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Lifestyle Factors and 5-Year Abdominal Fat Accumulation in a Minority Cohort: The IRAS Family Study

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Abstract

The objective of this study was to examine whether lifestyle factors were associated with 5-year change in abdominal fat measured by computed tomography (CT) in the Insulin Resistance and Atherosclerosis (IRAS) Family Study. We obtained abdominal CT scans at baseline and at 5 years, from African Americans (AA) (N = 339) and Hispanic Americans (N = 775), aged 18–81 years. Visceral (VAT) and subcutaneous (SAT) adipose tissue was measured at the L4/L5 vertebral level. Physical activity was documented by self-report of vigorous activity and a 1-year recall instrument. Dietary intake was assessed at follow-up using a semi-quantitative food frequency questionnaire referencing the previous year. Generalized linear models, accounting for family structure, were used to assess the associations between percent change in fat accumulation and smoking, physical activity, total calories, polyunsaturated, monounsaturated, protein, and saturated fat intake, percent of calories from sweets, and soluble and insoluble fiber. Soluble fiber intake and participation in vigorous activity were inversely related to change in VAT, independent of change in BMI. For each 10 g increase in soluble fiber, rate of VAT accumulation decreased by 3.7% (P = 0.01). Soluble fiber was not associated with change in SAT (0.2%, P = 0.82). Moderately active participants had a 7.4% decrease in rate of VAT accumulation and a 3.6% decrease in rate of SAT accumulation versus less active participants (P = 0.003 and P = 0.01, respectively). Total energy expenditure was also inversely associated with accumulation of VAT. Soluble fiber intake and increased physical activity were related to decreased VAT accumulation over 5 years.

INTRODUCTION

Central obesity has been associated with hypertension, dyslipidemia, insulin resistance, fatty liver disease, and type 2 diabetes (1). Longitudinal studies indicate a direct relationship between levels of visceral adipose tissue (VAT) and future risk of impaired glucose tolerance and type 2 diabetes, independent of total adiposity (2–5). Unfortunately, the

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DISCLOSURE

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current arsenal of pharmaceutical agents for weight loss and weight loss management is small and ineffective. The Diabetes Prevention Program (6), however, showed that reductions in VAT and subcutaneous adipose tissue (SAT) led to decreased risk of type 2 diabetes, independent of total body fat (7). These studies suggest that central adiposity is an independent risk factor for type 2 diabetes.

While research has continued to elucidate the untoward consequences of obesity, specifically central adiposity, we still know little about why certain populations accumulate adipose tissue centrally. Several studies have documented that despite increased rates of type 2 diabetes and increased BMI, African Americans (AA) have lower levels of VAT than their white (8) or Hispanic counterparts (9). Similarly, the Insulin Resistance and Atherosclerosis (IRAS) Family Study found that the AA population had a low prevalence of VAT and hepatic steatosis, compared to Hispanics, despite increased BMI and insulin resistance (10).

We previously described the natural progression of abdominal adiposity assessed by computed tomography (CT) over 5 years, in African Americans and Hispanics in the IRAS Family Study (11). We observed large increases in VAT and SAT areas, particularly in young adulthood, which became attenuated with age. AA women were at particularly high risk of fat accumulation.

As with many other chronic diseases, lifestyle plays a crucial role in the prevention and modification of obesity (12–14). While many studies have assessed predictors of change in waist circumference (a surrogate for VAT), few predictors of directly measured abdominal obesity have been identified (15,16). In one study of white college students, total dietary fat was the strongest predictor of abdominal visceral fat (17). In a Japanese cohort, regaining previously lost VAT was linked with a diet high in rice, pickles, miso, alcohol, and meat (18). Another study in middle-aged white adults found that high intensity physical activity had a significant impact on VAT reduction (19). In our own study of African Americans and Hispanics, aged 18–80, short sleep duration was a risk factor for increased accumulation of VAT (20).

Current literature cites the inverse correlation between smoking and surrogate measures of waist circumference abdominal adiposity (21) and metabolic syndrome. Data connecting smoking to direct measures of abdominal adiposity, however, are scarce. A study conducted in Japanese men revealed that those men with higher pack years had higher VAT when compared to less frequent smokers (22). In the present study, we explore the effects of other lifestyle factors (dietary intake, physical activity, and smoking) on the 5-year change in central adiposity (measured by CT) in a large biethnic cohort.

METHODS AND PROCEDURES

Study population and data collection

The IRAS Family Study was designed to explore genetic and epidemiologic contributions to abdominal adiposity and glucose homeostasis traits among Hispanic and AA families. The study was an extension of IRAS, in which the primary objective was to determine the relationship between insulin resistance and atherosclerosis in 1,625 individuals. In the IRAS Family Study, family members of the IRAS cohort were recruited to participate in a baseline clinical examination between 1999 and 2002. Additional families were recruited from the general population to supplement the IRAS families. Ascertainment and recruitment of families were based upon family size, and not on extreme phenotype (e.g., diabetes, obesity). Hispanic families were recruited from San Antonio, TX, and the San Luis Valley, CO. African-American families were recruited from Los Angeles, CA. Follow-up examinations were conducted ~5 years after baseline examinations.

There were 1,856 participants who attended the baseline IRAS Family Study examination and our analysis included 1,114 participants. Of the 742 participants not included in our analysis, 405 (55.5%) did not attend the follow-up visit; 24 (3.2%) died between visits; 229 (30.8%) did not have CT scans at both time points (137 women and 93 men; 147 Hispanics and 82 African Americans); 4 (0.5%) had incomplete dietary records and 77 (10.4%) had other missing data. Of the 229 without CT at both visits, 12 did not have a baseline CT scan completed, 60 did not have a follow-up CT scan completed, and the remainder had scans that were determined to be unusable (distributed somewhat equally across the three recruitment sites). The only difference between the 1,114 participants included and the 742 not included was gender (females are more likely to be included). Other variables considered were age, race, smoking status, physical activity, BMI, SAT, and VAT.

The institutional review boards at the respective institutions approved the protocol, and written informed consent was given by each participant.

Anthropometric measurements

Measurements followed identical protocols at two time points, the baseline and follow-up visits (23). Height and weight were measured to the nearest 0.5 cm and 0.1 kg, respectively. BMI was calculated as weight (kg)/height (m)^2. Abdominal fat mass was measured by CT under a common protocol. The effective whole-body radiation dose for this study did not exceed 100 mrem. Exclusions for the CT scan included the inability to lay supine, weight exceeding the limit for the CT table (generally 350–400 pounds), and pregnancy. All participants were gowned and all tight undergarments were removed. Participants were placed in a supine position with the feet or head directed toward the gantry and with their arms above their heads. Care was taken to position participants symmetrically on the CT table. No pads or cushions, other than the standard table pad, were used.

All participants received an anterior–posterior scout scan of the abdomen and pelvis (diaphragm through symphysis pubis) followed by three axial images. Optimal parameters for the scout varied with CT model and individual body habitus. After the scout was obtained, the L4–L5 disc space was located by counting the lumbar vertebrae, with L1 being the first non-rib bearing vertebra. If there were more or less than five non rib-bearing lumbar vertebrae, the disc space closest to the iliac crest was considered to be L4–L5. The L2–L3 disc was identified as the second one above L4–L5. Two axial images were acquired. A single 10 mm-thick image was obtained through the L2–L3 disc space, followed by a single 10 mm-thick axial image through the L4–L5 disc space during suspended respiration.

Scans were read centrally using IDL Version 6.3 software (Research Systems, Boulder, CO). The reading required that a border was drawn within the muscle separating the visceral fat from subcutaneous fat to grossly separate these compartments. Next, the following areas were outlined and factored out of the visceral fat computation: liver, intra-abdominal vessels, spleen, segment aorta/iliac arteries, bowel fat, and kidney fat. Once these areas were excluded, the areas of VAT and SAT were calculated. VAT and SAT at the L2–L3 and L4–L5 levels were highly correlated. Thus, we chose to use L4–L5 for consistency with the literature, because this slice is highly correlated to visceral fat total volume (24).

Dietary assessment

Dietary intake was assessed at the follow-up examination using the Block Brief 2000 instrument, a retrospective, 1-year, semi-quantitative food frequency interview. This questionnaire contains a reduced food list (about 70 food items). It provides estimates of usual and customary dietary intake. Because it has fewer foods, estimates of energy and macronutrients will be lower than “true” levels. However, it will rank individuals along the distribution of intake. The food list for this questionnaire came from the NHANES III dietary recall data. The nutrient database was developed from the USDA Nutrient Database for Standard Reference. Individual portion size is asked, and pictures are provided. Completed questionnaires were edited initially at the clinical sites and additional editing and quality control checks, including internal consistency and range, were conducted by NutritionQuest (Berkeley, CA) using the Block/DietSys edit check program.

For this analysis, we selected total kilocalories; percent calories from sweets; and intake of soluble and insoluble fiber, total protein, and monounsaturated, polyunsaturated, and saturated fat. We chose these diet variables because of their noted relationship to change in weight or BMI. The variables came directly from the calculations done by the NutritionQuest except for soluble fiber and insoluble fiber. Soluble fiber was calculated as the sum of fiber from bean, vegetables, and fruits. Insoluble fiber was calculated as fiber from grains.

Other lifestyle factors

Smoking status was assessed by questionnaire and categorized as never, current, or former.

Participants estimated their usual frequency of participation in vigorous activities as ranging from "rarely or never" to "5 or more times per week". Vigorous activity was described to the participants as "activities that make you sweat, increase your heart rate or increase your breathing". Based on the responses, we collapsed the responses *post hoc* into three categories: "rarely" (n = 265); a middle group, "sometimes," (n = 738) that reported vigorous activity 1–3 times/month, 1 time/week and 2–4 times/week; and 5+ times/week (n = 111).

Participants estimated energy expenditure using a validated (25), modified 1-year recall of physical activities. A 1-year recall minimizes misclassification due to seasonal or shorter-term (e.g. 1 week) intra-individual variations in activity patterns. This instrument was modified for increased sensitivity to rural activity patterns in the San Luis Valley Diabetes Study and for improved interview flow. For IRAS, the instrument was further modified to allow for estimation of caloric expenditure and to enhance ethnic and cultural sensitivity (W. Haskell, personal communication).

The unit of measurement is kcal energy expended per kg body weight per year. Essentially, each activity group consists of activities requiring similar energy expenditure estimated as METS. For this purpose, 1 MET is equal to 1 kcal expended/kg body weight/h and is also equal to the ratio of active energy expenditure to resting energy expenditure, where resting energy expenditure is assumed to be equal to 1 MET. Accounting for hours of sleep (1 MET) and assuming that time not reported in sleep or in moderate or vigorous activity groups is spent in light activity (1.5 METS), we derived an estimate of total energy expenditure. Energy expenditure as estimated from this instrument is consistent with responses to both the overall ranking of activity and with the frequency of participation in vigorous activity.

We used education as a surrogate for socioeconomic status (26). Education (highest grade or year of school completed) was assessed by questionnaire and then grouped into three categories, "less than high school," "high school graduate," and "more than high school." Baseline sleep duration (hours) was assessed by questionnaire ("On average, about how many hours of sleep do you get a night?").

All exposure variables were obtained at the baseline examination with the exception of the dietary data. The dietary data were obtained at the follow-up examination. Despite being obtained at follow-up, the food frequency interview reflects dietary intake over the previous year. Consequently, it was used as a predictor variable in these analyses.

Statistical analyses

SAS version 9.1 (SAS Institute, Cary, NC) was used for all statistical analyses. Data are presented as N (percent) for categorical variables and mean (s.d.) for continuous variables. SAT and VAT variables did not require transformation because they were approximately normally distributed. Univariate comparisons across race/gender categories were calculated using χ^2 tests of association for categorical variables, and one way ANOVAs for continuous variables. The major outcomes were rates of 5-year percent change in SAT and VAT. Initially, we examined Spearman correlations between these outcomes and baseline lifestyle factors, including nutrient intake, tobacco use, and physical activity. Eleven regression models were then fit to test for associations with select baseline lifestyle factors using GEE1 linear regression with exchangeable correlation to account for family structure.

Covariates in the base model included age, gender, race, kcal, and baseline fat measure (baseline VAT and BMI for the VAT change model, and baseline SAT for the SAT change model). Total calories were included in all models where we scaled the estimates (β coefficients) by using the pooled standard deviation. Interaction effects between each lifestyle factor and race, age, and gender were tested within these base models. All interaction P values were nonsignificant (ranging from 0.10 to 0.83 for age interactions, 0.09 to 0.77 for race interactions, and 0.10 to 0.51 for gender interactions), and thus interaction terms were not included in the final modeling. Education level, kcal (for all models), sleep duration, sleep–age interaction, and percent change in BMI were added to fully adjusted models. In the VAT models, we adjusted for BMI. We did not adjust for BMI in the SAT models due to significant colinearity between the two.

RESULTS

Participant characteristics

This report includes data on 1,114 people, 339 African Americans, and 775 Hispanics, who attended both the baseline and 5-year follow-up IRAS Family Study examination and who had complete CT scan and dietary data available for analysis. The cohort was 62% female and 30% African American. The mean age at baseline was 42.3 years (range 18–81 years). The mean kcal consumption was 1,847 kcal/day and only 11% participated in vigorous activity five times per week or more. Short sleep ($\leq$5 h) was more common in AAs and long sleep ($\geq$8 h) more common in Hispanics. 22% were current smokers. African-American men had the largest 5-year increase in SAT (17%) while African-American women had the greatest increase in VAT (14%) (Table 1).

Single nutrient analysis models

The models that considered single nutrients as predictors of percent change in VAT revealed a single significant association with soluble fiber. For every 10 g of soluble fiber, the rate of VAT accumulation decreased by 3.73% (P = 0.01) over 5 years, independent of change in BMI (Table 2). We further evaluated this finding within race-sex groups despite a nonsignificant test for interaction (P = 0.12). The effect of soluble fiber was most pronounced in African Americans. The rate of VAT accumulation decreased by 17 ± 9.4% and 14 ± 8.3% for African-American men and women, respectively, for every 10 g of soluble fiber. This is in contrast to 6% and 2% increases in Hispanic men and women, respectively.

The models that considered single nutrients as predictors of percent change in SAT revealed a significant association with percent calories from sweets and protein. For every 10% increase in calories from sweets there was a 1.5% ± 0.7 ($P = 0.02$) decrease in SAT accumulation over 5 years. For every 40 g increase in protein consumption, there was a 5.4% ± 2.0 ($P = 0.01$) increase in SAT accumulation over 5 years.

Smoking analyses

The models that considered smoking as a predictor of percent change in SAT revealed a significant association for current smokers. Participants that currently smoke had a 3.3% ± 1.5 ($P = 0.03$) decrease in SAT compared to nonsmokers. No associations were observed between smoking and VAT.

Physical activity analyses

In participants reporting vigorous activity “sometimes,” the rate of VAT accumulation decreased by 7.4 ± 2.6% ($P = 0.003$) and the rate of SAT accumulation decreased by 3.6 ± 1.4% ($P = 0.01$) compared to those reporting rarely or never. A dose–response effect was not observed as those in the most active category (5+ times/week) did not differ in abdominal fat accumulation compared to those in the rarely/never category. Total energy expenditure was also inversely related to VAT accumulation ($P = 0.047$), but not SAT.

DISCUSSION

This epidemiologic study investigated the relationship between single nutrient intake, reported physical activity, energy expenditure, and smoking status with 5-year changes in CT-measured abdominal adiposity in a large cohort of African-American and Hispanic men and women. Increased soluble fiber intake was associated with decreased rate of VAT accumulation, but not SAT. This finding was most pronounced in African Americans. Notably, this finding replicates a report by Davis and colleagues (27), who studied the impact of dietary intake on metabolic risk factors in 85 overweight Latino children over 2 years. They found that increased total dietary fiber and insoluble fiber were associated with decreased VAT ($r = -0.29$, $P = 0.02$ and $r = -0.27$, $P = 0.03$, respectively) independent of change in BMI. Furthermore, decreased total dietary fiber was associated with significantly increased VAT compared to those who increased total dietary fiber (21% vs. −4%; $P = 0.02$ (27)). None of the other nutrient characteristics they assessed were associated with change in VAT or SAT.

Although the fiber–obesity relationship has been extensively studied, the relationship between fiber and specific fat depots has not. Our study is valuable because it provides specific information on how dietary fiber, specifically soluble fiber, may affect weight accumulation, specifically through the abdominal fat depots. Apart from the previous report (19), we are unaware of any studies that have examined this question. Reduced intake of dietary fiber has been shown cross-sectionally and prospectively to be related to overweight (28), obesity (29), and weight gain (29,30). Soluble fiber sources (e.g., fruit fiber and apples) were also inversely associated with long term weight gain (31). The higher satiety value associated with dietary fiber, when compared to digestible complex carbohydrates and simple sugars, promotes consumption of meals with lower energy content and longer durations between meals (32), which is a likely explanation for reduced weight gain.

In our previous study (11), we demonstrated that VAT steadily increased over 5 years, especially in younger participants. Results from the current study reveal that increased consumption of soluble fiber led to a decreased rate of VAT accumulation, suggesting that increased soluble fiber intake may be instrumental in slowing this natural progression.

We found an association between current smoking and accumulation of SAT but not VAT. In contrast, a study of 157 middle-aged Turkish men and women found that women who smoked had lower VAT (by 31 cm^2, $P = 0.005$) after 4 years compared to nonsmokers (33).

Persons reporting vigorous physical activity from one time/month to four times per week had reduced 5-year accumulations of VAT and SAT relative to those reporting that their participation in vigorous activity was rare or never. This finding persisted for VAT accumulation using the total energy expenditure variable obtained from the 1-year physical activity recall instrument, and is consistent to other studies of lifestyle and abdominal fat accumulation, namely the Framingham Heart Study (34). In the Framingham Heart Study, diets consistent with the 2005 Dietary Guidelines Adherence Index and greater physical activity were inversely associated with SAT and VAT ($P < 0.0001$–0.002) in a cross-sectional analysis. Other studies indicate that increased physical activity lead to greater reductions in total adiposity rather than in VAT (35), while others indicate a slight benefit of physical activity on VAT and SAT in obese individuals (36). In contrast, in a cohort of postmenopausal women, Nicklas *et al*. found no preferential loss of abdominal fat with either moderate- or vigorous-intensity aerobic exercise plus caloric restriction, compared to a caloric restriction-alone group (5). Interestingly, we found no dose–response relationship between frequency of vigorous activity and decreased VAT or SAT accumulation. A possible explanation for this finding is that those with the highest levels of vigorous activity also increased their caloric intake. Although our statistical analyses attempted to control for this possibility, other factors for which we were unable to control may characterize this subset.

The strengths of our study are its longitudinal design, its use of precise measures of abdominal fat areas by CT, and the use of a large minority cohort known to be disproportionately affected by metabolic disorders such as insulin resistance and diabetes. Limitations include the use of self-reported measures, which have limited accuracy (37), the failure of 405 participants to attend the 5-year follow-up exam, and use of a recall instrument for dietary intake data.

In summary, our study is the first to describe the impact of lifestyle factors on changes in CT-derived abdominal fat depots in a large minority cohort. Increased soluble fiber intake and vigorous physical activity significantly decreased the rate of VAT accumulation in two high-risk populations. As we continue to explore the reasons for the rapidly escalating rates of obesity and diabetes in young people, particularly ethnic minority groups, interventions that increase the intake of dietary fiber may be a possible approach for prevention.

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Table 1

Baseline characteristics of the cohort, and 5-year percent change in adiposity measures.

	African-American men (s.d.)	African-American women (s.d.)	Hispanic men (s.d.)	Hispanic women (s.d.)
N	131	208	296	479
Age (years)	44.8 (14.5)	43.4 (13.3)	39.5 (13.2)	41.5 (12.8)
BMI				
Baseline (kg/m^2)	28.7 (4.6)	30.5 (7.6)	28.1 (5.2)	28.9 (6.4)
Percent change from baseline	3.7 (8.8)	6.4 (12.5)	3.0 (8.4)	3.4 (9.8)
SAT				
Baseline (cm^2)	268.4 (136.6)	414.9 (188.4)	261.1 (126.2)	386.1 (155.6)
Percent change from baseline	17.5 (37.9)	13.3 (28.2)	14.2 (32.6)	10.0 (25.3)
VAT				
Baseline (cm^2)	109.2 (64.0)	93.0 (59.5)	120.2 (57.9)	99.4 (56.1)
Percent change from baseline	10.4 (42.2)	14.4 (40.5)	12.9 (45.1)	9.5 (39.0)
Nutrients (per day)[a]				
Total calories, kcal	1,946 (1,049)	1,575 (866)	2,208 (1,021)	1,661 (867)
Percent calories from sweets	11.4 (8.0)	11.3 (9.9)	12.7 (9.7)	11.8 (9.8)
Soluble fiber (beans, vegs, fruit), g	11.9 (9.3)	10.0 (6.2)	12.7 (8.4)	10.5 (6.5)
Insoluble fiber, g	7.4 (4.4)	5.9 (3.7)	8.7 (4.4)	6.7 (4.1)
Protein, g	76.1 (41.3)	63.2 (35.4)	89.4 (45.0)	69.3 (37.6)
Monounsaturated fat, g	29.4 (18.1)	24.6 (16.4)	35.7 (18.9)	25.9 (15.6)
Polyunsaturated fat, g	16.1 (10.1)	14.8 (9.3)	16.3 (8.2)	13.3 (7.9)
Saturated fat, g	25.5 (15.2)	21.8 (13.9)	31.9 (16.6)	24.0 (14.6)
Smoking status, N (%)				
Current	30 (23.8)	42 (20.4)	79 (26.7)	100 (20.9)
Former	35 (27.8)	49 (23.8)	81 (27.4)	62 (12.9)
Nonsmoker	61 (48.4)	115 (55.8)	136 (46.0)	317 (66.2)
Vigorous physical activity, N (%)				
Rarely/never	18 (13.7)	65 (31.3)	36 (12.2)	146 (30.5)
1–3 times/month	16 (12.2)	43 (20.7)	49 (16.6)	137 (28.6)
1 time/week	16 (12.2)	29 (13.9)	38 (12.8)	58 (12.1)
2–4 times/week	59 (45.0)	53 (25.5)	123 (41.6)	117 (24.4)
5+ times/week	22 (16.8)	18 (8.7)	50 (16.9)	21 (4.4)
Total energy expenditure (kcal/kg/year)	15,839 (3,531)	14,739 (2,658)	18,317 (5,037)	15,592 (3,080)
Education				
<High school	5(4.3)	17 (8.8)	51 (17.5)	63 (13.8)
High school graduate	26 (22.2)	46 (23.7)	115 (39.4)	220 (48.0)
>High school	86 (73.5)	131 (67.5)	126 (43.2)	175 (38.2)
Sleep duration				

	African-American men (s.d.)	African-American women (s.d.)	Hispanic men (s.d.)	Hispanic women (s.d.)
5 hours or less	37 (29.4)	60 (29.1)	34 (11.5)	53 (11.1)
6 or 7 hours	79 (62.7)	110 (53.4)	168 (56.8)	249 (52.0)
8 or more hours	10 (7.9)	36 (17.5)	94 (31.8)	117 (37.0)

SAT, subcutaneous adipose tissue; VAT, visceral adipose tissue.

[a]Nutrient data were collected at follow-up.

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Table 2

Estimates from individual GEE models for lifestyle factors and 5 year change in VAT and SAT

		Change in VAT		Change in SAT	
		Fully adjusted model[a]		Fully adjusted model[a]	
Model number		**Estimate (s.e.)**	***P* value**	**Estimate (s.e).)**	***P* value**
Nutrient models[b]					
1	Total calories (per 1,000 kcal)	0.71 (1.43)	0.62	0.20 (1.22)	0.87
2	% Cal from sweets (per 10 percent)	−0.66 (0.96)	0.50	−1.50 (0.66)	0.02
3	Soluble fiber (per 10 grams)	−3.73 (1.39)	0.01	0.24 (1.08)	0.82
4	Insoluble fiber (per 5 grams)	−1.74 (1.59)	0.27	1.59 (1.25)	0.20
5	Protein (per 40 grams)	−0.85 (2.64)	0.75	5.42 (1.98)	0.01
6	Monounsaturated fat (per 20 grams)	−3.07 (3.44)	0.37	−1.79 (2.00)	0.37
7	Polyunsaturated fat (per 10 grams)	1.43 (2.58)	0.58	0.01 (1.70)	0.99
8	Saturated fat (per 15 grams)	0.89 (2.54)	0.72	−0.90 (1.73)	0.60
Smoking models					
9	Current	3.05 (2.42)	0.20	−3.27 (1.54)	0.03
	Former	3.41 (2.70)	0.21	−2.00 (1.68)	0.23
	Non-smoker (REF)	—	—	—	—
Physical activity models					
10	Vigorous activity, 5+ times/week	−2.51 (4.57)	0.58	−0.17 (2.57)	0.95
	Sometimes, 1–3 ×/month or 1×/week or 2–4 ×/week	−7.40 (2.56)	0.003	−3.55 (1.43)	0.01
	Rarely/never (REF)	—	—	—	—
11	Total Energy Expenditure	−0.0005 (0.0002)	0.047	−0.0003 (0.0002)	0.14

SAT, subcutaneous adipose tissue; VAT, visceral adipose tissue.

[a]Fully adjusted: age, race, sex, family, baseline fat measures, and kcal, education, sleep, age–sleep, change in BMI.

[b]Scaled to approx. pooled standard deviation.