



Dietary Fiber Is Independently Related to Blood Triglycerides Among Adults with Overweight and Obesity

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ABSTRACT

Background: Metabolic syndrome (MetS), a cluster of visceral adiposity-related risk factors, affects approximately 35% of the United States population. Although improvement in diet quality is an important approach to reducing MetS risk, the role of particular dietary components remains unclear, especially among younger adults. Individual dietary components have been implicated in ameliorating or exacerbating MetS risk; however, the extent to which these factors contribute to MetS prevention has received little attention.

Objective: This cross-sectional study aimed to assess relations between diet and individual MetS components in young to middle-aged adults who are overweight and/or obese.

Methods: Participants aged 25–45 y ($N = 117$) with overweight and obesity, but no other diagnosed metabolic disease, recorded dietary intake over 7 d. MetS components (waist circumference, blood pressure, glucose, triglycerides [TGs], and high-density lipoprotein cholesterol [HDL]) were measured. Visceral adipose tissue was measured by dual-energy X-ray absorptiometry. Linear regression was used to assess relations between diet and MetS risk factors, adjusting for age, sex, and visceral adipose tissue.

Results: MetS prevalence in this sample was 32%. Energy-adjusted total fiber intake ($\beta = -0.21$, $P = 0.02$) was inversely associated with TG concentrations. No significant relations were observed between other dietary factors and MetS components. These findings indicate that among MetS components, TG concentrations are potentially sensitive to fiber consumption.

Conclusions: These results provide cross-sectional evidence supporting the protective influence of dietary fiber on MetS components among young to middle-aged adults. Additional, well-designed clinical trials are needed to assess the causal relations between various types of dietary fiber and metabolic disease. *Curr Dev Nutr* 2018;3:nzy094.

Introduction

Obesity currently affects over 1 in 3 adults in the United States, and is responsible for numerous comorbid diseases (1). To date, no country has been successful in decreasing its prevalence of obesity in adults, and effective preventive strategies are needed to halt the rising prevalence of obesity worldwide (2). Central adiposity has been implicated in impaired metabolic health and is a component of the metabolic syndrome (MetS). MetS is a cluster of related risk factors, including visceral adiposity, hyperglycemia, dyslipidemia (specifically elevated TGs and decreased HDL cholesterol), and hypertension, and has been shown to increase risk of cardiovascular disease (CVD) and type 2 diabetes mellitus (T2DM) (3). These interrelated risk factors, when examined together, form a comprehensive picture of an individual's metabolic health and risk of chronic



Keywords: metabolic syndrome, visceral adiposity, soluble fiber, young adults, obesity

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Abbreviations used: CVD, cardiovascular disease; DBP, diastolic blood pressure; MetS, metabolic syndrome; SBP, systolic blood pressure; T2DM, type 2 diabetes mellitus; VAT, visceral adipose tissue.

disease. MetS prevalence in the United States is currently 34.7% and increases with age (4). Dietary and lifestyle strategies to intervene before MetS development are needed, particularly in young and middle adulthood (20–39 y of age) in order to prevent or delay chronic disease onset and related comorbidities.

Lifestyle modifications, such as diet, are frequently the first treatments recommended by healthcare professionals for the management of MetS components. Evidence connecting a healthy diet with reduced chronic disease risk is regularly communicated to the US public through published dietary guidelines (5–7). These guidelines consistently recommend limiting intake of added sugars and saturated fat (e.g., SFA) to less than 10% of total calories each, while increasing intake of unsaturated fats and dietary fiber. Substantial evidence linking these dietary components with risk factors for CVD, T2DM, and MetS has been obtained and outlined in reviews and policy statements (8–11). High intake of added sugars, consumed primarily in the form of sucrose or high-fructose corn syrup, has been associated with increased risk of abdominal obesity and hypertriglyceridemia in observational studies (8, 9). However, clinical trials and meta-analyses have reported variable results, and thus the causal implications of added sugar intake on cardiometabolic health remain debated (10). The role of saturated compared with unsaturated fat on blood lipids and other MetS components has also continued to be debated among the scientific community. Recent statements from the American Heart Association recommend the replacement of saturated with unsaturated fatty acids, specifically in the form of PUFAs and MUFAs to improve lipid profiles, including total cholesterol, HDL, TG, and LDL cholesterol. (11). Both MUFAs and PUFAs have been shown to decrease TG concentrations when replaced for SFA, through increased postprandial TG clearance and downregulation of lipogenesis, respectively (12). Dietary fiber supplementation, in the form of soluble fiber doses ranging from 3 to 34 g/d, has also been implicated in improvements in glycemic and insulinemic response (significant reductions in fasting glucose by 0.17 mmol/L and insulin by 15.9 pmol/L) and body composition (significant reductions in body weight by 2.52 kg, BMI by -0.84 kg/m^2 , and percentage body fat by 0.41%) (13). The role of dietary fiber on blood pressure is also promising. Two recent meta-analyses concluded that soluble fiber in the form of β -glucan is effective in lowering both systolic blood pressure (SBP) between 0.92 and 1.59 mmHg, and diastolic blood pressure (DBP) between 0.39 and 0.71 mmHg after mean doses of 4 and 8.7 g/d, respectively (14, 15). Soluble fiber includes pectins, β -glucan, and gums, and has gel-forming properties that delay gastric emptying and improve glycemic control. These fibers are also digested by the gastrointestinal microbiota, which is also evidenced to exert numerous benefits on metabolic health (16). Conversely, insoluble fibers include cellulose and lignin, and are generally poorly fermented by the gastrointestinal microbiota.

Given that the majority of existing studies connecting dietary components to MetS have been conducted among middle and older-aged adults (17–19), there is a paucity of data regarding dietary implications for MetS risk factors in younger-aged cohorts. Therefore, the objective of this study was to examine the cross-sectional interrelations between nutritional factors that have been previously associated with MetS risk factors in older cohorts among a cohort of healthy, young adults who are overweight and/or obese. We anticipated that differential relations would emerge between intake of dietary components common

in a Western dietary pattern (high in added sugars and SFA, low in unsaturated fat and fiber) and MetS components. We further hypothesized that MetS would have an inverse association with dietary fiber and unsaturated fat and a positive association with added sugars and saturated fat. In addition, given the heterogenous nature of dietary fiber, we aimed to examine the influence of total fiber as well as its subcategories of insoluble and soluble fiber. Understanding associations between diet, MetS, and its underlying components is necessary to develop evidence-based dietary approaches to preventing MetS and the onset of obesity-related chronic diseases.

Methods

Participants

Adults aged 25–45 years ($N = 117$) with overweight or obesity ($\text{BMI} \geq 25 \text{ kg/m}^2$) were recruited from the surrounding community via public signage, e-mail, and flyers in well-populated community areas to participate in this cross-sectional assessment. Inclusion criteria included no previous history of physician-diagnosed gastrointestinal or metabolic disease. All participants provided written informed consent, and all study procedures were approved by the University of Illinois Institutional Review Board (Protocol #16277) and conformed to standards for the use of human participants in research as outlined in the seventh revision of the Declaration of Helsinki. Subjects were compensated monetarily for their participation in this study.

Anthropometrics and biological measures

Height and weight were measured in triplicate by trained research staff using a Seca Model 240 stadiometer and Tanita WB-300 Plus digital scale. Waist circumference was measured in triplicate using inelastic tape at the level of the umbilicus. Blood pressure was measured in a seated position using an automatic blood pressure monitor (Omron Healthcare Co.). Visceral adipose tissue (VAT) was measured through dual-energy X-ray absorptiometry using a Hologic Horizon W bone densitometer (APEX Software version 5.6.0.5). Venous blood was collected from the antecubital vein following a 10-h overnight fast. The Piccolo Xpress Analyzer (Abaxis, Inc.) was used to analyze lipoprotein concentrations from lithium heparinized whole blood. Plasma glucose concentrations were determined using a biochemical analyzer (YSI Incorporated). MetS was defined according to the International Diabetes Federation guidelines, waist circumference ≥ 94 cm (for males, or ≥ 90 cm for males of South Asian, Chinese, or Japanese descent) or ≥ 80 cm (for females), plus any two of the following: fasting glucose ≥ 100 mg/dL, TGs ≥ 150 mg/dL, HDL cholesterol ≤ 40 mg/dL (for males) or 50 mg/dL (for females), systolic blood pressure ≥ 130 or diastolic blood pressure ≥ 85 (20). Overweight and obesity were defined by $\text{BMI} \geq 25$ or 30 kg/m^2 , respectively.

Dietary assessment

Participants were provided with a 7-d food record with detailed instructions given by a trained member of the research staff at the completion of their first laboratory visit. The diet records were returned at a subsequent laboratory visit. In addition, the record contained written instructions for recording food intake, including how to describe food-preparation methods, added fats, brand names, and ingredients of

TABLE 1 Mean demographic and biomarker information for study sample ($N = 117$)¹

Variable	All	Males ($n = 44$)	Females ($n = 73$)	<i>P</i> value
Age, years	34.5 ± 6.1	33.6 ± 6.3	34.8 ± 6.0	0.32
BMI, kg/m ²	31.5 ± 6.0	28.8 ± 3.0	33.6 ± 6.5	0.01
Visceral adipose tissue, g	625 ± 285	558 ± 211	665 ± 316	0.03
WC, cm	102 ± 15.2	98.4 ± 9.4	104 ± 14.4	0.83
With diagnostic WC, % (<i>n</i>)	88 (102)	68 (31)	100 (73)	
SBP, mmHg	117 ± 15.6	121 ± 14.3	114 ± 16.1	0.20
With diagnostic SBP, % (<i>n</i>)	20 (23)	21 (9)	19 (14)	
DBP, mmHg	83.5 ± 12.4	83.2 ± 11.8	83.6 ± 13.0	0.89
With diagnostic DBP, % (<i>n</i>)	40 (47)	36 (16)	42 (31)	
TG, mg/dL	101 ± 65.2	122 ± 82.8	93.6 ± 50.4	0.04
With diagnostic TG, % (<i>n</i>)	17 (20)	23 (10)	13 (10)	
HDL, mg/dL	56.9 ± 18.9	55.7 ± 26.3	57.3 ± 14.3	0.71
With diagnostic HDL, % (<i>n</i>)	29 (34)	21 (9)	34 (25)	
GLU, mg/dL	95.5 ± 13.8	98.9 ± 17.5	93.7 ± 11.5	0.57
With diagnostic GLU, % (<i>n</i>)	21 (25)	30 (13)	15 (12)	
Metabolic syndrome criteria met	2.0 ± 1.0	1.9 ± 1.3	2.0 ± 0.9	0.44
Total cholesterol, mg/dL	172 ± 47.8	166 ± 58.0	175 ± 40.1	0.31
LDL cholesterol, mg/dL	99.2 ± 37.4	97.2 ± 44.8	101 ± 32.1	0.63

¹Values are means ± SDs unless otherwise indicated. Significant differences between males and females were determined by Student's *t*-test, at a significance level of $P < 0.05$. MetS criteria are total criteria according to International Diabetes Federation guidelines. DBP, diastolic blood pressure; GLU, glucose; MetS, metabolic syndrome; SBP, systolic blood pressure; WC, waist circumference.

mixed dishes and recipes. Participants with ≥ 7 consecutive days of entries were included in analyses. Trained staff under supervision by a registered dietitian entered food records into the Nutrition Data Systems-Research Version 2015 (Nutrition Coordinating Center, University of Minnesota) software. All food records were double-entered by different staff members, and any discrepancies were settled by a third party examining the original record. The mean intake of added sugars, dietary fiber, and percentage of total calories from SFAs, MUFAs, and PUFAs (%SFAs, %MUFAs, and %PUFAs, respectively) were extracted as primary outcomes from the nutrient intake properties file. Added sugars and dietary fiber were also adjusted for total energy intake and expressed as grams per 1000 kcal.

Statistical analysis

Data were inspected for normal distribution of residuals, and non-normal variables (i.e., TG and HDL) were log-transformed before analysis. Student's *t*-test was used to determine significant differences in variables of interest by sex. Associations between dietary factors known to influence MetS risk (i.e., added sugars, fiber, %SFAs, %MUFAs, %PUFAs) and MetS risk factors were assessed using multiple hierarchical linear regression. Potential confounding factors (age, sex, and VAT) and dietary components with the exception of fiber were entered into step 1 of the regression models. Insoluble, soluble, and total dietary fiber were incorporated individually in step 2 regression models. Analyses were performed separately for dependent variables (MetS risk factors). Logistic regression was also used to determine associations between dietary components and presence/absence of individual MetS components. R^2 was used to assess the variability explained by the model, and the significance of the change in the R^2 value between the 2 steps was used to assess the contribution of dietary fiber in explaining variance in MetS risk factors. Significance was determined at an alpha of 0.05, and trend-level significance was determined at $P < 0.10$. Statistical Package for the Social Sciences 24 (IBM) was used for all analyses.

Results

A total of 117 individuals (62% females) were included in the cross-sectional analysis. Participant characteristics and MetS risk factors are presented in **Table 1**. The sample was primarily Caucasian (78%, $N = 91$) with the remaining individuals reporting race as American Indian/Alaskan Native ($N = 2$), Asian ($N = 10$), African American ($N = 8$), and mixed ethnicity ($N = 6$). The majority of participants (85%) reported completing college or a graduate degree. Females had significantly greater BMI and VAT than males, and significantly lower TG concentrations ($P < 0.05$). The prevalence of overweight and obesity in the sample was 45% and 55%, respectively. Thirty-seven individuals (32% of sample, 40% females) presented with abdominal obesity plus 2 risk factors, indicating MetS. This is comparable with the national prevalence of MetS in the United States (33%) and prevalence among non-Hispanic whites (33%) (21). When the sample was analyzed on presence or absence of MetS, individuals with MetS had a significantly higher BMI than those without MetS (31.2 compared with 34.5 kg/m², $P = 0.01$). Individuals with MetS also had higher mean values of all MetS components than those without MetS (**Supplementary Table 1**, all $P > 0.05$).

Mean dietary intake is presented in **Table 2**. Males reported consuming significantly more kilocalories and a higher percentage of calories from carbohydrates, and protein than females. Females consumed significantly more added sugars per 1000 kcal than males. There were no significant sex differences in energy-adjusted fiber intake, %SFAs, %PUFAs, or %MUFAs between males and females. In addition, there were no significant differences in dietary intake between individuals with or without MetS.

Linear regression models were significant for MetS components, excluding those with glucose ($P = 0.21$) and HDL ($P = 0.06$) as dependent variables (**Table 3**). Of all dietary components examined, only soluble and total dietary fiber were found to have estimated regression coefficients that were statistically significant ($\beta = -0.23$,

TABLE 2 Dietary intake for study sample ($N = 117$) determined from means of 7-d diet records¹

Variable	All	Males ($n = 44$)	Females ($n = 73$)	<i>P</i> value
Total energy, kcal	2200 ± 556	2460 ± 555	2060 ± 493	0.01
Calories from carbohydrate, %	44.4 ± 7.4	43.0 ± 8.5	45.3 ± 6.5	0.08
Calories from protein, %	16.4 ± 3.8	17.2 ± 4.6	15.8 ± 2.9	0.03
Calories from fat, %	36.7 ± 5.3	36.5 ± 5.3	36.9 ± 5.3	0.64
Total dietary fiber, g	20.2 ± 7.5	21.5 ± 7.5	18.9 ± 7.1	0.06
Total fiber/1000 kcal, g	9.4 ± 3.2	9.0 ± 3.3	9.3 ± 3.0	0.59
Total insoluble fiber/1000 kcal, g	6.25 ± 2.4	6.20 ± 2.5	6.27 ± 2.4	0.88
Total soluble fiber/1000 kcal, g	2.87 ± 0.9	2.70 ± 0.9	2.98 ± 1.0	0.13
Added sugars, g	56.2 ± 31.8	55.1 ± 30.6	57.0 ± 32.8	0.73
Added sugars/1000 kcal, g	25.6 ± 13.3	10.1 ± 1.4	12.7 ± 1.6	0.01
SFA (percentage of kcals)	12.3 (2.3)	12.0 (2.2)	12.4 (2.4)	0.25
PUFAs (percentage of kcals)	8.5 (2.0)	8.3 (1.9)	8.6 (2.0)	0.62
MUFAs (percentage of kcals)	12.9 (2.3)	13.0 (2.4)	12.8 (2.3)	0.41
Cholesterol, mg	308 ± 126	349 ± 148	277 ± 107	0.01

¹Values are means ± SDs unless otherwise indicated. Significant differences between males and females were determined by Student's *t*-test, at a significance level of $P < 0.05$.

$P = 0.01$ and $\beta = -0.21$, $P = 0.02$, respectively), relating inversely to TG concentrations. The change in R^2 for triglycerides and insoluble fiber intake was also trending toward statistical significance ($\Delta R^2 = 0.03$, $P = 0.07$). VAT was also found to be significantly associated with all MetS components except glucose.

Logistic regression also revealed that for a unit change in soluble and total fiber intake, the odds of hypertriglyceridemia were 0.67 (95% CI: 0.46, 0.96) and 0.75 (95% CI: 0.57, 0.96), respectively (both $P < 0.05$), indicating an inverse relation between fiber consumption and TG concentrations ≥ 150 mg/dL, all other predictors being held constant. No other odds ratios for other MetS components were statistically significant (Supplementary Table 2).

Discussion

In the present study, total and soluble dietary fiber were independent contributors to the variability of TG concentrations in healthy young-to-middle-aged adults with overweight and obesity. Dietary fat and added sugar, dietary components connected with metabolic dysfunction in previous studies, did not explain significant variance in TGs or any other MetS risk factor. In addition, the relation between total and soluble fiber and TGs persisted after adjusting for age, sex, and VAT. Overall, the findings of this study indicate that TG concentrations appear to be inversely related to dietary fiber intake among young adults with overweight and obesity.

TABLE 3 Regression analyses for dietary components explaining variability in risk factors for metabolic syndrome¹

	Waist circumference		Systolic blood pressure		Diastolic blood pressure		Glucose		HDL		TG	
	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2
Step 1		0.68*		0.18*		0.17*		0.08		0.11*		0.22*
Age	0.01		0.07		0.06		-0.02		-0.02		0.12	
Sex	-0.03		0.28*		0.04		0.14		-0.18*		0.11	
Visceral adipose tissue	0.80*		0.24*		0.29*		0.01		0.30		0.41*	
Added sugars	0.04		0.10		0.15		0.08		-0.06		-0.07	
SFA, %	0.06		0.00		-0.09		-0.23		-0.05		0.05	
PUFA, %	0.06		0.07		0.05		-0.03		0.04		-0.05	
MUFA, %	-0.07		-0.19		-0.06		-0.23		-0.05		0.02	
Step 2		0.00		0.00		0.01		0.01		0.00		0.03*
Insoluble fiber	-0.03		-0.03		-0.11		-0.13		-0.08		-0.17 [†]	
Step 2		0.01		0.01		0.00		0.01		0.01		0.04*
Soluble fiber	0.08		0.12		-0.01		-0.11		0.03		-0.23*	
Step 2		0.00		0.00		0.01		0.02		0.00		0.03*
Total fiber	0.06		0.01		-0.09		-0.15		-0.04		-0.21*	

¹Linear regression analyses were used to determine β and R^2 estimates for metabolic syndrome risk factors and dietary factors at significance levels of $*P < 0.05$ and $^{\dagger}P < 0.1$. Females were assigned the reference group in the analysis.

TG concentrations are an important predictor of CVD (22), despite the direct mechanism of TG and CVD pathophysiology remaining somewhat unclear. TG-rich lipoproteins (VLDL, chylomicrons, and their remnants) have atherogenic properties, and thus management of TG concentrations is a key aspect of metabolic health (23). Elevated TG concentrations are strongly associated with visceral adiposity, insulin resistance, CVD, and other indicators of metabolic dysfunction due to excess adipose tissue mass (24). Hypertriglyceridemia promotes the exchange of TG from VLDL for cholesterol esters from LDL and HDL particles, creating small, lipid-poor particles. Small HDL particles are more susceptible to degradation, thus contributing to the low-HDL cholesterol concentrations often observed in individuals with obesity. There have been strong associations between TG and VAT (24, 25). Although BMI is widely used for diagnosis of obesity, it does not take into account the distribution of adipose tissue throughout the body. Thus, more precise measures, such as VAT mass, are preferred. In addition, abdominal adiposity, not excess body weight, is a component of MetS. VAT is present in all individuals, but in the setting of excess energy intake and decreased expenditure, adipocytes can potentially exceed their storage capacity of the lipid droplet. As the adipocytes become hypertrophic, they can release FFAs into circulation. The FFAs secreted from VAT can contribute to insulin resistance and elevated production of TG-enriched VLDL (26, 27). Increased VAT mass has also been associated with elevated CVD risk (28). Therefore, adjustment for VAT was a significant strength of the current study and provides insights into the observed robustness of the relation between dietary fiber and TG concentrations.

In the present study, intake of soluble and total fiber was significantly inversely associated with TG concentrations, after adjustment for age, sex, and VAT. Increased dietary fiber intake has been linked to reductions in VAT among children and older adults (29, 30). This may be due in part to the satiating effects of fiber, and specific to soluble fiber, the gel formation, and fermentation by the gastrointestinal microbiota. The former results in delayed gastric emptying and inhibition of nutrient absorption, resulting in improved glycemic control and lower weight gain (31). Dietary-fiber-induced changes to the gut microbiota may also have benefits to the metabolic health of the host organism. Specific to lipid metabolism, SCFAs produced by gut microbes can also impact energy intake and metabolic control through altering levels of lipogenesis and cholesterol synthesis (32). Dietary patterns that are higher in fiber are often lower in energy-dense, nutrient-poor foods that could contribute to excess adiposity (33). Given these data, it is plausible that the relations between dietary fiber and TG concentrations may be indirectly due to VAT. Other indirect mechanisms for these findings may be due in part to changes in insulin sensitivity due to fiber intake (12, 34). Insulin resistance often also results in hypertriglyceridemia, due to increased hepatic TG production (35). However, the interactions between dietary fiber, insulin resistance, and hypertriglyceridemia remain to be elucidated.

Whereas there has been considerable research examining the influence of dietary fiber on weight regulation, glycemic control, and both total and LDL-cholesterol concentrations (12, 36, 37), the potentially protective influence of fiber on TG concentrations has received comparatively less examination. Regarding TG, our findings are similar to those observed in previous studies examining fiber intake and TG concentrations in adults (38–40). Furthermore, the

associations between TG concentrations and soluble fiber intake were also statistically significant. Previous studies have reported that soluble fiber in the form of psyllium (dose of 10.5 g/d) or oat β -glucan (dose of ≥ 3 g/d) did not affect TG concentrations, although total and LDL-cholesterol levels were significantly decreased by 0.30 mmol/L (11.6 mg/dL, $P < 0.01$) and 0.25 mmol/L (9.67 mg/dL, $P = 0.04$), respectively (34, 36). Another meta-analysis examining the cardiometabolic effects of the soluble fiber glucomannan, a common fiber supplement, observed significant reductions in TG concentrations by 11.1 mg/dL ($P < 0.05$) among adults with obesity-related comorbidities after doses ranging from 1.2 to 15.1 g/d (41). From these conflicting results, it is evident that additional research is needed to determine the comparative effectiveness of various fiber types on TG concentrations throughout the lifespan. As dietary fiber is found both inherently in foods and in supplemental forms, examination of the dietary pattern as a whole, rather than individual components, is warranted. For example, soluble fiber is present in foods such as apples, bananas, barley, and oats, as well as in commercially available supplements, but the individual fiber types could differ in terms of viscosity and fermentability (42). Therefore, more work is needed to determine the effects of specific fiber types on outcomes related to metabolic health.

The effects of other dietary components explored in this study, i.e., added sugars, SFA, MUFAs, and PUFAs, were chosen due to previous evidence linking them with features of MetS (8, 11, 15). However, they were not found to be associated with MetS in this sample of young and middle-aged adults. Owing to epidemiological evidence associating added sugar consumption and obesity-related comorbidities, the current upper limit for added sugar consumption is 10% of total calories (5, 43). However, a recent review has outlined the presence of conflicting or null evidence on the effects of added sugar on cardiometabolic risk, and thus added sugars remain a controversial topic, and future research is warranted (44). The role of dietary fat, specifically the composition of saturated and unsaturated fat in the diet, remains controversial as well. SFA has been shown to delay clearance of LDL apolipoproteins, thus maintaining these particles in circulation (45). A recent Cochrane review also concluded that replacement of SFA for unsaturated fat in the form of MUFAs and PUFAs is effective in decreasing CVD risk due to hypolipidemic effects (46). However, these effects may not be as robust among individuals without diagnosis of comorbidities (47).

This study was not without limitations. The cross-sectional design does not allow for causal inferences between fiber intake and risk factors of MetS to be established. These associative relations will need to be further examined in clinical trials to better elucidate the mechanisms by which fiber intake can modify cardiometabolic risk factors. In addition, the use of self-report dietary intake data invites measurement error, especially in the case of total energy intake (48). However, dietary self-report, particularly food records, has been shown to correlate with objective measures of intake of specific dietary components (49). In a recent longitudinal study, Park et al. examined self-reported intake and associations with biomarkers of nutrient intake in order to determine accuracy of the reports, and found that multiple-day food records were accurate in capturing energy-adjusted intake of specific dietary components (50). In the present study, the use of food records to capture intake of dietary components is justified, given the need for development and validation research for intakes of dietary factors such

as added sugars and dietary fiber. The aforementioned limitations notwithstanding, this study did have several strengths. The age range of participants in this study (ages 25–45 y) is an understudied group, as the majority of research in the field of chronic disease prevention is conducted in middle to advanced age adults. By studying the metabolic health and behaviors of a younger adult population, new insights can be gained into the early stages of disease progression, and dietary and lifestyle factors that may delay the onset of obesity-related diseases can be identified. In addition, we tested the influence of dietary components following the adjustment for VAT, which is a hallmark feature of metabolic dysregulation and antecedent to progression toward to MetS and obesity-related chronic diseases.

In conclusion, this study provides a novel insight into the relations between dietary fiber intake and blood triglyceride status, a biomarker of MetS and CVD. The age range in this study is understudied in the field of obesity-related chronic disease prevention. Further work is needed, in the form of well-designed experimental trials, to establish causal relations between dietary components and metabolic health in adults at risk of development of metabolic syndrome.

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