin C, potassium, vitamin E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil); depression/anxiety diagnosis and/or medication use (SSRIs, other antidepressants, minor tranquilizers).

Multivariable Model 4 further adjusted for BMI $\geq$ 25.
Table 6. Multivariable-adjusted association of plant-based adherence score quartiles with risk of moderate to severe erectile dysfunction, omitting mild phenotype.

<table>
<thead>
<tr>
<th>Plant-Based Diet Index</th>
<th>No. Cases/Total Men</th>
<th>Adjusted for age (years), energy intake (kcal/d)</th>
<th>Multivariate Adjusted Model 2</th>
<th>Multivariate Adjusted Model 3</th>
<th>Multivariate Adjusted Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>28/381</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Q2</td>
<td>29/424</td>
<td>0.93 (0.54 to 1.59)</td>
<td>0.87 (0.49 to 1.54)</td>
<td>0.89 (0.50 to 1.58)</td>
<td>0.89 (0.50 to 1.58)</td>
</tr>
<tr>
<td>Q3</td>
<td>20/447</td>
<td>0.59 (0.35 to 1.08)</td>
<td>0.63 (0.34 to 1.16)</td>
<td>0.65 (0.34 to 1.22)</td>
<td>0.64 (0.34 to 1.22)</td>
</tr>
<tr>
<td>Q4</td>
<td>15/422</td>
<td>0.49 (0.28 to 0.97)</td>
<td>0.56 (0.28 to 1.10)</td>
<td>0.58 (0.29 to 1.17)</td>
<td>0.58 (0.29 to 1.17)</td>
</tr>
</tbody>
</table>

P for trend 0.02 0.05 0.08 0.08

Cell contents are demonstrate relative risk (RR) and 95% confidence intervals (CI) of moderate to severe erectile dysfunction (IIEF-5 score=5-16) omitting mild phenotype (IIEF-5 score 17-21) among men 18-31 according to plant-based diet adherence score quartiles from the Growing Up Today Study (N=1,674).

Model 2 adjusted for age (continuous); energy intake (kcal/d); race (white or other); cigarette smoking at least weekly; sexual activity in the last 12 months; married or currently living with partner, cardiometabolic disease diagnosis and/or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other antihypertensive, statins, other cholesterol lowering drugs).

Model 3 further adjusted for alcohol intake at baseline (svg/d); taking any supplements (multivitamin, vitamin A, vitamin D, vitamin B6, vitamin C, potassium, vitamin E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil); depression/anxiety diagnosis and/or medication use (SSRIs, other antidepressants, minor tranquilizers).

Multivariable Model 4 further adjusted for BMI ≥ 25.
Figure 9. Multivariate adjusted association of plant-based adherence score quartiles with risk of any erectile dysfunction, stratified by diet category.

Figures demonstrate multivariate adjusted relative risk (RR) and 95% confidence intervals (CI) of any erectile dysfunction (IIEF-5 score=5-21) among men 18-31 according to adherence quartiles by animal, healthy, and less healthy diet scores.

Figure 9a. Independent variable, animal-based foods quartiles. Animal foods include food: animal fat, eggs, dairy, meat, and seafood. Figure 9b. Independent variable, healthy plant-based foods quartiles. Healthy plant foods include: whole grains, fruit, vegetables, nuts, seeds, legumes, non-hydrogenated oils, coffee and tea. Figure 9c. Independent variable, less healthy plant-based foods quartiles. Less healthy plant foods: fruit juices, refined grains, potatoes, hydrogenated oils, sugar-sweetened beverages, and sugar-based foods (Table 1).

Multivariate adjusted for age (continuous); energy intake (kcal/d); race (white or other); cigarette smoking at least weekly; sexual activity in the last 12 months; married or currently living with partner, cardiometabolic disease diagnosis and/or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs).
Table 7. Multivariable-adjusted association of plant-based adherence score quintiles with risk of any erectile dysfunction.

<table>
<thead>
<tr>
<th>Plant-Based Diet Index</th>
<th>No. Cases/Total Men</th>
<th>Adjusted for age, energy intake (kcal/d)</th>
<th>Multivariate Adjusted Model 2</th>
<th>Multivariate Adjusted Model 3</th>
<th>Multivariate Adjusted Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>76/354</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Q2</td>
<td>92/396</td>
<td>1.10 (0.78 to 1.56)</td>
<td>1.03 (0.71 to 1.48)</td>
<td>1.01 (0.70 to 1.46)</td>
<td>1.01 (0.70 to 1.46)</td>
</tr>
<tr>
<td>Q3</td>
<td>84/425</td>
<td>0.89 (0.62 to 1.27)</td>
<td>0.96 (0.59 to 1.26)</td>
<td>0.87 (0.59 to 1.27)</td>
<td>0.87 (0.59 to 1.27)</td>
</tr>
<tr>
<td>Q4</td>
<td>65/398</td>
<td>0.71 (0.49 to 1.03)</td>
<td>0.75 (0.51 to 1.11)</td>
<td>0.74 (0.50 to 1.10)</td>
<td>0.74 (0.50 to 1.10)</td>
</tr>
<tr>
<td>Q5</td>
<td>65/391</td>
<td>0.73 (0.50 to 1.07)</td>
<td>0.75 (0.49 to 1.12)</td>
<td>0.74 (0.49 to 1.11)</td>
<td>0.74 (0.49 to 1.11)</td>
</tr>
</tbody>
</table>

*P for trend* 0.01 0.05 0.05 0.05

**Cell contents are adjusted relative risk (RR) and 95% confidence intervals (CI) associated with any erectile dysfunction (IIEF-5 score = 5-21) among men 18-31 according to plant-based diet adherence score quintiles from the Growing Up Today Study (N=1,964).**

Model 2 adjusted for age (continuous); energy intake (kcal/d); race (white or other); cigarette smoking at least weekly; sexual activity in the last 12 months; married or currently living with partner, cardiometabolic disease diagnosis and/or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other antihypertensive, statins, other cholesterol lowering drugs).

Model 3 further adjusted for alcohol intake at baseline (svg/d); taking any supplements (multivitamin, vitamin A, vitamin D, vitamin B6, vitamin C, potassium, vitamin E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil); depression/anxiety diagnosis and/or medication use (SSRIs, other antidepressants, minor tranquilizers).

Model 4 further adjusted for BMI ≥ 25.
Table 8. Multivariable-adjusted association of plant-based diet adherence score quintiles with risk of moderate to severe erectile dysfunction.

<table>
<thead>
<tr>
<th>Plant-Based Diet Index</th>
<th>No. Cases/ Total Men</th>
<th>Adjusted for age, energy intake (kcal/d)</th>
<th>Multivariate Adjusted Model 2</th>
<th>Multivariate Adjusted Model 3</th>
<th>Multivariate Adjusted Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>24/358</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
<td>Ref.</td>
</tr>
<tr>
<td>Q2</td>
<td>19/398</td>
<td>0.71 (0.38 to 1.32)</td>
<td>0.61 (0.33 to 1.15)</td>
<td>0.57 (0.30 to 1.07)</td>
<td>0.57 (0.30 to 1.07)</td>
</tr>
<tr>
<td>Q3</td>
<td>22/434</td>
<td>0.74 (0.40 to 1.37)</td>
<td>0.71 (0.38 to 1.32)</td>
<td>0.73 (0.39 to 1.37)</td>
<td>0.73 (0.39 to 1.37)</td>
</tr>
<tr>
<td>Q4</td>
<td>15/397</td>
<td>0.55 (0.28 to 1.08)</td>
<td>0.59 (0.30 to 1.15)</td>
<td>0.58 (0.32 to 1.15)</td>
<td>0.58 (0.30 to 1.15)</td>
</tr>
<tr>
<td>Q5</td>
<td>12/389</td>
<td>0.47 (0.22 to 0.98)</td>
<td>0.46 (0.22 to 0.99)</td>
<td>0.45 (0.21 to 0.99)</td>
<td>0.45 (0.21 to 0.99)</td>
</tr>
<tr>
<td>P for trend</td>
<td>0.04</td>
<td>0.06</td>
<td>0.07</td>
<td>0.08</td>
<td></td>
</tr>
</tbody>
</table>

Cell contents are adjusted relative risk (RR) and 95% confidence intervals (CI) of any erectile dysfunction (IIEF-5 score=5-16) among men 18-31 according to plant-based diet adherence score quintiles from the Growing Up Today Study (N=1,964).

Model 2 adjusted for age (continuous); energy intake (kcal/d); race (white or other); cigarette smoking at least weekly; sexual activity in the last 12 months; married or currently living with partner, cardiometabolic disease diagnosis and/or medication use (diabetes, hypertension, high cholesterol and/or high triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs).

Model 3 further adjusted for alcohol intake at baseline (svg/d); taking any supplements (multivitamin, vitamin A, vitamin D, vitamin B6, vitamin C, potassium, vitamin E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil); depression/anxiety diagnosis and/or medication use (SSRIs, other antidepressants, minor tranquilizers).

Model 4 further adjusted for BMI ≥ 25.

Abbreviations: Q, quartile; Ref., reference, RR, relative risk; CI, confidence intervals
Chapter IV.
Discussion

Significance of Results

In this study I evaluated an association between adherence to a plant-based dietary pattern and erectile dysfunction in a cohort of men 18-31 years of age. To my knowledge this is the first study evaluating the relationship between diet and ED in young men. I found that men who were in the highest quartile of adherence to a plant-based dietary pattern had a lower risk of erectile dysfunction compared to those in the lowest quartile of adherence. This association was robust to alternative definitions of the outcome and various modeling strategies. My findings suggest that diet may be a modifiable risk factor for ED in young men. Although there is a paucity of data regarding ED in men under 40, my findings are supported by similar previous studies. First, previous studies have concluded diet is a modifiable risk factor for cardiometabolic conditions (Esselstyn et al., 2014). Second, cardiometabolic conditions are highly correlated with erectile issues in men over 40 (Vlachopoulos et al., 2013). Third, other modifiable lifestyle risk factors are associated with ED in young men, such as smoking (Wen et al., 2017), sedentary behavior (Hsiao et al., 2012), and alcohol (Arackal & Benegal, 2007). Forth, cardiovascular and metabolic diseases are present, although not always clinically apparent in some men under 40 (McGill et al., 2000; Yao et al., 2018). Lastly, it was found that diet is a significant risk factor for erectile dysfunction in men over 40 with
comorbid conditions (Gupta et al., 2011; Esposito et al., 2006; Maiorino et al., 2016; Wing et al., 2010), as well as independent comorbid conditions (Bauer et al., 2020). Studies utilizing similar plant-based dietary patterns, emphasizing the consumption of plant-based foods, such as grains, fruit, vegetables, legumes and nuts, as well as minimizing consumption of animal-based foods, such as eggs, meat, and dairy were associated with a reduced risk of several cardiometabolic diseases, and more recently erectile dysfunction. Further studies are needed to support the correlation between plant-based diet adherence and erectile dysfunction in young men.

Strengths and Limitations

There are several limitations of note in this study. Measurement error in diet assessment is always of concern, although semi-quantitative FFQs have been validated as an accurate method of long-term dietary assessment for adults (Feskanich et al., 1993), as well as for adolescents (Rockett, Wolf, & Colditz, 1995; Rockett et al., 1997). However, as diet assessment preceded assessment of ED, the most likely form of measurement error in this study is random non-differential error in relation to outcome leading to attenuation towards the null hypothesis and suggesting that the true relation may be stronger than reported here. Another important limitation is the magnitude of dietary contrast between quartiles of plant-based diet adherence. For example, the highest quartile of plant-based diet adherence reported a mean 22.5 grams per day (SD ± 5.2g/d) of saturated fat, suggesting these participants consume many animal-based products. Furthermore, crude fiber intake in the highest quartile of plant-based consumption only reported a mean of 7.0 grams per day (SD ± 2.2g/d). These individuals do not meet dietary guidelines for
fiber intake of 25-30 grams per day, recommended by the American Heart Association (AHA) (van Horn, 1997). These results indicate that even those with the highest adherence to a plant-based dietary pattern are below dietary recommendations for fruit, vegetable, grain, legume, or nut consumption. Nevertheless, randomized-control trials with plant-based dietary interventions are recommended to support evidence of an association between diet and ED. In this study, associations are likely underestimated and may be further supported by greater variations across dietary quartiles. Although healthy plant-based and unhealthy plant-based diet indices have been previously reported (Kim et al., 2019; Martinez-Gonzalez et al., 2014; Satija et al., 2016; Satija et al., 2017), food items rarely contain only one type of food. For instance, unhealthy plant-based diets have shown mixed and less significant associations of cardiometabolic risk (Kim et al., 2019; Satija et al., 2017). Less significant associations between unhealthy plant-based foods and disease risk may be the result of complex food items such as white bread, cake, and pastries, many of which contain dairy and eggs. FFQs containing greater detail as well as modern food items are needed.

The outcome variable may also be prone to error due to self-reporting. The IIEF-5 has been previously validated and is the tool frequently used to assess erectile function in both clinical and research settings. A useful measure in young men would be to include information on weak masturbatory erections, as many men at this age are not sexually active. I took measures to address the incomplete IIEF-5 questions that are more conservative than other studies, likely underestimating my outcome. The only blank question that qualified the observation as invalid was the first question pertaining to erectile confidence. I utilized this question as a measure for other blank questions
pertaining to sexual intercourse. Standardizing measures of erectile dysfunction would be empirically and clinically relevant for future assessment of ED.

In this study, I utilized confounding variables similar to other studies, though these are all self-reported and prone to inconsistency between successive studies. Other confounders to consider are behavioral and lifestyle factors that have previously shown associative measures with healthier dietary pattern consumption (Jacka et al., 2011). Studies have shown that healthier diets are also correlated with lifestyle factors, such as lower risk of depression, sedentary behavior, and obesity, which could modify the outcome. Although disparities in obesity and anxiety/depression were not observed across dietary quartiles, these correlates were utilized in regression computations. I did not have corresponding data on physical activity. Although ED and modifiable diseases have shown improvement with physical activity (Hsiao et al., 2012), highly active individuals are still at risk of vascular disease (Basilico, 1999). Furthermore, this cohort is racially homogeneous; a racially diverse cohort would be a more accurate representation of the United States population.

Conclusion and Implications

Although erectile dysfunction is not considered a critical malady, proper erectile function is associated with quality of life, inter-personal relationships, self-esteem, and fertility. Moreover, erectile issues are highly correlated with life-threatening cardiometabolic diseases in middle-aged and older men. If ED is a harbinger of forthcoming cardiometabolic disease, it is important to address erectile issues as high-risk. ED is observed in more than half of the adult population, and although evidence is
not yet sufficient, is likely a significant issue among young men as well. If erectile dysfunction proves to be primarily a vascular issue in young men, similar to middle-aged and older men, proper diagnostics and treatment are important for prevention and early intervention of future cardiometabolic disease. Plant-based dietary adherence has been shown to prevent and reverse cardiometabolic disease. This study represents an opportunity for identification, as well as prevention and treatment of erectile dysfunction and potentially cardiometabolic disease in young men.

A significant association between increased adherence to a plant-based dietary pattern and reduced risk of erectile dysfunction in young men was observed in this cohort study. If ED is modifiable with lifestyle interventions, it is likely that many of these patients are being misdiagnosed with psychological ED. Further studies are needed to assess the etiology of ED within this age group. Because young men may present with subclinical disease biomarkers, plant-based dietary intervention may be a suitable recommendation to assess if erectile function improves. It is important to address erectile issues as potential early onset cardiometabolic disease by incorporating erectile function questions into health assessments of all young men and emphasizing the importance of plant-based foods as healthy lifestyle disease mitigation.
References


Fryar, C.D., Carroll, M.D., & Ogden, C.L. (2018). Prevalence of overweight, obesity, and


validated questionnaire. Eur Urol, 47(1), 80-85; discussion 85-86. doi:10.1016/j.eururo.2004.08.017


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Appendix I.

SAS Code

******************************************************************************;
*** Pathname: /udd/nkcan/thesis/PBDI_ED.sas ***;
*** Programmer: Cassandra Neitling ***;
******************************************************************************;
libname library "/proj/nhsass/nhsas00/formatsv9";
filename nhstools "/proj/nhsass/nhsas00/nhstools/sasautos";
libname readfmt "/proj/nhsass/nhsas00/formats";
filename channing "/usr/local/channing/sasautos";
filename ehmac "/udd/stleh/ehmac"; *AGE-STANDARDIZATION MACRO*;
libname projd "/proj/nkglbs/nkglb0b"; *PROJECT DIRECTORY*;
libname can "/udd/nkcan/thesis"; *MY HOME DIRECTORY*;
******************************************************************************;

*** STANDARD OPTIONS TO INCLUDE IN A GUTS PROGRAM ***;
options fmtsearch=(readfmt);
options ls=132 ps=78 nocenter nofmterr;
options mautosource sasautos=(nhstools channing ehmac);
******************************************************************************;

1. Project name: Plant-based diets and risk of erectile dysfunction in young men
2. Exposure: Adherence to plant-based diet in men aged 17-29 at baseline from
   GUTS food frequency questionnaire, 2011.
3. Outcome: Any ED (score 5-21), or moderate to severe ED (score 5-16) from the IIEF-5
   questionnaire asked at follow-up, 2013.
4. Exclusion criteria: All 5 IIEF questions missing, missing confidence question, only valid _nts
5. Prepared datasets:
   Exposure - pbd(continuous), pbd(quarters)
   Outcome - iief5a(continuous), iiefcat(categories), mmsed(5-16), anyed(5-21)
   Covariates - age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm
   Final Dataset - finalmrg(merged files), allcode(cohort), raw_rank(quintiles_qs),
   pbd(continuous), pbd(quarters)
******************************************************************************;

* DIETARY PARAMETERS:
Animal-based foods: Animal fat (butter, spreadable butter, lard), eggs (eggs,
egg whites, light mayonnaise, mayonnaise), dairy (milk, cream, chocolate milk,
whipped cream, frozen yogurt, yogurt, pudding, ice cream, cheese, pizza,
chocolate, meal replacement drinks, chowder, salad dressing, dairy-based coffee
drinks), meat (hotdogs, chicken or turkey dogs, meat sandwiches, meat-based mixed
dinners, bacon, hamburgers, liver, meat burritos, meat pasta dishes), seafood
(canned tuna, fish sticks or cakes, shrimp, fish)
Healthy plant-based foods: Whole grains (popcorn, rye bread, whole meal bread,
tortillas, whole grain crackers, oatmeal, cooked breakfast cereals, brown rice,
veggie burgers, oat bran, wheat germ, protein and energy bars), fruit (Raisins,
grapes, prunes, bananas, plantains, melons, avocado, apples or pears, applesauce,
citrus, berries, peaches, apricots), vegetables (cauliflower, cabbage, Brussels
sprouts, carrots, corn, yams, squash, dark greens, spinach, lettuce, celery,
peppers, onions, tomatoes, broccoli, garlic, vegetables in a sandwich, burrito,
mixed dish or pasta), nuts & seeds (flaxseed, peanut butter, peanuts, walnuts,
other nuts or seeds, peanut butter sandwich), legumes (string beans, beans,
lentils, tofu, soy burger, peas, lima beans, soy milk, tofu burrito, tofu mixed dish), non-hydrogenated oils (olive oil, vegetable oil, low-calorie salad dressing), tea & coffee (tea, decaf tea, coffee, decaf coffee)

Less healthy plant-based foods: fruit juices (apple juice, orange juice, other fruit juices, prune juice, smoothies), refined grains (white bread, crackers, bagels, English muffins, white rice, pasta, breakfast cereal, pretzels, noodle soup, muffins, biscuits, cornbread), potatoes (French fries, mashed potatoes, potato chips, potato salad), sugar-sweetened beverages (soda, lemonade, fruit punch, vitamin water, sports drinks, energy drinks), sugar-based foods (candy, dark chocolate, fruit snacks, popsicles, jams or honey, ketchup, added sugar, pancakes, waffles, French toast, Twinkies®, cookies, brownies, doughnuts, cake, pie, pastries, Pop-Tarts®), hydrogenated oils (margarine, vegetable shortening)

IIEF-5 Questions:
During the past year, confidence that you could get and keep an erection?
In the past year during sexual activity, maintain erection to completion?
How often were your erections hard enough for penetration?
How often were you able to maintain your erection after penetration?
How often was it satisfactory for you?

COVARIATES:
Demographic correlates: age, race/ethnicity, BMI≥25, sexual activity, marital/partner status
Health correlates: total caloric intake, multivitamin, other supplement (vitamin A, vitamin D, vitamin B6, vitamin C, potassium, vitamin E, calcium, selenium, niacin, zinc, iron, folic acid, cod liver oil, flax oil)

Substance use: smoking, alcohol
Medical conditions: cardiometabolic diagnosis or medication (diabetes, hypertension, high cholesterol, triglycerides, insulin, oral hypoglycemic, thiazide diuretic, calcium blocker, beta-blocker, ACE inhibitor, other anti-hypertensive, statins, other cholesterol lowering drugs), anxiety or depression diagnosis or medication (SSRIs, other antidepressants, minor tranquilizers)

%gab11_nts (keep=id calor11n);
%gab11_ant (keep=id prot11a aprot11a vprot11a dprot11a tfat11a afat11a vfat11a dfat11a carbo11a crude11a chol11a alco11a mon11a poly11a sat11a);
%gutsder9613 (keep=id momid age13 ow_ob13 bmi13 natal_sex);
%boys204 (keep=id white204b);
%boys96 (keep=id white96b);
%gutssfq11 (keep=id /*animal foods & beverages*/ skim11f m1or211f whole11f whip11f cream11f fryog11f icecr11f plosg11f yoglt11f yog11f cotch11f crrch11f othch11f macch11f pizza11f eggwh11f eggolm11f eggg11f dog11f ctogol11f chksl11f chwol11f chwol11f bacon11f sbol11f proc11f beeff11f hamb11f hamb11f bmx11f pork11f ctuna11f fishs11f shrim11f dksfh11f ofish11f slfs11f instb11f protpl11f chowd11f lmayo11f mayo11f
dress11f livb11f livc11f but11f sbul1f cdff11f cdffs11f latte11f
lates11f ifcf11f icffs11f icdf11f icds11f fflh11f frbut11f frflal1f
/*healthy plant-based foods & beverages*/ popc11f whbr11f crack11f
probl11f rais11f grape11f prun11f ban11f ptn11f cant11f
hnyd11f wtrml11f avol11f apsau11f appl11f oran11f grfr11f straw11f
blue11f peach11f apric11f tom11f toj11f tosa11f sal11f sbean11f
beans11f toff1f peas11f brocc11f cauli11f cabb11f bruss11f rar11f
car11f corn11f mix11f yams11f osqua11f eggpl11f kale11f rspin11f
csp11f ilett11f rlett11f cerly11f grpepl11f onio11f onio11f
flax11f ryebr11f dkb11f tort11f bric11f craxw11f oat11f ccker11f
soy11f dtea11f teal1f decal11f decfl11f coff11f cofffl1f brarl1f
powr11f pbut11f ffpop11f pmtn11f wnut11f omtn11f oatbr11f bran11f
wgerml1f tomsol11f /*less healthy plan-based foods & beverages*/
ketch11f garl1f oo11f frmarr11f folv11f froil11f fsh11f chocoi11f
cdyw11f cdhocol1f cdwy11f aj11f ojca11f oj11f othj11f engli1f past11f
fries11f mashpi11f marg11f cer11f lecafl1f lnco11f coke11f otsug11f
punch11f sodas11f vh2o11f rd11f pch11f sugar11f jam11f pretz11f
wtrml11f oran11f straw11f peach11f water11f /vtce11f k11f vita11f vite11f
cal11f sel11f nia11f zinc11f iron11f foli11f cdol11f flaxol11f);

%boys211 (keep=id /*animal-based foods & beverages*/ skim11b m1or211b
whole211b chocm211b insth211b prosh211b pyou211b yogl211b yog211b
cotch211b crah211b but211b sbu211b slid211b cream211b mayol211b chowd211b
saldr211b egg211b eburg211b burg211b pizza211b chnug211b dog211b ctdog211b
bacon211b procrm211b bee221b cwhi211b chw211b pork211b fishs211b cuna211b
dkfish211b shrim211b olish211b macch211b otchc211b pudd211b fryog211b iccer211b
fsan211b sands211b sta211b stbr211b stt211b stct211b ftur11b bch211b brbf211b
fhas211b pctl211b ptk211b finx211b mtch211b mtbf211b mfs211b cdfw211b cdfsw211b
latex211b latte211b latte211b icfl211b icfls211b icflw211b icd211b
icds211b icd211b /*healthy plant-based foods & beverages*/
whbr211b crack11b cer11b lcdr211b powbr211b probt211b brbr211b rais211b grape11f
ban211b appl211b apsau211b cant211b wtrml211b oran211b straw211b peach211b qj211b aj211b
tom11f toj211f sban211b brocc211b corn211b peas211b rspin211b csp211b
bruss211b grpepl211b yams211b eggg211b ccar211b ccar211b cerl211f ilett211b
onio211b onio211b out211b ccker211b dkb211b brice211b tort211b soy211b sou211b
salsa211b pbut211b tea211b dcafl211b cff211b vbur211b tosal211b beans211b tosa211b
pocpc211b pmtn211b wnut211b omtn211b seeds211b stvg211b stpb211b btrt211b bthn211b
btrv211b ptv211b tptl211b mttf211b mtvf211b defc211b cff211b
/*less healthy plant-based foods*/ sugar211b fsnk211b pops211b pr211b bchipl211b
marg211b ketch211b jam211b lecafl211b cke211b otsug211b punch211b sodas211b
spdrk211b rdbs211b rdul211b fries211b mashp211b engl211b wtrce211b ptsld211b chip211b
popt211b smth211b cdwy211b twink211b sroll211b donut211b cooki211b brwni211b pie211b
choco211b cdwy211b muf211b cmbr211b bsect211b panca211b frst211b
/*supplements for covariates*/ mvit211b vsup211b);

%boys13 (keep= id /*IIEF variables*/ erconf13b erdiff13b ablpen13b aftpent13b
sexsat13b /*covariates for dataset3*/ marry13b lpart13b ofsmk13b aale13b nalc13b
sexact13b dbdl13b hbdp13b choild13b insul13b ohypo13b thiaz13b ceblo13b betab13b ace13b bprx13b
oclr13b stat13b anx13b dprtd13b srr13b antid13b val13b);

******************************************************************;
* MERGE: valid calorie, guts1 ffq, guts2 ffq, 2013 no ed missing *;
******************************************************************;
/*no IIEF-5 questions missing & if missing confidence, delete*/
data noedmiss;
set boys13;
array edmiss1 [5] erconf13b erdiff13b ablpen13b aftpen13b sexsat13b;
array edmiss2 [5] erconf13m erdiff13m ablpen13m aftpen13m sexsat13m;
do i=1 to 5;
if edmiss1 {i} =6 then edmiss2 {i} =0;
if edmiss1 {i} =. then edmiss2 {i} =0;
if edmiss1 {i} =1 then edmiss2 {i} =1;
if edmiss1 {i} =2 then edmiss2 {i} =2;
if edmiss1 {i} =3 then edmiss2 {i} =3;
if edmiss1 {i} =4 then edmiss2 {i} =4;
if edmiss1 {i} =5 then edmiss2 {i} =5;
end;

eief5 = sum(erconf13m, erdiff13m, ablpen13m, aftpen13m, sexsat13m);
if eief5 = 0 then delete;
if erconf13m = 0 then delete;
run;
data menonly;
set gutsder9613;
if natal_sex =1;
run;
data finalmrg;
merge gab11_nts (in=a) noedmiss (in=b) menonly (in=c)
boys211 gutsffq11 gab11_ant boys204 boys96;
by id;
if a=1;
if b=1;
if c=1;
run;
******************************************************************;
* ADJ SERVINGS PER DAY
******************************************************************;
data cohort;
set finalmrg;
******************************************************************GUTS I******************************************************************;
/*animal-based foods & beverages*/
skim11 = skim11f; m1or211 = m1or211f;
whole11 = whole11f; whip11 = whip11f; cream11 = cream11f; fryog11 = fryog11f;
iece11 = iecr11f; ployog11 = ployog11f; yoglt11 = yoglt11f; yog11 = yog11f;
cotch11 = cotch11f; crch11 = crch11f; otch11 = othch11f; macch11 = macch11f;
pizza11 = pizza11f; eggwh11 = eggwh11f; eggom11 = eggom11f; egg11 = egg11f;
dog11 = dog11f; cdog11 = cdog11f; chksa11 = chksa11f; chwi11 = chwi11f;
chwo11 = chwo11f; bacon11 = bacon11f; sboll11 = sboll11f; procm11 = procm11f;
beef11 = beef11f; hamb11 = hamb11f; hamb1 = hamb11f; bmix11 = bmix11f;
pork11 = pork11f; ctuna11 = ctuna11f; fishs11 = fishs11f; shrim11 = shrim11f;
dksfh11 = dksfh11f; ofish11 = ofish11f; slfst11 = slfst11f; instb11 = instb11f;
propt11 = propt11f; chowd11 = chowd11f; lmayo11 = lmayo11f; mayol11;
dress11 = dress11f; livb11 = livb11f; livc11 = livc11f; but11 = but11f;
sbu11 = sbu11f; cdffl1 = cdffl1f; cdfs11 = cdfs11f; latte11 = latte11f;
lattes11 = lattes11f; icff11 = icff11f; icffs11 = icffs11f; icdl11 = icdl11f;
icds11=icds11f; ffh11=ffh11f; frbut11=frbut11f; fral11=fral11f;
/*healthy plant-based foods & beverages*/ whbr11=whbr11f;
protb11=protb11f; rais11=rais11f; grape11=grape11f; prun11=prun11f;
prunj11=prunj11f; ban11=ban11f; pltn11=pltn11f; cant11=cant11f;
hnydw11=hnydw11f; wtrml11=wtrml11f; avo11=avo11f; aspau11=aspau11f;
app11=app11f; oran11=oran11f; grfr11=grfr11f; stav11=stav11f;
blueb11=blueb11f; peach11=peach11f; apric11=apric11f; tom11=tom11f;
toj11=toj11f; tosa11=tosau11f; salsa11=salsa11f; sbean11=sbean11f;
beans11=beans11f; tofu11=tofu11f; peas11=peas11f; brocc11=brocc11f;
cauli11=cauli11f; cabb11=cabb11f; bruss11=bruss11f; rac11=rac11f;
cr11=ccar11f; corn11=corn11f; mixv11=mixv11f; yams11=yams11f;
osqua11=osqua11f; eggpl11=eggpl11f; kale11=kale11f; rsin11=rsin11f;
cspin11=cspin11f; ilett11=ilett11f; rlett11=rlett11f; celry11=celry11f;
graeppl11=graeppl11f; oniov11=oniov11f; onio11=onio11f; flaxs11=flaxs11f;
ryebr11=ryebr11f; dkbr11=dkbr11f; tort11=tort11f; brice11=brice11f;
crwx11=crwx11f; oat11=oat11f; ccker11=ccker11f; soy11=soy11f;
decaf11=decaf11f; defs11=defs11f; coff11=coff11f; coffs11=coffs11f;
sta11=sta11f; tea11=tea11f; brbar11=brbar11f; powrb11=powrb11f;
pbut11=pbut11f; fpop11=fpop11f; pnut11=pnut11f; wnut11=wnut11f;
onut11=onut11f; oab11=oab11f; bran11=bran11f; wgerm11=wgerm11f;
tomso11=tomso11f; garlic11=garlic11f; oolll11=oolll11f; popc11=popc11f;
/*less healthy plant-based foods & beverages*/ crack11=crack11f;
pretz11=pretz11f; aj11=aj11f; ojc11=ojc11f; oj11=oj11f; othj11=othj11f;
engl11=engl11f; wrce11=wrce11f; pasta11=pasta11f; fries11=fries11f;
mashp11=mashp11f; pchip11=pchip11f; cer11=cer11f; lc11=lc11f;
lnoc11=lnoc11f; coke11=coke11f; otsug11=otsug11f; punch11=punch11f;
sodas11=sodas11f; vh2011=vh2011f; rdbul11=rdbul11f; sugar11=sugar11f;
jam11=jam11f; ktch11=ktch11f; frolv11=frolv11f; fro11=fro11f;
choco11=choco11f; cdw11=cdw11f; cokn11=cokn11f; cokr11=cokr11f;
cokh11=cokh11f; browni11=browni11f; donut11=donut11f; cake11=cake11f;
pie11=pie11f; sroll11=sroll11f; dcho11=dcho11f; cdw11=cdw11f;
muff11=muff11f; panca11=panca11f; frmrar11=frmrar11f; frsh11=frsh11f;
/*type of fat – gutsffq11*/
if ffh11=1 then fhsvg11=0.00; /*never or <1/wk;*/
else if ffh11=2 then fhsvg11=0.29; /*1-3/wk;*/
else if ffh11=3 then fhsvg11=0.71; /*4-6/wk;*/
else if ffh11=4 then fhsvg11=1.00; /*1/day;*/
else if fh11=. then fhsvg11=0.00; /*none or pt;*/
array ftary11x [6] frbut11x frmar11x fro11x frsh11x fral11x;
do i=1 to 6;
if ftary11{[i]}.=1 then ftary11x{[i]}=1.00; /*yes;*/
else ftary11x{[i]}=0.00; /*pt;*/
end;
/*animal fat – gutsffq11*/
array anfat1{2} but11 sbu11;
afatsvg1=0.00;
do i=1 to DIM (anfat1);
select (anfat1{[i]});
when (1) svg=0.00; /*never or <1/mo;*/
when (2) svg=0.07; /*1-3/mo;*/
when (3) svg=0.14; /*1/wk;*/
when (4) svg=0.43;  *2-4/wk;
when (5) svg=0.80;  *5-6/wk;
when (6) svg=1.00;  *1/d;
when (7) svg=2.50;  *2-3/d;
when (8) svg=4.50;  *4-5/d;
when (9) svg=6.00;  *6+/d;
otherwise svg=0.00;  *pt;
end;

afatsvg1= afatsvg1+svg;
end;

butsvg11=ffhsvg11*frbut11x;  *butter – animal group;
larsvg11=ffhsvg11*frla11x;  *lard – animal group;

afatsum1=sum(afatsvg1, butsvg11, larsvg11);

/*eggs – gutsffq111*/
array eggs1{5} eggwh11 eggom11 egg11  lmayo11 mayo11;
eggsvg1=0.00;
do i=1 to DIM (eggs1);
select (eggs1{i});
when (1) svg=0.00;  *never or <1/mo;
when (2) svg=0.07;  *1-3/mo;
when (3) svg=0.14;  *1/wk;
when (4) svg=0.43;  *2-4/wk;
when (5) svg=0.80;  *5-6/wk;
when (6) svg=1.00;  *1/d;
when (7) svg=2.50;  *2-3/d;
when (8) svg=4.50;  *4-5/d;
when (9) svg=6.00;  *6+/d;
otherwise svg=0.00;  *pt;
end;

eggsvg1=eggsvg1+svg;
end;

eggsum1=eggsvg1;

/*dairy – gutsffq111*/
array dairy1{22} skim11 m1or211 whole11 whip11 cream11 fryog11 icecr11 plyog11 yogfl11 yog11 cotch11 crch11 othch11 macch11 pizza11 choco11 cdyw11 slfst11 instb11 protpl1 chowd11 dress11;
dairsvg1=0.00;
do i=1 to DIM (dairy1);
select (dairy1{i});
when (1) svg=0.00;  *never or <1/mo;
when (2) svg=0.07;  *1-3/mo;
when (3) svg=0.14;  *1/wk;
when (4) svg=0.43;  *2-4/wk;
when (5) svg=0.80;  *5-6/wk;
when (6) svg=1.00;  *1/d;
when (7) svg=2.50;  *2-3/d;
when (8) svg=4.50;  *4-5/d;
when (9) svg=6.00;  *6+/d;
otherwise svg=0.00;  *pt;
end;

dairsvg1=dairsvg1+svg;
end;

/*coffee, dairy – gutsffq11*/
array cary11x [4] cdff11x latte11x icff11x icd11x;
do i=1 to 4;
  if cary11{i}=1 then cary11x{i}=0.00; *never or <1/mo;
  if cary11{i}=2 then cary11x{i}=0.07; *1-3/mo;
  if cary11{i}=3 then cary11x{i}=0.14; *1/wk;
  if cary11{i}=4 then cary11x{i}=0.43; *2-4/wk;
  if cary11{i}=5 then cary11x{i}=0.80; *5-6/wk;
  if cary11{i}=6 then cary11x{i}=1.00; *1/d;
  if cary11{i}=7 then cary11x{i}=2.50; *2-3/d;
  if cary11{i}=8 then cary11x{i}=4.50; *4-5/d;
  if cary11{i}=9 then cary11x{i}=6.00; *6+/d;
  if cary11{i}=0 then cary11x{i}=0.00; *pt;
  if cary11{i}=. then cary11x{i}=0.00; *pt;
end;

/*cappuccino, mocha, latte nonfat - size, frequency – gutsffq11*/
if cdffs11=1 then cas11x=1.00; *small 12oz;
else if cdffs11=2 then cas11x=2.00; *medium 16oz;
else if cdffs11=3 then cas11x=2.60; *large 21oz;
else cas11x=1.00; *pt;

casvg11=cas11x*cdff11x;

/*cappuccino, mocha, latte low fat whole milk - size, frequency – gutsffq11*/
if lattes11=1 then las11x=1.00; *small 12oz;
else if lattes11=2 then las11x=2.00; *medium 16oz;
else if lattes11=3 then las11x=2.60; *large 21oz;
else las11x=1.00; *pt;

lasvg11=las11x*latte11x;

/*nonfat iced coffee drinks - size, frequency – gutsffq11*/
if icffs11=1 then icns11x=1.00; *small 12oz;
else if icffs11=2 then icns11x=2.00; *medium 16oz;
else if icffs11=3 then icns11x=2.60; *large 21oz;
else icns11x=1.00; *pt;

insvg11=icns11x*icff11x;

/*low fat whole milk iced coffee drinks - size, frequency – gutsffq11*/
if icds11=1 then icfs11x=1.00; *small 12oz;
else if icds11=2 then icfs11x=2.00; *medium 16oz;
else if icds11=3 then icfs11x=2.60; *large 21oz;
else icfs11x=1.00; *pt;

ifsvg11=icfs11x*icd11x;

dairsum1=sum(dairsvg1, casvg11, lasvg11, insvg11, ifsvg11);
/*meat – gutsffq11*/
array meat1{13} dog11 ctdog11 chka11 chwi11 chwo11 bacon11 sbol11 procm11 beef11 hamb11 hamb11 bmix11 pork11;
meatsvg1=0.00;
do i=1 to DIM (meat1);
select (meat1 {i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
meatsvg1=meatsvg1+svg;
end;

if livb11=1 then lvbsvg11=0.00; *never;
else if livb11=2 then lvbsvg11=0.02; *<1/mo;
else if livb11=3 then lvbsvg11=0.04; *1/mo;
else if livb11=4 then lvbsvg11=0.09; *2-3/mo;
else if livb11=5 then lvbsvg11=0.14; *1+/wk;
else lvbsvg11=0.00; *none or pt;

if livc11=1 then lvcsvg11=0.00; *never;
else if livc11=2 then lvcsvg11=0.02; *<1/mo;
else if livc11=3 then lvcsvg11=0.04; *1/mo;
else if livc11=4 then lvcsvg11=0.09; *2-3/mo;
else if livc11=5 then lvcsvg11=0.14; *1+/wk;
else lvcsvg11=0.00; *none or pt;

meatsum1=sum(meatsvg1, lvcsvg11, lvbsvg11);

/*seafood – gutsffq11*/
array seaf1{5} ctuna11 fishs11 shrim11 dkfsh11 ofish11;
seafsvg1=0.00;
do i=1 to DIM (seaf1);
select (seaf1 {i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
seafsvg1=seafsvg1+svg;
end;
seafsum1=seafsvg1;

/*whole grain – gutsffq11*/
array whgr1{16} whbr11 popc11 ryebr11 dkbr11 tort11 craxw11
oat11 ccer11 ffpop11 brice11 oatbr11 bran11 wgerm11 prob11 brbar11 powrb11;
whgrsvg1=0.00;
do i=1 to DIM (whgr1);
select (whgr1{i});
when (1) svg=0.00;  
*never or <1/mo;
when (2) svg=0.07;  
*1-3/mo;
when (3) svg=0.14;  
*1/wk;
when (4) svg=0.43;  
*2-4/wk;
when (5) svg=0.80;  
*5-6/wk;
when (6) svg=1.00;  
*1/d;
when (7) svg=2.50;  
*2-3/d;
when (8) svg=4.50;  
*4-5/d;
when (9) svg=6.00;  
*6+/d;
otherwise svg=0.00;  
*pt;
end;
whgrsvg1=whgrsvg1+svg;
end;
whgrsum1=whgrsvg1;

/*fruit – gutsffq11*/
array frt1{17} rais11 grape11 prune11 ban11 pltn11 cant11
hnydw11 wtrml11 avo11 apsau11 appl11 oran11 grfr11 straw11 blueb11 peach11 apric11;
frtsvg1=0.00;
do i=1 to DIM (frt1);
select (frt1{i});
when (1) svg=0.00;  
*never or <1/mo;
when (2) svg=0.07;  
*1-3/mo;
when (3) svg=0.14;  
*1/wk;
when (4) svg=0.43;  
*2-4/wk;
when (5) svg=0.80;  
*5-6/wk;
when (6) svg=1.00;  
*1/d;
when (7) svg=2.50;  
*2-3/d;
when (8) svg=4.50;  
*4-5/d;
when (9) svg=6.00;  
*6+/d;
otherwise svg=0.00;  
*pt;
end;
frtsvg1=frtsvg1+svg;
end;
frtsum1=frtsvg1;

/*vegetables – gutsffq11*/
array veg1{26} cauli11 cabb11 bruss11 rcar11 ccar11 corn11
mixv11 yams11 osqua11 eggp11 kale11 rspin11 cspin11 ilett11
rlett11 celry11 grep11 oniov11 oniog11 tom11 toj11 tosau11
salsa11 broccoli11 tomo11 garlic11;
vegsvg1=0.00;
do i=1 to DIM (veg1);
select (veg1{i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;

vegsvg1 =vegsvg1+svg;
end;

vegsum1= vegsvg1;

/*nuts & seeds – gutsffq11*/
array nuts1{5} flaxs11 pbut11 pnut11 wnut11 onut11;
nutsvg1=0.00;
do i=1 to DIM (nuts1);
select (nuts1{i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
nutsvg1=nutsvg1+svg;
end;
nutsum1= nutsvg1;

/*legumes – gutsffq11*/
array lgm1{5} sbean11 beans11 tofu11 peas11 soy11;
lgmsvg1=0.00;
do i=1 to DIM (lgm1);
select (lgm1{i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
lgmsvg1 = lgmsvg1 + svg;
end;

lgmsum1 = lgmsvg1;

/* non-hydrogenated oils – gutsffq11 */
array noil1[1] ooil11;
oilsvg1 = 0.00;
do i=1 to DIM (noil1);
select (noil1[i]);
when (1) svg = 0.00; *never or <1/mo;
when (2) svg = 0.07; *1-3/mo;
when (3) svg = 0.14; *1/wk;
when (4) svg = 0.43; *2-4/wk;
when (5) svg = 0.80; *5-6/wk;
when (6) svg = 1.00; *1/d;
when (7) svg = 2.50; *2-3/d;
when (8) svg = 4.50; *4-5/d;
when (9) svg = 6.00; *6+1/d;
otherwise svg = 0.00; *pt;
end;

noilsvg1 = noilsvg1 + svg;
end;

olvsvg11 = ffhsvg11 * froil11x; * olive oil – plant group;
oilsvg11 = ffhsvg11 * froil11x; * vegetable oil – plant group;

noilsum1 = sum (noilsvg1, olvsvg11, oilsvg11);

/* tea & coffee – gutsffq11 */
array cft1[2] dtea11 tea11;
cftsvg1 = 0.00;
do i=1 to DIM (cft1);
select (cft1[i]);
when (1) svg = 0.00; *never or <1/mo;
when (2) svg = 0.07; *1-3/mo;
when (3) svg = 0.14; *1/wk;
when (4) svg = 0.43; *2-4/wk;
when (5) svg = 0.80; *5-6/wk;
when (6) svg = 1.00; *1/d;
when (7) svg = 2.50; *2-3/d;
when (8) svg = 4.50; *4-5/d;
when (9) svg = 6.00; *6+1/d;
otherwise svg = 0.00; *pt;
end;

cftsvg1 = cftsvg1 + svg;
end;

/* coffee, size, frequency – gutsffq11 */
if decaf11 = 1 then dcsvg11 = 0.00; *never or <1/mo;
else if decaf11 = 2 then dcsvg11 = 0.07; *1-3/mo;
else if decaf11 = 3 then dcsvg11 = 0.14; *1/wk;
else if decaf11 = 4 then dcsvg11 = 0.43; *2-4/wk;
else if decaf11=5 then dcsvg11=0.80; *5-6/wk;
else if decaf11=6 then dcsvg11=1.00; *1/d;
else if decaf11=7 then dcsvg11=2.50; *2-3/d;
else if decaf11=8 then dcsvg11=4.50; *4-5/d;
else if decaf11=9 then dcsvg11=6.00; *6+/d;
else dcsvg11=0.0; *pt;

if decafs11=1 then dcs11x=1.5; *small 12oz;
else if decafs11=2 then dcs11x=2.00; *medium 16oz;
else if decafs11=3 then dcs11x=2.60; *large 21oz;
else dcs11x=1.00;

dcs11x=dcs11x*decaf11;

if coff11=1 then cf11=0.00; *never or <1/mo;
else if coff11=2 then cf11=0.07; *1-3/mo;
else if coff11=3 then cf11=0.14; *1/wk;
else if coff11=4 then cf11=0.43; *2-4/wk;
else if coff11=5 then cf11=0.80; *5-6/wk;
else if coff11=6 then cf11=1.00; *1/d;
else if coff11=7 then cf11=2.50; *2-3/d;
else if coff11=8 then cf11=4.50; *4-5/d;
else if coff11=9 then cf11=6.00; *6+/d;
else cf11=0.0; *pt;

if coffs11=1 then cf11=1.5; *small 12oz;
else if coffs11=2 then cf11=2.00; *medium 16oz;
else if coffs11=3 then cf11=2.60; *large 21oz;
else cf11=1.00; *pt;

cf11=cf11*coff11;

cftsum1=sum(cf11, dc11, cf11);

/*fruit juices – gutsfq11*/
array frj1{5} aj11 ojca11 oj11 othj11 prunj11;
frj1=0.00;
do i=1 to DIM (frj1);
select (frj1[i]);
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
frj1=frj1+svg;
end;
frjsum1=frj1;
/*refined grains – gutsffq11*/
array rfgr1{7} crack11 engl11 wrice11 pasta11 cer11 pretz11 muff11;
rfgrsvgl=0.00;
do i=1 to DIM (rfgr1);
select (rfgr1{i});
when (1) svg=0.00;   *never or <1/mo;
when (2) svg=0.07;   *1-3/mo;
when (3) svg=0.14;    *1/wk;
when (4) svg=0.43;    *2-4/wk;
when (5) svg=0.80;    *5-6/wk;
when (6) svg=1.00;    *1/d;
when (7) svg=2.50;    *2-3/d;
when (8) svg=4.50;    *4-5/d;
when (9) svg=6.00;    *6+/d;
otherwise svg=0.00;    *pt;
end;
rfgrsvgl=rfgrsvgl+svg;
end;
rfgrsuml= rfgrsvgl;

/*potatoes – gutsffq11*/
array pot1{3} fries11 mashp11 pchip11;
potsvg1=0.00;
do i=1 to DIM (pot1);
select (pot1{i});
when (1) svg=0.00;   *never or <1/mo;
when (2) svg=0.07;   *1-3/mo;
when (3) svg=0.14;    *1/wk;
when (4) svg=0.43;    *2-4/wk;
when (5) svg=0.80;    *5-6/wk;
when (6) svg=1.00;    *1/d;
when (7) svg=2.50;    *2-3/d;
when (8) svg=4.50;    *4-5/d;
when (9) svg=6.00;    *6+/d;
otherwise svg=0.00;    *pt;
end;
potsvg1=potsvg1+svg;
end;
potsuml= potsvg1;

/*hydrogenated oils – gutsffq11*/
array hoil1{1} marg11;
hoilsvgl=0.00;
do i=1 to DIM (hoil1);
select (hoil1{i});
when (1) svg=0.00;   *never or <1/mo;
when (2) svg=0.07;   *1-3/mo;
when (3) svg=0.14;    *1/wk;
when (4) svg=0.43;    *2-4/wk;
when (5) svg=0.80;    *5-6/wk;
when (6) svg=1.00;    *1/d;
when (7) svg=2.50;    *2-3/d;
when (8) svg=4.50;    *4-5/d;
when (9) svg=6.00;    *6+/d;
otherwise svg=0.00;    *pt;
end;
hoilsvgl=hoilsvgl+svg;
end;
hoilsuml= hoilsvgl;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;

hoilsvg1=hoilsvg1+svg;
end;

marsvg11=fhsvg11*frmar11x; *margarine – plant group;
vshsvg11=fhsvg11*frsh11x; *veg shortening – plant group;

hoilsum1=sum(hoilsvg1, marsvg11, vshsvg11);

/*/sugar sweetened beverages – gutsf111*/
array ssb1{3} punch11 vh2o11 rdbul11;
ssbsvg1=0.00;
do i=1 to DIM (ssb1);
select (ssb1{i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;

ssbsvg1=ssbsvg1+svg;
end;

/*/soda size frequency – gutsf111*/
array sd11{4} lccaf11 lcnoc11 coke11 otsug11;
ssbsvg1=0.00;
do i=1 to DIM (sd11);
select (sd11{i});
when (1) svg=0.00; *never or <1/mo;
when (2) svg=0.07; *1-3/mo;
when (3) svg=0.14; *1/wk;
when (4) svg=0.43; *2-4/wk;
when (5) svg=0.80; *5-6/wk;
when (6) svg=1.00; *1/d;
when (7) svg=2.50; *2-3/d;
when (8) svg=4.50; *4-5/d;
when (9) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;

ssbsvg1=ssbsvg1+svg;
end;

if sodas11=1 then sds11x=1.00; *8oz;
else if sodas11=2 then sds11x=1.50; *12oz;
else if sodas11=3 then sds11x=2.25; *18oz;
else if sodas11=4 then sds11x=2.00;  *21oz;
else sds11x=1.00;  *pt;

sdsvg11=sdsvg11*sds11x;

ssbsum1=sum(ssbsvg1, sdsvg11);

/*sugar-based foods – gutsfqi11*/
array sbf1{13} dchoc11 cdywo11 jam11 ketch11 panca11 coknf11
cokr11 cokh11 brwni11 donut11 cake11 pie11 sroll11;

sbfsvg1=0.00;
do i=1 to DIM (sbf1);
select (sbf1{i});
  when (1) svg=0.00;  *never or <1/mo;
  when (2) svg=0.07;  *1-3/mo;
  when (3) svg=0.14;  *1/wk;
  when (4) svg=0.43;  *2-4/wk;
  when (5) svg=0.80;  *5-6/wk;
  when (6) svg=1.00;  *1/d;
  when (7) svg=2.50;  *2-3/d;
  when (8) svg=4.50;  *4-5/d;
  when (9) svg=6.00;  *6+/d;
otherwise svg=0.00;  *pt;
end;
sbfsvg=sbfsvg+svg;
end;

if sugar11=. then sgsvg11=0.00;
else sgsvg11=sugar11;
sbfsum1=sum(sbfsvg1, sgsvg11);

******************************************************************************
GUTS II******************************************************************************;
/*animal-based food & beverages*/
skim211=skim211b; m1or2211=m1or2211b;
whole211=whole211b; chocm211=chocm211b; instb211=instb211b;
prosh211=prosh211b; plyog211=plyog211b; yoglf211=yoglf211b;
yog211=yog211b; cotch211=cotch211b; crch211=crch211b; but211=but211b;
sbu211=sbu211b; whip211=whip211b; cream211=cream211b; mayo211=mayo211b;
chowd211=chowd211b; saldr211=saldr211b; egg211=egg211b; cburg211=cburg211b;
burg211=burg211b; pizza211=pizza211b; cnug211=cnug211b; dog211=dog211b;
tdog211=tdog211b; bacon211=bacon211b; procm211=procm211b; beef211=beef211b;
chwi211=chwi211b; chwo211=chwo211b; pork211=pork211b; fishes211=fishes211b;
tcuna211=tcuna211b; dfksh211=dfksh211b; shrim211=shrim211b; ofish211=ofish211b;
macch211=macch211b; othch211=othch211b; choco211=choco211b; cdwy211=cdwy211b;
pudd211=pudd211b; fryog211=fryog211b; iccer211=iccer211b; fsan211=fsan211b;
sands211=sands211b; ssa211=ssa211b; sbf211=sbf211b; stt211=stt211b;
sta211=stc211b; fbur211=fbur211b; bchr211=bchr211b; bbf211=bbf211b;
fpas211=fpas211b; ptc211=ptct211b; pbf211=ptbf211b; fmx211=fmx211b;
mch211=mch211b; mtbf211=mtbf211b; mfs211=mfs211b; cdf211=cdf211b;
cdfs211=cdfs211b; cdfw211=cdfw211b; lat211=lat211b; lasses211=lasses211b;
lataw211=lataw211b; iced211=iced211b; icd211=icd211b; icdw211=icdw211b;
/*healthy plant-based foods & beverages*/
whbr211=whbr211b; lcsdr211=lcsdr211b; powbr211=powbr211b; protb211=protb211b;
brbar211=brbar211b; rais211=rais211b; grape211=grape211b; ban211=ban211b; app211=app211b; apsau211=apsau211b;
array sary211 [6] stsa211 stbf211 stt211 stvg211 stct211 stpb211;
array sary211x [6] stsa211x stbf211x stt211x stvg211x stct211x stpb211x;
do i=1 to 6;
if sary211[i]=1 then sary211x[i]=1; *type sandwich yes;
if sary211[i]=0 then sary211x[i]=0; *pt;
if sary211[i]=. then sary211x[i]=0; *pt;
end;

/*general frequency & size arrays – burritos - boys211*/
if fbur211=1 then fbur211x=0.00; *never;
else if fbur211=2 then fbur211x=0.04; *<1/mo;
else if fbur211=3 then fbur211x=0.07; *1-3/mo;
else if fbur211=4 then fbur211x=0.14; *1/wk;
else if fbur211=6 then fbur211x=0.80; *5-6/d;
else if fbur211=7 then fbur211x=1.00; *1/d;
else if fbur211=8 then fbur211x=2.50; *2-3/d;
else if fbur211=9 then fbur211x=4.50; *4-5/d;
else if fbur211=10 then fbur211x=6.00; *6+/d;
else fbur211x=0.00; *pt;
if sands211=1 then sds211x=1.00; *small;
else if sands211=2 then sds211x=2.00; *medium;
else if sands211=3 then sds211x=3.00; *large;
else sds211x=1.00; *small or pt;

/*general frequency & size arrays – sandwiches - boys211*/
if fsan211=1 then fsan211x=0.00; *never;
else if fsan211=2 then fsan211x=0.04; *<1/mo;
else if fsan211=3 then fsan211x=0.07; *1-3/mo;
else if fsan211=4 then fsan211x=0.14; *1/wk;
else if fsan211=5 then fsan211x=0.43; *2-4/wk;
else if fsan211=6 then fsan211x=0.80; *5-6/d;
else if fsan211=7 then fsan211x=1.00; *1/d;
else if fsan211=8 then fsan211x=2.50; *2-3/d;
else if fsan211=9 then fsan211x=4.50; *4-5/d;
else if fsan211=10 then fsan211x=6.00; *6+/d;
else fsan211x=0.00; *pt;
if sands211=1 then sds211x=1.00; *small;
else if sands211=2 then sds211x=2.00; *medium;
else if sands211=3 then sds211x=3.00; *large;
else sds211x=1.00; *small or pt;

else if fbur211=4 then fbur211x=0.14;
else if fbur211=5 then fbur211x=0.43;
else if fbur211=6 then fbur211x=0.80;
else if fbur211=7 then fbur211x=1.00;
else if fbur211=8 then fbur211x=2.50;
else if fbur211=9 then fbur211x=4.50;
else if fbur211=10 then fbur211x=6.00;
else fbur211x=0.00;

array bary211[5] btch211 btbf211 bttf211 btbn211 btvg211;
array bary211x[5] btch211x btbf211x bttf211x btbn211x btvg211x;

do i=1 to 5;
if bary211{i}=1 then bary211x{i}=1; /*type burrito yes;*/
if bary211{i}=0 then bary211x{i}=0; /*pt;*/
if bary211{i}=. then bary211x{i}=0; /*pt;*/
end;

/*general frequency & size arrays - pasta - boys211*/
array mary211[5] mtch211 mtbf211 mttf211 mtvg211 mtfs211;
array mary211x[5] mtch211x mtbf211x mttf211x mtvg211x mtfs211x;

else if fbur211=4 then fbur211x=0.14; /*1/wk;*/
else if fbur211=5 then fbur211x=0.43; /*2-4/wk;*/
else if fbur211=6 then fbur211x=0.80; /*5-6/d;*/
else if fbur211=7 then fbur211x=1.00; /*1/d;*/
else if fbur211=8 then fbur211x=2.50; /*2-3/d;*/
else if fbur211=9 then fbur211x=4.50; /*4-5/d;*/
else if fbur211=10 then fbur211x=6.00; /*6+/d;*/
else fbur211x=0.00; /*pt;*/

if fpas211=1 then fpas211x=0.00; /*never;*/
else if fpas211=2 then fpas211x=0.04; /*<1/mo;*/
else if fpas211=3 then fpas211x=0.07; /*1-3/mo;*/
else if fpas211=4 then fpas211x=0.14; /*1/wk;*/
else if fpas211=5 then fpas211x=0.43; /*2-4/wk;*/
else if fpas211=6 then fpas211x=0.80; /*5-6/d;*/
else if fpas211=7 then fpas211x=1.00; /*1/d;*/
else if fpas211=8 then fpas211x=2.50; /*2-3/d;*/
else if fpas211=9 then fpas211x=4.50; /*4-5/d;*/
else if fpas211=10 then fpas211x=6.00; /*6+/d;*/
else fpas211x=0.00; /*pt;*/

/*general frequency & size arrays - mixed dish - boys211*/
array mary211[5] mtch211 mtbf211 mttf211 mtvg211 mtfs211;
array mary211x[5] mtch211x mtbf211x mttf211x mtvg211x mtfs211x;

if fbap211=1 then fbur211x=0.14; /*1/wk;*/
else if fbap211=2 then fbur211x=0.43; /*2-4/wk;*/
else if fbap211=6 then fbur211x=0.80; /*5-6/d;*/
else if fpas211=7 then fbur211x=1.00; /*1/d;*/
else if fpas211=8 then fbur211x=2.50; /*2-3/d;*/
else if fpas211=9 then fbur211x=4.50; /*4-5/d;*/
else if fpas211=10 then fbur211x=6.00; /*6+/d;*/
else fpas211x=0.00; /*pt;*/

array mary211[5] mtch211 mtbf211 mttf211 mtvg211 mtfs211;
array mary211x[5] mtch211x mtbf211x mttf211x mtvg211x mtfs211x;

if fbap211=1 then fbur211x=0.14; /*1/wk;*/
else if fbap211=2 then fbur211x=0.43; /*2-4/wk;*/
else if fbap211=6 then fbur211x=0.80; /*5-6/d;*/
else if fpas211=7 then fbur211x=1.00; /*1/d;*/
else if fpas211=8 then fbur211x=2.50; /*2-3/d;*/
else if fpas211=9 then fbur211x=4.50; /*4-5/d;*/
else if fpas211=10 then fbur211x=6.00; /*6+/d;*/
else fpas211x=0.00; /*pt;*/
if mary211[i]=. then mary211x[i]=0;
end;

/*animal fat - boys211*/
array anfat2{2} but211 sbu211;
afatsvg2=0.00;
do i=1 to DIM (anfat2);
select (anfat2[i]);
  when (1) svg=0.00; *never;
  when (2) svg=0.04; *<1/mo;
  when (3) svg=0.07; *1-3/mo;
  when (4) svg=0.14; *1/wk;
  when (5) svg=0.43; *2-4/wk;
  when (6) svg=0.80; *5-6/wk;
  when (7) svg=1.00; *1/d;
  when (8) svg=2.50; *2-3/d;
  when (9) svg=4.50; *4-5/d;
  when (10) svg=6.00; *6+/d;
  otherwise svg=0.00; *pt;
end;
afatsvg2= afatsvg2+svg;
end;
afatsum2= afatsvg2;

/*eggs - boys211*/
array eggs2{2} mayo211 egg211;
eggsvg2=0.00;
do i=1 to DIM (eggs2);
select (eggs2[i]);
  when (1) svg=0.00; *never;
  when (2) svg=0.04; *<1/mo;
  when (3) svg=0.07; *1-3/mo;
  when (4) svg=0.14; *1/wk;
  when (5) svg=0.43; *2-4/wk;
  when (6) svg=0.80; *5-6/wk;
  when (7) svg=1.00; *1/d;
  when (8) svg=2.50; *2-3/d;
  when (9) svg=4.50; *4-5/d;
  when (10) svg=6.00; *6+/d;
  otherwise svg=0.00; *pt;
end;
eggsvg2= eggsvg2+svg;
end;
eggsum2= eggsvg2;

/*dairy - boys211*/
array dairy2{23} skim211 m1or2211 whole211 chocm211 instb211 prosh211 yoglt211 yog211 cotch211 crch211 whip211 cream211 chowd211 saldr211 pizza211 macch211 othch211 choco211 cdyw211 pudd211 fryog211 icecr211;
dairsvg2=0.00;
do i=1 to DIM (dairy2);
select (dairy2[i]);
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
dairsvg2=dairsvg2+svg;
end;

/*coffee, dairy - boys211*/
array cary211 [4] cdff211 icff211 icd211;
array cary211x [4] cdff211x icff211x icd211x;
do i=1 to 4;
if cary211[i]=1 then cary211x[i]=0.00; *never;
if cary211[i]=2 then cary211x[i]=0.04; *<1/mo;
if cary211[i]=3 then cary211x[i]=0.07; *1-3/mo;
if cary211[i]=4 then cary211x[i]=0.21; *1-2/wk;
if cary211[i]=5 then cary211x[i]=0.64; *3-6/wk;
if cary211[i]=6 then cary211x[i]=1.00; *1/d;
if cary211[i]=7 then cary211x[i]=2.00; *2+/d;
if cary211[i]=8 then cary211x[i]=0.00; *pt;
if cary211[i]=. then cary211x[i]=0.00; *pt;
end;

/*cappuccino, mocha, latte nonfat - size, whip, frequency - boys211*/
if cdffs211=1 then cas211x=1.00; *small 12oz;
else if cdffs211=2 then cas211x=2.00; *medium 16oz;
else if cdffs211=3 then cas211x=2.60; *large 21oz;
else cas211x=1.00; *pt;
if cdffw211=1 then caw211x=1.00; *yes whip;
else if cdffw211=2 then caw211x=0.00; *no whip;
else caw211x=0.00; *pt;
casvg211=(cas211x+caw211x)*cdff211x;

/*cappuccino, mocha, latte low fat whole milk - size, whip, frequency - boys211*/
if lattes211=1 then las211x=1.00; *small 12oz;
else if lattes211=2 then las211x=2.00; *medium 16oz;
else if lattes211=3 then las211x=2.60; *large 21oz;
else las211x=1.00; *pt;
if lattew211=1 then law211x=1.00; *yes whip;
else if lattew211=2 then law211x=0.00; *no whip;
else law211x=0.00; *pt;
lasvg211=(las211x+law211x)*latte211x;
/*nonfat iced coffee drinks - size, whip, frequency - boys211*/
if icffs211=1 then icns211x=1.00;  *small 12oz;
else if icffs211=2 then icns211x=2.00;  *medium 16oz;
else if icffs211=3 then icns211x=2.60;  *large 21oz;
else icns211x=1.00;  *pt;
if icffw211=1 then icnw211x=1.00;  *yes whip;
else if icffw211=2 then icnw211x=0.00;  *no whip;
else icnw211x=0.00;  *pt;
insvg211=(icns211x+icnw211x)*icff211x;

/*low fat whole milk iced coffee drinks - size, whip, frequency - boys211*/
if icds211=1 then icfs211x=1.00;  *small 12oz;
else if icds211=2 then icfs211x=2.00;  *medium 16oz;
else if icds211=3 then icfs211x=2.60;  *large 21oz;
else icfs211x=1.00;  *pt;
if icdw211=1 then icfw211x=1.00;  *yes whip;
else if icdw211=2 then icfw211x=0.00;  *no whip;
else icfw211x=0.00;  *pt;
ifsvg211=(icfs211x+icfw211x)*icd211x;
dairstum2=sum(dairstv2, casvg211, lasvg211, insvg211, ifsvg211);

/*meat - boys211*/
array meat2{11} cburg211 burg211 chnug211 dog211 ctbdog211 bacon211
procm211 beef211 chwi211 chwo211 pork211;
meatsvg2=0.00;
do i=1 to DIM (meat2);
select (meat2{i});
when (1) svg=0.00;  *never;
when (2) svg=0.04;  *<1/mo;
when (3) svg=0.07;  *1-3/mo;
when (4) svg=0.14;  *1/wk;
when (5) svg=0.43;  *2-4/wk;
when (6) svg=0.80;  *5-6/wk;
when (7) svg=1.00;  *1/d;
when (8) svg=2.50;  *2-3/d;
when (9) svg=4.50;  *4-5/d;
when (10) svg=6.00;  *6+/d;
otherwise svg=0.00;  *pt;
end;
meatsvg2=meatsvg2+svg;
end;
spsvg211=fsan211x*sds211x*stsa211x;  *freq, size - sandwich type processed meat – angroup;
ssbsvg211=fsan211x*sds211x*stbf211x;  *freq, size - sandwich type beef – animal group;
scsvg211=fsan211x*sds211x*stct211x;  *freq, size - sandwich type chicken turkey – angroup;
bcsvg211=fbur211x*btch211x;  *freq - burrito type chicken turkey – animal group;
bfsvg211=fbur211x*btbf211x;  *freq - burrito type beef – animal group;
pcsvg211=fpas211x*ptct211x;  *freq - pasta type chicken turkey – animal group;
\( \text{meatsum2} = \text{sum(} \text{meatsvg2, spsvg211, sbsvg211, scsvg211, bcsvg211, bfsvg211, pcsvg211, pbsvg211, mcsvg211, mbsvg211)\); \\
\)

\( \text{/*seafood - boys211*/} \)

\( \text{array seaf2[5] fishes211 ctuna211 dkfsh211 shrim211 ofish211;} \)

\( \text{seafsvg2}=0.00; \)

\( \text{do i=1 to DIM (seaf2);} \)

\( \text{select (seaf2[i]);} \)

\( \text{when (1) svg=0.00; \quad \text{*never;}} \)

\( \text{when (2) svg=0.04; \quad \text{*<1/mo;}} \)

\( \text{when (3) svg=0.07; \quad \text{*1-3/mo;}} \)

\( \text{when (4) svg=0.14; \quad \text{*1/wk;}} \)

\( \text{when (5) svg=0.43; \quad \text{*2-4/wk;}} \)

\( \text{when (6) svg=0.80; \quad \text{*5-6/wk;}} \)

\( \text{when (7) svg=1.00; \quad \text{*1/d;}} \)

\( \text{when (8) svg=2.50; \quad \text{*2-3/d;}} \)

\( \text{when (9) svg=4.50; \quad \text{*4-5/d;}} \)

\( \text{when (10) svg=6.00; \quad \text{*6+/d;}} \)

\( \text{otherwise svg=0.00; \quad \text{*pt;}} \)

\( \text{end;} \)

\( \text{seafsvg2}=\text{seafsvg2}+\text{svg;} \)

\( \text{end;} \)

\( \text{mfsvg211=fmix211x*mtfs211x; \quad \text{*freq - mix dish fish – animal group;}} \)

\( \text{stsvg211=fsan211x*sds211x*stt211x; \quad \text{*freq, size - sandwich type tuna – animal group;}} \)

\( \text{seafsum2=\text{sum(} \text{seafsvg2, stsvg211, mfsvg211)\);} \)

\( \text{/*whole grain - boys211*/} \)

\( \text{array whgr2[11] whbr211 oat211 cckcer211 dkbr211 brice211 tort211 popc211 powrb211 protb211 brbar211 vburg211;} \)

\( \text{whgrsvg2}=0.00; \)

\( \text{do i=1 to DIM (whgr2);} \)

\( \text{select (whgr2[i]);} \)

\( \text{when (1) svg=0.00; \quad \text{*never;}} \)

\( \text{when (2) svg=0.04; \quad \text{*<1/mo;}} \)

\( \text{when (3) svg=0.07; \quad \text{*1-3/mo;}} \)

\( \text{when (4) svg=0.14; \quad \text{*1/wk;}} \)

\( \text{when (5) svg=0.43; \quad \text{*2-4/wk;}} \)

\( \text{when (6) svg=0.80; \quad \text{*5-6/wk;}} \)

\( \text{when (7) svg=1.00; \quad \text{*1/d;}} \)

\( \text{when (8) svg=2.50; \quad \text{*2-3/d;}} \)

\( \text{when (9) svg=4.50; \quad \text{*4-5/d;}} \)

\( \text{when (10) svg=6.00; \quad \text{*6+/d;}} \)

\( \text{otherwise svg=0.00; \quad \text{*pt;}} \)

\( \text{end;} \)

\( \text{whgrsvg2}=\text{whgrsvg2}+\text{svg;} \)

\( \text{end;} \)
whgrsum2= whgrsvg2;

/*fruit - boys211*/
array frt2{10} rais211 grape211 ban211 appl211 apsau211
cant211 wtrml211 oran211 straw211 peach211;
frtsum2=0.00;
do i=1 to DIM (frt2);
select (frt2{i});
  when (1) sv2=0.00; *never;
  when (2) sv2=0.04; *<1/mo;
  when (3) sv2=0.07; *1-3/mo;
  when (4) sv2=0.14; *1/wk;
  when (5) sv2=0.43; *2-4/wk;
  when (6) sv2=0.80; *5-6/wk;
  when (7) sv2=1.00; *1/d;
  when (8) sv2=2.50; *2-3/d;
  when (9) sv2=4.50; *4-5/d;
  when (10) sv2=6.00; *6+/d;
otherwise sv2=0.00; *pt;
end;
frtsum2=frtsum2+sv2;
end;

/*vegetables - boys211*/
array veg2{19} tom211 toj211 brocc211 corn211 mixv211 rspin211
cspin211 bruss211 grepe211 yams211 eggp211 car211 rcar211
celry211 ilett211 oniov211 oniog211 salsa211 tosau211;
vegsum2=0.00;
do i=1 to DIM (veg2);
select (veg2{i});
  when (1) sv2=0.00; *never;
  when (2) sv2=0.04; *<1/mo;
  when (3) sv2=0.07; *1-3/mo;
  when (4) sv2=0.14; *1/wk;
  when (5) sv2=0.43; *2-4/wk;
  when (6) sv2=0.80; *5-6/wk;
  when (7) sv2=1.00; *1/d;
  when (8) sv2=2.50; *2-3/d;
  when (9) sv2=4.50; *4-5/d;
  when (10) sv2=6.00; *6+/d;
otherwise sv2=0.00; *pt;
end;
vegsum2=vegsum2+sv2;
end;

svsvg211=fsan211x*sds211x*stvg211x; *freq, size - sandwich type veggie – plant group;
bvsvg211=fbur211x*btvg211x; *freq - burrito type veggie – plant group;
pvsvg211=fpas211x*ptvg211x; *freq - pasta type veggie – plant group;
mvsvg211=fmi211x*mtvg211x; *freq – mix dish veggie – plant group;
vegsum2= sum(vegsum2, svsvg211, bvsvg211, pvsvg211, mvsvg211);
/*nuts & seeds - boys211*/
array nuts2{5} pbut211 pnut211 wnut211 onut211 seeds211;
nutsvg2=0.00;
do i=1 to DIM (nuts2);
select (nuts2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
nutsvg2=nutsvg2+svg;
end;

sbsvg211=fsan211x*sds211x*stpb211x; *freq, size - sandwich type peanut butter – plant group;
nutsum2=sum(nutsvg2, sbsvg211);

/*legumes - boys211*/
array lgm2{5} sbean211 peas211 soy211 tofu211 beans211;
lgmsvg2=0.00;
do i=1 to DIM (lgm2);
select (lgm2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
lgmsvg2=lgmsvg2+svg;
end;
btsvg211=fbur211x*bttf211x; *freq - burrito type tofu – plant group;
bbsvg211=fbur211x*bttb211x; *freq - burrito type bean – plant group;
mtsvg211=fmix211x*mttf211x; *freq – mix dish tofu – plant group;
lgmsum2=sum(lgmsvg2, btsvg211, bbsvg211, mtsvg211);

/*non-hydrogenated vegetable oils - boys211*/
array noil2{1} lcsdr211;
nويلsvg2=0.00;
do i=1 to DIM (noil2);
select (nail2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;

nailsvg2=nailsvg2+svg;
end;
nailsum2= nailsvg2;

/*tea & coffee - boys211*/
array cft2{1} tea211;
cftsvg2=0.00;
do i=1 to DIM (cft2);
select (cft2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
cftsvg2=cftsvg2+svg;
end;

/*coffee, size, frequency - boys211*/
if decaf211=1 then dcsvg211=0.00;
else if decaf211=2 then dcsvg211=0.04;
else if decaf211=3 then dcsvg211=0.07;
else if decaf211=4 then dcsvg211=0.21;
else if decaf211=5 then dcsvg211=0.64;
else if decaf211=6 then dcsvg211=1.00;
else if decaf211=7 then dcsvg211=2.00;
else dcsvg211=0.0;

if decfs211=1 then dcs211x=1.5; *small 12oz;
else if decfs211=2 then dcs211x=2.00; *medium 16oz;
else if decfs211=3 then dcs211x=2.60; *large 21oz;
else dcs211x=1.00; *pt;
dcsvg211=dcsvg211*dcs211x;
if coff211=1 then cfsvg211=0.00;  
*never; 
else if coff211=2 then cfsvg211=0.04;  
*<1/mo; 
else if coff211=3 then cfsvg211=0.07;  
*1-3/mo; 
else if coff211=4 then cfsvg211=0.21;  
*1-2/wk; 
else if coff211=5 then cfsvg211=0.64;  
*3-6/wk; 
else if coff211=6 then cfsvg211=1.00;  
*1/d; 
else if coff211=7 then cfsvg211=2.00;  
*2+/d; 
else cfsvg211=0.0;  
*pt; 

if coffs211=1 then cfs211x=1.5;  
*small 12oz; 
else if coffs211=2 then cfs211x=2.00;  
*medium 16oz; 
else if coffs211=3 then cfs211x=2.60;  
*large 21oz; 
else cfs211x=1.00;  
*pt; 

cfsvg211=cfsvg211*cfs211x;  
cftsum2=sum(cftsvg2, dcsvg211, cfsvg211);  

/*fruit juices - boys211*/ 
array frj2{3} oj211 aj211 smth211; 
frjsvg2=0.00; 
do i=1 to DIM (frj2);  
select (frj2[i]);  
when (1) svg=0.00;  
*never; 
when (2) svg=0.04;  
*<1/mo; 
when (3) svg=0.07;  
*1-3/mo; 
when (4) svg=0.14;  
*1/wk; 
when (5) svg=0.43;  
*2-4/wk; 
when (6) svg=0.80;  
*5-6/wk; 
when (7) svg=1.00;  
*1/d; 
when (8) svg=2.50;  
*2-3/d; 
when (9) svg=4.50;  
*4-5/d; 
when (10) svg=6.00;  
*6+/d; 
otherwise svg=0.00;  
*pt; 
end;  

frjsvg2=frjsvg2+svg;  
end;  

frjsum2= frjsvg2;  

/*refined grains - boys211*/ 
array rfgr2{10} crack211 cer211 engl211 wrice211 soup211 pretz211 popt211 crnbr211 bisct211 muff211; 
rfgrsvg2=0.00; 
do i=1 to DIM (rfgr2);  
select (rfgr2[i]);  
when (1) svg=0.00;  
*never; 
when (2) svg=0.04;  
*<1/mo; 
when (3) svg=0.07;  
*1-3/mo; 
when (4) svg=0.14;  
*1/wk; 
when (5) svg=0.43;  
*2-4/wk; 
when (6) svg=0.80;  
*5-6/wk; 
when (7) svg=1.00;  
*1/d; 
when (8) svg=2.50;  
*2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;

rfgrsvg2=rfgrsvg2+svg;
end;

ppsvg211=fpas211x*ptpl211x; *freq - pasta type plain – plant group;

rfgrsum2=sum(rfgrsvg2, ppsvg211);

/*potatoes - boys211*/
array pot2{5} chip211 fries211 mashp211 bchip211 ptsld211;
potsvg2=0.00;
do i=1 to DIM (pot2);
select (pot2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
potsvg2=potsvg2+svg;
end;
potsum2= potsvg2;

/*hydrogenated vegetable oils - boys211*/
array hoil2{1} marg211;
hoilsvg2=0.00;
do i=1 to DIM (hoil2);
select (hoil2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
hoilsvg2=hoilsvg2+svg;
end;
hoilsum2= hoilsvg2;

/*sugar sweetened beverages - boys211*/
array ssb2[4] punch211 spdrk211 rdbus211 rdbul211;
ssbsvg2=0.00;
do i=1 to DIM (ssb2);
select (ssb2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04;  *<1/mo;
when (3) svg=0.07;  *1-3/mo;
when (4) svg=0.14;  *1/wk;
when (5) svg=0.43;  *2-4/wk;
when (6) svg=0.80;  *5-6/wk;
when (7) svg=1.00;  *1/d;
when (8) svg=2.50;  *2-3/d;
when (9) svg=4.50;  *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
ssbsvg2=ssbsvg2+svg;
end;

/*soda size frequency – boys211*/
array sd211 [4] lcaf211 lcnoc211 coke211 otsug211;
ssdsvg211=0.0;
do i=1 to DIM (sd211);
select (sd211{i});
when (1) svg=0.00; *never;
when (2) svg=0.04;  *<1/mo;
when (3) svg=0.07 ; *1-3/mo;
when (4) svg=0.14;  *1/wk;
when (5) svg=0.43;  *2-4/wk;
when (6) svg=0.80;  *5-6/wk;
when (7) svg=1.00;  *1/d;
when (8) svg=2.50;  *2-3/d;
when (9) svg=4.50;  *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
ssdsvg211=ssdsvg211+svg;
end;
if sodas211=1 then sds211x=1.00;  *8oz;
else if sodas211=2 then sds211x=1.50;  *12oz;
else if sodas211=3 then sds211x=2.25;  *18oz;
else if sodas211=4 then sds211x=2.00;  *21oz;
else sds211x=1.00;  *pt;
ssdsvg211=ssdsvg211*sds211x;
ssbsvg2=ssbsvg2+svg;

/*/sugar-based foods - boys211*/
array sbf2[13] edywo211 ketch211 jam211 fnk211 pops211
panca211 frst211 twink211 sroll211 donut211 cooki211 brwni211 pie211;
sbfsvg2=0.00;
do i=1 to DIM (sbf2);
select (sbf2{i});
when (1) svg=0.00; *never;
when (2) svg=0.04; *<1/mo;
when (3) svg=0.07; *1-3/mo;
when (4) svg=0.14; *1/wk;
when (5) svg=0.43; *2-4/wk;
when (6) svg=0.80; *5-6/wk;
when (7) svg=1.00; *1/d;
when (8) svg=2.50; *2-3/d;
when (9) svg=4.50; *4-5/d;
when (10) svg=6.00; *6+/d;
otherwise svg=0.00; *pt;
end;
sbfsvg2=sbfsvg2+svg;
end;
if sugar211=1 then sgsvg211=0.00;  *No<1tsp/d;
else if sugar211=2 then sgsvg211=1.50;  *1-2tsp/d;
else if sugar211=3 then sgsvg211=3.50;  *3-4tsp/d;
else if sugar211=4 then sgsvg211=5.00;  *5+tsp/d;
else sgsvg211=0.00;  *pt;
sbfsum2=sum(sbfsvg2, sgsvg211); 
******************************************************************;
* OUTCOME: ED *
******************************************************************;
********blank IIEF-5 = confidence******************************************;
erconf13a=erconf13m;
if erdiff13m=0 then erdiff13a=erconf13a;
else if erdiff13m=6 then erdiff13a=erconf13a;
else erdiff13a=erdiff13m;
if ablpen13m=0 then ablpen13a=erconf13a;
else if ablpen13m=6 then ablpen13a=erconf13a;
else ablpen13a=ablpen13m;
if aftpen13m=0 then aftpen13a=erconf13a;
else if aftpen13m=6 then aftpen13a=erconf13a;
else aftpen13a=aftpen13m;
if sexsat13m=0 then sexsat13a=erconf13a;
else if sexsat13m=6 then sexsat13a=erconf13a;
else sexsat13a=sexsat13m;
********IIEF-5 categories******************************************;
iief5a=sum(erconf13a, erdiff13a, ablpen13a, aftpen13a, sexsat13a);
if iief5a ge 22 then iiefcat=1;  *reference no ed;
else if iief5a ge 17 & iief5a lt 22 then iiefcat=2;  *mild ed;
else if iief5a ge 12 & iief5a lt 17 then iiefcat=3;  *moderate ed;
else if iief5a ge 8 & iief5a lt 12 then iiefcat=4;  *moderate/severe ed;
else iiefcat=5;  *severe ed;

/*mmsed: dichotomized mild-moderate, moderate, severe ed score (5-16)/
if iiefcat ge 3 then mmsed=1;
else mmsed=0;

/*anyed: dichotomized mild, mild-moderate, moderate, severe ed score (5-21)/
if iiefcat ge 2 then anyed=1;
else anyed=0;

******************************************************************;
* COVARIATES
****************************************************
**************;
********************boys13 Covariates*********************************;
marry13=marry13b; lpart13=lpart13b; oftsmk13=oftsmk13b; aalc13=aalc13b;
nalc13=nalc13b; sexact13=sexact13b; dbd13=dbd13b; hbpd13=hbpd13b;
chold13=chold13b; insul13=insul13b; ohypo13=ohypo13b; thiaz13=thiaz13b;
ccl13=ccl13b; betab13=beta13b; ace13=ace13b; bprx13=bprx13b;
oclrx13=oclrx13b; stat13=stat13b; anxd13=anxd13b; depr13=depr13b;
ssri13=ssri13b; antid13=antid13b; val13=val13b;

/*relationship status*/
if marry13=1 or lpart13=1 then rship13x=1;  *married or living with partner;
else rship13x=0;  *never married, separated, divorced, widowed, pt;

/*smoking cigarettes at least weakly*/
if oftsmk13=4 then ofsmk13x=1;  *1/wk;
else if oftsmk13=5 then ofsmk13x=1;  *1/d;
else ofsmk13x=0;  *never <1/wk pt;

/*alcohol continuous variable*/
if aalc13=2 then falc13x=0.36;  *<1/mo;
else if aalc13=3 then falc13x=0.14;  *<1/wk;
else if aalc13=4 then falc13x=0.21;  *1-2/wk;
else if aalc13=5 then falc13x=0.57;  *3-5/wk;
else if aalc13=6 then falc13x=0.86;  *6/wk;
else if aalc13=7 then falc13x=1.00;  *1/d;
else falc13x=0;  *pt;

if nalc13=2 then nalc13x=0.5;  *<1 drink;
else if nalc13=3 then nalc13x=0.5;  *1 drink;
else if nalc13=4 then nalc13x=1.0;  *2 drinks;
else if nalc13=5 then nalc13x=2.0;  *3 drinks;
else if nalc13=6 then nalc13x=3.0;  *4 drinks;
else if nalc13=7 then nalc13x=4.0;  *5 drinks;
else if nalc13=8 then nalc13x=5.0;  *6+ drinks;
else nalc13x=0;  *pt;

alcsvg13=falc13x*nalc13x;

/*sexually active last 12mo*/
if sexact13=1 then sexact13x=1;  *yes sexually active;
else sexact13x=0;   *no pt;

/* medical conditions – cardiometabolic*/
if dbd13 ge 1 then db13x=1;  *any diabetes dx;
else db13x=0;  *no pt;

if hbpd13 ge 1 then hbp13x=1;  *any hypertension dx;
else hbp13x=0;  *no pt;

if chold13 ge 1 then chol13x=1;  *any high chol triglycerides dx;
else chol13x=0;  *no pt;

if insul13=1 or ohypo13=1 or db13x=1 then dbdm13x=1;  *any diabetes dx or medication;
else dbdm13x=0;  *none or pt;

if thiaz13=1 or ccblo13=1 or betab13=1 or ace13=1 or
bprx13=1 or hbp13x=1 then hbpdm13x=1;  *any hypertension dx or medication;
else hbpdm13x=0;  *none or pt;

if oclrx13=1 or stat13=1 or chol13x=1 then chodm13x=1;  *any high cholesterol dx or medication;
else chodm13x=0;  *none or pt;

if dbdm13x=1 or hbpdm13x=1 or chodm13x=1 then carmetdm=1;  *any cardio met dx or med;
else carmetdm=0;  *none or pt;

/* medical conditions – anxiety depression*/
if anxd13 ge 1 or deprd13 ge 1 then depan13x=1;  *any anx dep dx;
else depan13x=0;  *no pt;

if ssri13=1 or antid13=1 or val13=1 or depan13x=1 then dadm13x=1;  *any dep anx dx or med;
else dadm13x=0;  *no pt;

************************** gutsffq11 Covariates*******************************;
mvit11=mvit11f; vita11=vita11f; vtd11=vtd11f; vtbd11=vtbd11f;
vitc11=vitc11f; k11=k11f; vite11=vite11f; cal11=cal11f; sel11=sel11f;
nia11=nia11f; zinc11=zinc11f; iron11=iron11f; foli11=foli11f; cod11=cod11f;
flaxo11=flaxo11f;

if mvit11=2 then mulvit11=1;
else mulvit11=0;

if vita11=2 or vtd11=3 or vtd11=2 or vtbd11=2 or
vitc11=2 or vitc11=3 or k11=2 or vite11=2 or cal11=2 or
sel11=2 or nia11=2 or zinc11=2 or iron11=2 or foli11=2 or
cod11=2 or flaxo11=2 then othvit11=1;
else othvit11=0;

if mulvit11=1 or othvit11=1 then anysup1=1;
else anysup1=0;

**************************boys211 Covariates*******************************;
mvit211=mvit211b; vsup211=vsup211b;

if mvit211=1 then mulvit21=1;
else mulvit21=0;
if vsup211=1 then othvit21=1;
else othvit21=0;

if mulvit21=1 or othvit21=1 then anysup2=1;
else anysup2=0;

if mulvit11=1 or mulvit21=1 then mulvit=1;
else mulvit=0;

if othvit11=1 or othvit21=1 then othvit=1;
else othvit=0;

if anysup1=1 or anysup2=1 then anysup=1;
else anysup=0;

**************gab11_nts Covariates**************
calor11=calor11n;

**************gutsder9613 Covariates**************

ow_ob13a=ow_ob13;

if ow_ob13a=1 then bmige25=1; * bmi greater eq 25;
else bmige25=0; * lt 25 or pt;

**************boys204 boys96 Covariates**************

white204=white204b; white96=white96b;

if white204=1 or white96=1 then racecov=1; * race/ethnicity white;
else racecov=0;

if racecov=. then racecov=1; * additional blanks;

**************gab11_ant boys96 Covariates**************

prot11=prot11a; aprot11=aprot11a; vprot11=vprot11a; dprot11=dprot11a;
tfat11=tfat11a; afat11=afat11a; vfat11=vfat11a; dfat11=dfat11a; carbo11=carbo11a;
 crude11=crude11a; chol11=chol11a; alco11=alco11a; mon11=mon11a; poly11=poly11a;
sat11=sat11a;

**************gab11_ant Covariates**************

afatsum=sum(afatsum1, afatsum2);
eggsum=sum(eggsum1, eggsum2);
dairsum=sum(dairsum1, dairsum2);
meatsum=sum(meatsum1, meatsum2);
seafsum=sum(seafsum1, seafsum2);
whgrsum=sum(whgrsum1, whgrsum2);
frtsum=sum(frtsum1, frtsum2);
vegsum=sum(vegsum1, vegsum2);
nutsum=sum(nutsum1, nutsum2);
lgmsum=sum(lgmsum1, lgmsum2);
noilsum=sum(noilsum1, noilsum2);
cftsum=sum(cftsum1, cftsum2);
frjsum=sum(frjsum1, frjsum2);
rfgrsum=sum(rfgrsum1, rfgrsum2);

* FINAL ANALYSES *

**************gab11_ant Covariates**************

afatsum=sum(afatsum1, afatsum2);
eggsum=sum(eggsum1, eggsum2);
dairsum=sum(dairsum1, dairsum2);
meatsum=sum(meatsum1, meatsum2);
seafsum=sum(seafsum1, seafsum2);
whgrsum=sum(whgrsum1, whgrsum2);
frtsum=sum(frtsum1, frtsum2);
vegsum=sum(vegsum1, vegsum2);
nutsum=sum(nutsum1, nutsum2);
lgmsum=sum(lgmsum1, lgmsum2);
noilsum=sum(noilsum1, noilsum2);
cftsum=sum(cftsum1, cftsum2);
frjsum=sum(frjsum1, frjsum2);
rfgrsum=sum(rfgrsum1, rfgrsum2);
potsum=sum(potsum1, potsum2);
ssbsum=sum(ssbsum1, ssbsum2);
sbfsum=sum(sbfsum1, sbfsum2);
hoilsum=sum(hoilsum1, hoilsum2);

run;

proc rank data=cohort out=raw_rank groups=5;
  var afatsum eggsum dairsum
  meatsum seafsum whgrsum frtsum vegsum
  nutsum lgmsum noilsum cifsum frjsum
  rfgrsum potsum ssbsum sbfsum hoilsum;
  ranks afatqs eggqs dairqs
  meatqs seafqs whgrqs frtqs vegqs
  nutqs lgmqs noilqs cifqs frjqs
  rfgrqs potqs ssbqs sbfqs hoilqs;
run;

data pbdi_score;
  set raw_rank;
  array qa5 [5] afatqs eggqs dairqs meatqs seafqs;
  array qa5x [5] afatpbdi eggpbdi dairpbdi meatpbdi seafpbdi;
  do i=1 to 5;
    if qa5{i}=0 then qa5x{i}=5;
    if qa5{i}=1 then qa5x{i}=4;
    if qa5{i}=2 then qa5x{i}=3;
    if qa5{i}=3 then qa5x{i}=2;
    if qa5{i}=4 then qa5x{i}=1;
  end;

  array qa6 [13] frjqs rfgrqs potqs ssbqs sbfqs hoilqs whgrqs frtqs vegqs
    nutqs lgmqs noilqs cifqs;
  array qa6x [13] frjpbdi rfgrpbdi potpbdi ssbpbdi sbfpbdi hoilpbdi whgrpbdi
    frtpbdi vegpbdi nutpbdi lgmpbdi noilpbdi cifpbdi;
  do i=1 to 13;
    if qa6{i}=0 then qa6x{i}=1;
    if qa6{i}=1 then qa6x{i}=2;
    if qa6{i}=2 then qa6x{i}=3;
    if qa6{i}=3 then qa6x{i}=4;
    if qa6{i}=4 then qa6x{i}=5;
  end;

  pbdi=sum(afatpbdi, eggpbdi, dairpbdi, meatpbdi, seafpbdi, frjpbdi,
    rfgrpbdi, potpbdi, ssbpbdi, sbfpbdi, whgrpbdi, frtpbdi, vegpbdi,
    nutpbdi, lgmpbdi, noilpbdi, cifpbdi, hoilpbdi);
run;

proc rank data=pbdi_score out=score_rank groups=4;
  var pbdi;
  ranks pbdiqs;
run;

data pbdi_rank;
  set score_rank;
  if pbdiqs=0 then pbdiq1=1; else pbdiq1=0;
if pbdiqs=1 then pbdiq2=1; else pbdiq2=0;
if pbdiqs=2 then pbdiq3=1; else pbdiq3=0;
if pbdiqs=3 then pbdiq4=1; else pbdiq4=0;
run;

**************************************;
* Correlates
**************************************;

/*FREQUENCY OVERALL*/
proc freq data=pbdi_rank;
tables pbdiq1 pbdiq2 pbdiq3 pbdiq4 / nocol nopercent; run;

/*FREQUENCY BY ED*/
proc freq data=pbdi_rank;
tables pbdiq1*anyed pbdiq2*anyed pbdiq3*anyed pbdiq4*anyed / nocol nopercent; run;
proc freq data=pbdi_rank;
tables pbdiq1*mmsed pbdiq2*mmsed pbdiq3*mmsed pbdiq4*mmsed / nocol nopercent; run;

/*FREQUENCY BY STRATIFIED*/

%macro freq_anyed(strat);
proc freq data=pbdi_rank; where &strat; title "&strat";
tables anyed / nocol nopercent; run; %mend;
%freq_anyed(age13 ge 25);
%freq_anyed(age13 lt 25);
%freq_anyed(sexact13x eq 0);
%freq_anyed(sexact13x eq 1);
%freq_anyed(rship13x eq 0);
%freq_anyed(rship13x eq 1);
%freq_anyed(ofsmk13x eq 0);
%freq_anyed(ofsmk13x eq 1);
%freq_anyed(carmetdm eq 0);
%freq_anyed(carmetdm eq 1);

/*FREQUENCY BY STRATIFIED*/
data nomild;
set pbdi_rank;
if iief5a ge 22 then iiefnomld=1; *reference no ed;
else if iief5a ge 17 & iief5a lt 22 then iiefnomld=.; *delete mild ed;
else if iief5a ge 12 & iief5a lt 17 then iiefnomld=2; *moderate ed;
else if iief5a ge 8 & iief5a lt 12 then iiefnomld=3; *moderate/severe ed;
else iiefnomld=4; *severe ed;
if iiefnomld=. then delete; *delete mild phenotype;
if iiefnomld ge 2 then msed_nom=1; *msed_nom=5-16;
else msed_nom=0;
run;

proc freq data=nomild;
tables pbdiq1*msed_nom pbdiq2*msed_nom pbdiq3*msed_nom pbdiq4*msed_nom / nocol
nopercent; run;

/*Ranks for primary GEE*/
proc rank data=pbdi_score out=score_quin groups=5;
var pbdi; ranks pbdiqs; run;

/*Dichotomized quintiles*/
data quin_rank;
set score_quin;
if pbdiqs=0 then pbdiq1=1; else pbdiq1=0;
if pbdiqs=1 then pbdiq2=1; else pbdiq2=0;
if pbdiqs=2 then pbdiq3=1; else pbdiq3=0;
if pbdiqs=3 then pbdiq4=1; else pbdiq4=0;
if pbdiqs=4 then pbdiq5=1; else pbdiq5=0;
run;

/*FREQUENCY BY ED*/
proc freq data=quin_rank;
tables pbdiq1*anyed pbdiq2*anyed pbdiq3*anyed pbdiq4*anyed pbdiq5*anyed / nocol nopercent;
run;
proc freq data=quin_rank;
tables pbdiq1*mmsed pbdiq2*mmsed pbdiq3*mmsed pbdiq4*mmsed pbdiq5*mmsed/ nocol
nopercent; run;

ledoncedes,d:

*RESULTS
*

ANY ED**************;

/*MODEL 1: Age, energy*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model anyed=pbdiqs
age13 calor11 / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; model anyed=pbdiqs
age13 calor11 / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

/*MODEL 2: Age, energy, race, sexual activity, married, smoking, cardiometabolic dx or med*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model anyed=pbdiqs
age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; model anyed=pbdiqs
age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

/*MODEL 3: Age, energy, race, sexual activity, married, smoking, cardiometabolic dx or med, supplement, alcohol, depression or anxiety dx or med*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model anyed=pbdiqs
MMS ED**********************************************************;
/*MODEL 1: Age, energy*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model mmsed=pbdiqs age13 calor11 / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
proc genmod data=score_rank descending; class momid; model mmsed=pbdiqs age13 calor11 / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
/*MODEL 2: Age, energy, race, sexual activity, married, smoking, cardiometabolic dx or med*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model mmsed=pbdiqs age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
proc genmod data=score_rank descending; class momid; model mmsed=pbdiqs age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
/*MODEL 3: Age, energy, race, sexual activity, married, smoking, cardiometabolic dx or med, supplement, alcohol, depression or anxiety dx or med*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model mmsed=pbdiqs age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm anysup alcsvg13 dadm13x / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
proc genmod data=score_rank descending; class momid; model mmsed=pbdiqs age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm anysup alcsvg13 dadm13x / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
/*MODEL 4: Age, energy, race, sexual activity, married, smoking, cardiometabolic dx or med, supplement, alcohol, depression or anxiety dx or med, BMI*/
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); model mmsed=pbdiqs age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm anysup alcsvg13 dadm13x bmige25 / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
proc genmod data=score_rank descending; class momid; model mmsed=pbdiqs age13 calor11 racecov sexact13x rship13x ofsmk13x carmetdm anysup alcsvg13 dadm13x bmige25 / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;
100
model anyed=pbdiqs age13 calor11 racecov sexact13x ofsmk13x carmetdm / type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

title "ofsmk13x=1";
proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); where ofsmk13x=1;
model anyed=pbdiqs age13 calor11 racecov rship13x sexact13x carmetdm
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; where ofsmk13x=1;
model anyed=pbdiqs age13 calor11 racecov rship13x sexact13x carmetdm
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid pbdiqs(ref='0'); where ofsmk13x=0;
model anyed=pbdiqs age13 calor11 racecov rship13x sexact13x carmetdm
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; where ofsmk13x=0;
model anyed=pbdiqs age13 calor11 racecov rship13x sexact13x carmetdm
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; where carmetdm=1;
model anyed=pbdiqs age13 calor11 racecov rship13x osmk13x sexact13x carmetdm
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; where carmetdm=1;
model anyed=pbdiqs age13 calor11 racecov rship13x osmk13x sexact13x
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

proc genmod data=score_rank descending; class momid; where carmetdm=0;
model anyed=pbdiqs age13 calor11 racecov rship13x osmk13x sexact13x
/ type3 dist=bin link=logit; repeated subject=momid / type=cs covb; run;

/*P INTERACTION*/
/*P interaction- age*/
data age_strat; set score_rank; if age13 ge 25 then age25=1; else age25=0; run;

proc genmod data=age_strat descending; class momid;
model anyed=pbdiqs age25 pbdiqs*age25 calor11 racecov ofsmk13x
sexact13x rship13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

/*P interaction- sexually active*/
proc genmod data=score_rank descending; class momid;
model anyed=pbdiqs sexact13x pbdiqs*sexact13x age13 calor11 racecov
osmk13x rship13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;
/*P interaction- relationship*/
proc genmod data=score_rank descending; class momid;
model anyed=pbdiqs rship13x pbdiqs*rship13x age13 calor11 racecov
ofsmk13x sexact13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

/*P interaction- smoke, at least weekly*/
proc genmod data=score_rank descending; class momid;
model anyed=pbdiqs ofsmk13x pbdiqs*ofsmk13x age13 calor11 racecov
sexact13x rship13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

/*P interaction- cardiometabolic dx or med*/
proc genmod data=score_rank descending; class momid;
model anyed=pbdiqs carmetdm pbdiqs*carmetdm age13 calor11 racecov
ofsmk13x rship13x sexact13x / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

THREE DIET INDICIES*****************************;
data three_score;
set pbdi_score;
a_score_sum=sum(afatpbdi, eggpbdi, dairpbdi, meatpbdi, seafpbdi);
h_score_sum=sum(whgrpbdi, frtpbdi, vegpbdi, nutpbdi, lgmpbdi, noilpbdi, cftpbdi);
l_score_sum=sum(frjpbdi, rfgrpbd, potpbdi, ssbpbd, sbfbd, hoilpbdi);
run;

proc rank data=three_score out=three_sc_q groups=4;
var a_score_sum h_score_sum l_score_sum; ranks a_score_qs h_score_qs l_score_qs; run;

proc genmod data=three_sc_q descending;
class momid a_score_qs(ref='0') h_score_qs(ref='0') l_score_qs(ref='0');
model anyed=a_score_qs h_score_qs l_score_qs age13 calor11
racecov sexact13x rship13x ofsmk13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;

proc genmod data=three_sc_q descending;
class momid; model anyed=a_score_qs h_score_qs l_score_qs age13 calor11
racecov sexact13x rship13x ofsmk13x carmetdm / type3 dist=bin link=logit;
repeated subject=momid / type=cs covb; run;
end;