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Associations between Dietary Fat Intake and Waist Circumference

Phonchit Teng Soukhamneut
University of Alabama at Birmingham

ASSOCIATIONS BETWEEN DIETARY FAT INTAKE AND WAIST CIRCUMFERENCE

by

PHONCHIT SOUKHAMNEUT

OLIVIA AFFUSO, COMMITTEE CHAIR
APRIL CARSON
EMILY LEVITAN

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PHONCHIT SOUKHAMNEUT

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ABSTRACT

The objective of this study was to assess: 1) trends in dietary fat intake from 2003-2016 2) the association between type of dietary fat intake and waist circumference (WC), 3) the association between type of dietary fat intake and body shape, and 4) whether these associations vary by sex and race/ethnicity. This secondary data analysis included 27,057 adults aged 19 to 65 from the National Health and Examination Survey (NHANES) 2003-2016. For WC, participants were categorized into high-risk (men: WC ≥ 40 in; women: WC ≥ 35 in) and low-risk (men: WC < 40 in; women: WC < 35 in). Total fat intake was categorized as high (TOTFAT ≥ 35%) and low (TOTFAT< 35%). Saturated fat intake was categorized into high (SATFAT ≥ 10%) and low (SATFAT < 10%). Unsaturated fat intake was categorized into high (UNSATFAT ≥ 25%) and low (UNSATFAT < 25%). Logistic regression was performed to assess the associations between DFI and WC and DFI and body shape, controlling for age, BMI, and total caloric intake. NHW men with high TOTFAT were found to have 1.41 (OR: 1.41, 1.19 – 1.68) times the odds of having a high-

risk WC compared to men with a diet low in TOTFAT, controlling for age, BMI, and total caloric intake. NHW men with a diet high in SATFAT were at increased odds of having a high-risk WC compared to men with a diet low in SATFAT, after controlling for covariates (OR: 1.49, 1.21 -1.84). NHW men with a diet high in UNSATFAT were at increased odds of having a high-risk WC compared to men with a diet low in UNSATFAT after controlling for covariates (OR: 1.375, 1.09 – 1.74). There were no significant associations found among NWB and MA men for any type of dietary fat intake. For women, no associations were found between type of dietary fat and WC by race/ethnicity. There were no associations between DFI and body shape by race/ethnicity groups and sex. Future studies are needed to further investigate the body shape cut-off points for increased risk associated with chronic disease.

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LIST OF ABBREVIATIONS

A/G	android to gynoid
BMI	body mass index
DFI	dietary fat intake
DXA	dual-energy x-ray absorptiometry
MA	Mexican American
NHB	Non-Hispanic Black
NHW	Non-Hispanic White
SATFAT	saturated fat intake
TOTFAT	total fat intake
UNSATFAT	unsaturated fat intake
WC	waist circumference

INTRODUCTION

In 2015-2016, the prevalence of obesity among adults in the U.S. was 39.8%[1] and an increasing linear trend has been seen among women from 2005-2014.[2] Aside from overall obesity as measured by body mass index (BMI), abdominal obesity measured by waist circumference, is a risk factor for several chronic diseases.[3] Previous studies have found increases in waist circumference are associated with increase in chronic disease risks (i.e., type 2 diabetes, CVD, and hypertension).[3] It is well known that apple body shape is associated with increased risk of chronic disease. Although, there are few studies have examined associations between dietary fat intake and abdominal obesity assessed by dual-energy x-ray absorptiometry (DXA) android-gynoid ratio (AGR). Along with the increase in BMI, there have been larger than expected increases in waist circumference, which indicates there have been changes in body fat distribution among the U.S population.[4]

Type of dietary fat intake is an important determinant in the development of chronic diseases. Dietary fats can be classified into two sub-types of fat: saturated and unsaturated. Saturated fats are mainly found in animal sources such as meats and dairy products. In a longitudinal study, an association between diets high in saturated fats and increases in waist circumference was found.[5] The second category of dietary fats are unsaturated fats, including polyunsaturated and monounsaturated. Studies have found diets replacing saturated fats with polyunsaturated fats lowered LDL-C and total cholesterol-HDL ratio,[6] known independent predictors of cardiovascular risk. Diets high in monounsaturated fats have been found to improve metabolic risk factors among patients with type 2 diabetes and prevent central body fat distribution compared to carbohydrate rich diets.[7]

To our knowledge, there are a lack of pre-existing literature investigating the relationship between type of dietary fat intake and waist circumference and no studies of a large, diverse, nationally representative sample to examine the associations by sex, and race/ethnicity. Thus, the objective of this study was to assess: 1) the trends in dietary fat intake from 2003-2016, 2) the association between type of dietary fat intake and waist circumference, 3) the association between type of dietary fat intake and body shape and 4) whether these associations vary by sex and race/ethnicity.

METHODS

Survey Design and Data

The study examined data from 2003-2016 National Health and Examination Survey (NHANES).[8] The survey examines a nationally representative sample of about 5,000 persons per year, and the data are released in 2-year cycles. This study included demographic, dietary, anthropometry, body composition, and health-related assessments.

Inclusion and Exclusion Criteria

The study included men and women aged 19 to 65. Pregnant or lactating women were excluded from the study to reduce potential confounding results due to the association of pregnancy and lactation with change in body composition. Participants with a BMI < 18.5 were also excluded to reduce potential extraneous influence from some possible underlying diseases that may negatively affect waist circumference. The total sample for the study was 27,057 participants.

Dietary Intake Assessment

Dietary intake was assessed through an in-person 24-hour dietary recall administered by trained interviewers. A second dietary recall was administered by telephone 3-10 days later. Only data from the in-person 24-hour recall was used for this analysis. Data were collected on the reported intake of dietary fats, as well as intake of saturated fats, total unsaturated fats, monounsaturated fats, and polyunsaturated fats.

Anthropometry

Body Mass Index (BMI) was calculated weight in kilograms over height in meters squared (kg/m^2) from measured height and weight (nearest 0.1 kg). The waist circumference of participants was measured just above the iliac crest to the nearest 1 mm using a steel measuring tape.

Body Composition

The DXA scans were acquired with a Hologic QDR-4500A fan-beam densitometer. Participants were required to change into paper gowns and remove all jewelry or any other personal effects that could affect the DXA scans. Hologic software version 8.26: a3* was used to administer all scans. The DXA scanner measures regional body fat mass first, and then computes the total body fat mass as the sum of regional body fat masses. Pregnant females and participants heavier than 300lbs (136kg) or taller than 6’5’’ (195cm) were excluded from the DXA data according to the NHANES criteria.[8] The android-gynoid ratio (AGR, an indicator of body fat distribution) was collected.

Statistical Analysis

Demographic data included age, BMI, sex, and race/ethnicity. Race/ethnicity consisted of non-Hispanic white (NHW), non-Hispanic black (NHB), Mexican American (MA), other Hispanic and other races, including multi-racial; however, the study only include NHW, NHB, and MA because they represent the largest proportion in the population, as recommended by NHANES analytic guidelines.[9] Means and standard deviations were calculated for continuous variables, and percentages were calculated for categorical variables. Roa-Scott Modified Chi-Squares was used to assess differences between categorical variables. Independent T-Tests were used to assess differences between continuous variables by categorical variables. To account for the complex survey design used in NHANES, all statistical analyses were performed using SAS V9.4 survey procedures (SAS Institute Inc., Cary, NC, USA) The SURVEYFREQ and SURVEYMEANS procedures were used to obtain the descriptive statistics. The SURVEYREG procedure was used to test linear trends in percent total fat intake by race/ethnicity from 2003-2016. The percent mean total fat intake for each 2-year cycle was used for comparison. The SURVEYREG procedure was used to test differences in mean TFI, SATFAT, and UNSATFAT by race/ethnicity for men and women from 2003-2016.

Waist circumference, TFI, and each type of fat intake was dichotomized for analyses. For WC, participants were categorized into high-risk (men: WC $\geq$ 40 inches; women: WC $\geq$ 35 inches) and low-risk (men: WC < 40 inches; women: WC < 35 inches).[3] For TFI, participants were categorized into high (TFI $\geq$ 35%) and low (TFI < 35%).[10] For SATFAT, participants were categorized into high (SATFAT $\geq$ 10%) and low (SATFAT < 10%).[9] For UNSATFAT, participants were categorized into high (UNSATFAT $\geq$ 25%) and low (UNSATFAT < 25%).[10] The SURVEYLOGISTIC procedure was used to assess the associations of WC risk (High/Low) based on TFI (High/Low), SATFAT (High/Low), and UNSATFAT (High/Low). The body fat distribution was characterized by an AGR $\geq$ 1 indicating an apple body shape (upper body adiposity) and an AGR < 1 indicating a pear body shape (lower body adiposity). Henceforth, the AGR characterized body shape will be referred to as body shape.

The SURVEYLOGISTIC procedure was used to assess the associations of body shape (Apple/Pear) based on TFI (High/Low), SATFAT (High/Low), and UNSATFAT (High/Low).

All statistical analyses performed were adjusted for the NHANES survey design. Sample weights were pulled from the day 1 dietary interview data. Data are reported as percentages or means ± SE. All statistical tests were considered significant at $p \leq 0.05$. BMI, age, and total caloric intake were included as covariates in all analyses.

RESULTS

Sample characteristics are presented in Table 1. The sample consisted of 75.27% NHW, 13.86% NHB, and 10.88% MA. Sample demographics can be found in Table 1, which include age, race/ethnicity, and BMI. The average age in the analyses was 41.46 ± 0.21 years for men and 42.23 ± 0.20 years for women. The average BMI in the analyses was 28.91 ± 0.09 kg/m^2 for men and 29.54 ± 0.12 kg/m^2 for women.

Table 1.
Demographic characteristics of the National Health and Nutrition Examination Survey (2003-2016) (mean ± SEM)

	Male **n = 13516**	**Female** **n = 13541**	**Total** **n = 27057**
Age (Years)	41.46±0.21	42.23±0.20	41.84±0.18
Race/Ethnicity			
Mexican American	3007 (11.73)	2980 (10.02)	5987 (10.88)
Non-Hispanic White	6725 (75.46)	6635 (75.07)	13360 (75.27)
Non-Hispanic Black	3784 (12.80)	3926 (14.91)	7710 (13.86)
Height (cm)	176.99±0.12	163.23±0.10	170.16±0.10

Weight (kg)	90.69±0.29	78.69±0.31	84.73±0.24
BMI (kg/m^2)	28.91±0.09	29.54±0.12	29.22±0.09
Waist Circumference (cm)	101.23±0.23	96.79±0.26	99.03±0.20

Linear Trends in Percent Total Fat Intake by Race/Ethnicity from 2003-2016.

Mean percent of total fat intake comparison is presented in Figure 1. For NHW men, percent of calories from total fat increased from 34.28% in 2003-2004 to 35.55% in 2015-2016. Percent of total calories from fat increased by 0.11% every survey cycle year (0.11%±0.08%, p=0.1862); however, the linear trend was not statistically significant. For NHB men, percent of total calories from fat increased from 32.80% in 2003-2004 to 34.72% in 2015-2016. Percent of total calories from fat increased by 0.17% every survey cycle year (0.17%±0.09%, p=0.0749); however, the trend was not significant. For MA men, percent of calories from total fat increased from 30.66% in 2003-2004 to 34.40% in 2015-2016. Percent of total calories from fat increased by 0.57% every survey cycle year (0.57%±0.11%, p<0.0001). For NHW women, percent of calories from total fat increased from 34.29% in 2003-2004 to 36.52% in 2015-2016. Percent of total calories from fat increased by 0.23% every survey cycle year (0.23%±0.07%, p=0.0013). For NHB, percent of calories from total fat increased from 34.70% in 2003-2004 to 36.18% in 2015-2016. Percent of total calories from fat increased by 0.24% every survey cycle year (0.24%±0.11%, p=0.0308). For MA women, percent of calories from total fat increased from 32.96% in 2003-2004 to 34.75% in 2015-2016. Percent of total calories from fat increased by 0.43% every survey cycle year (0.43%±0.12%, p=0.0005).

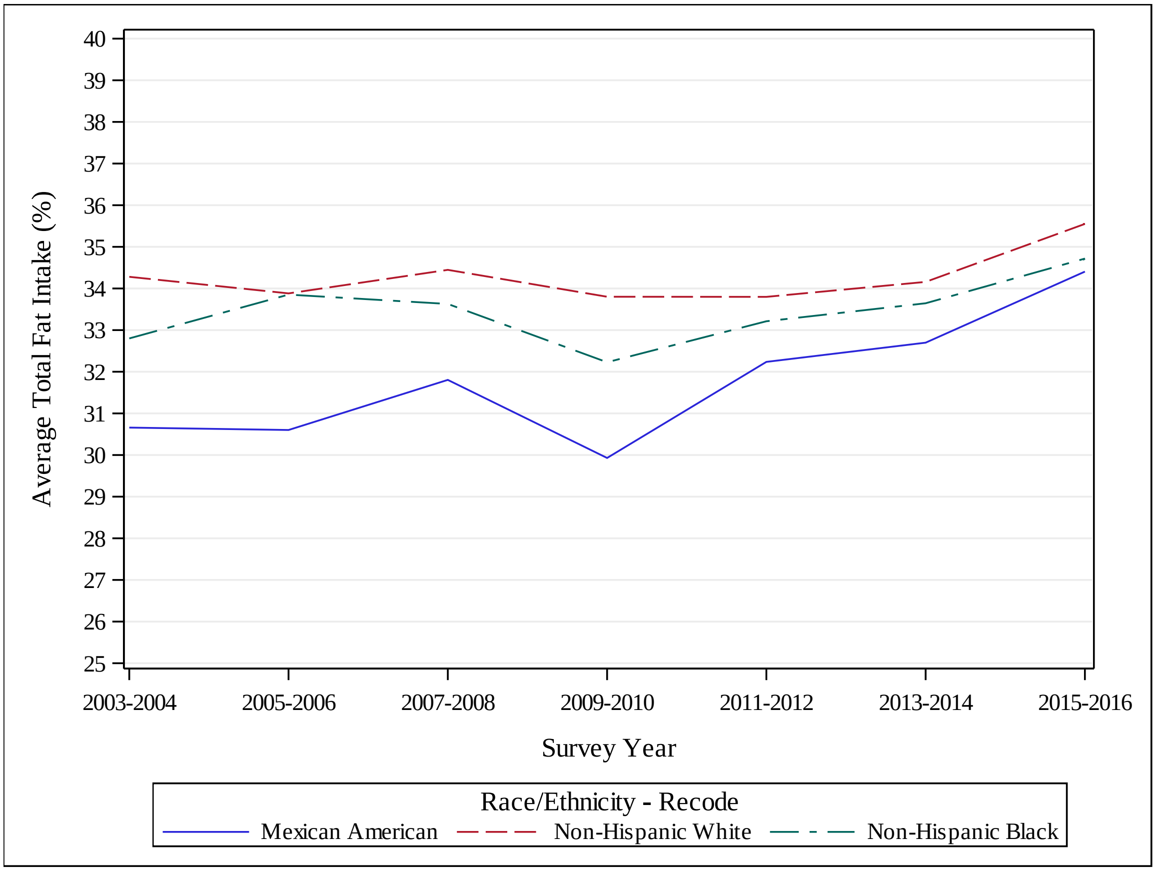

Figure 1

Linear trends in total fat intake (%) for men by race/ethnicity from 2003-2016

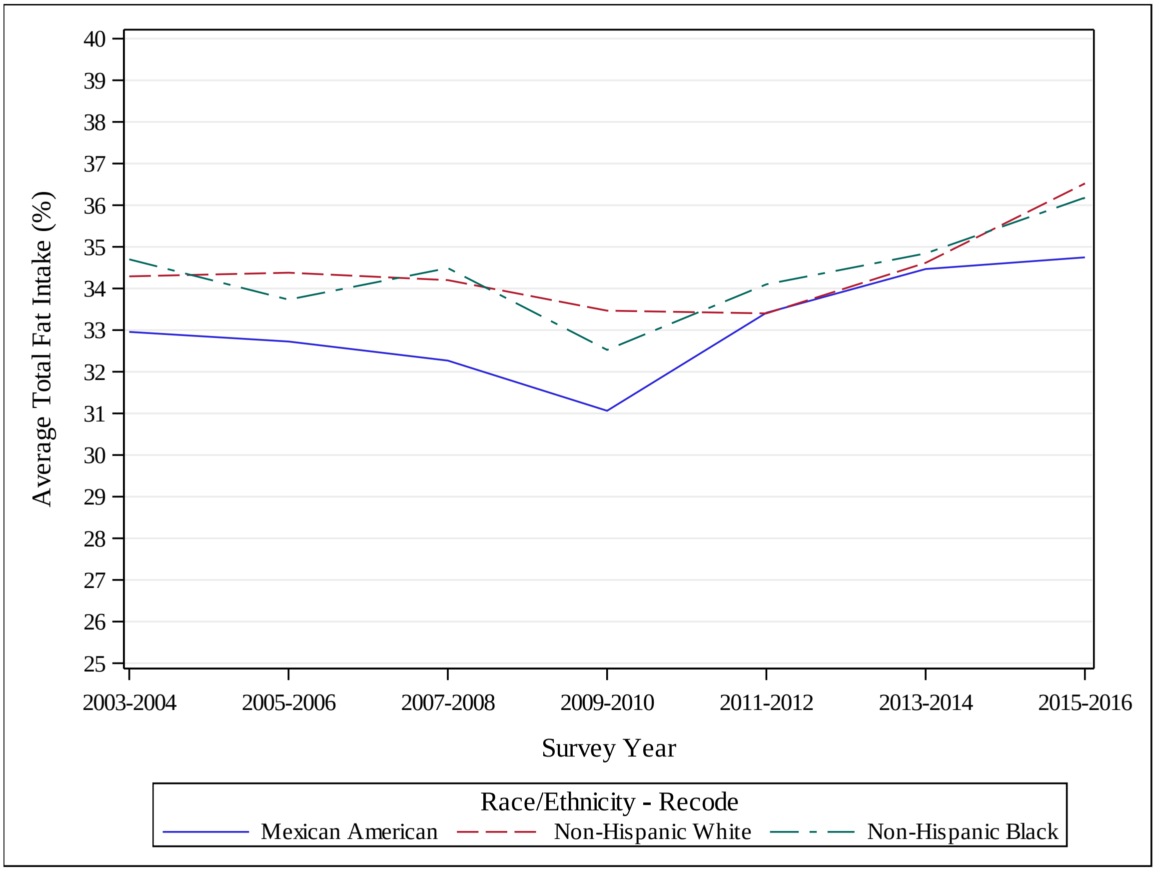

Figure 2

Linear trends in total fat intake (%) for women by race/ethnicity from 2003-2016

Mean Differences in Dietary Fat Intake by Race/Ethnicity for Men and Women

Results are presented in Table 2. For women, there were no significant differences in mean TOTFAT among any of the race/ethnicities. For men, there were significant differences in mean TOTFAT among MA and NHB when compared to NHW (96.95±1.39 and 97.92±1.34 compared to 104.02±0.86, respectively). For men, there were significant differences in mean SATFAT among MA and NHB compared to NHW (31.45±0.51 and 30.78±0.41 compared to 34.64±0.30, respectively). For men, there were only significant differences in UNSATFAT between MA and NHW (56.51±0.82

compared to 60.17±0.53, respectively). For women, there were no significant differences in mean SATFAT among any of the race/ethnicities. For women, there were significant differences in mean UNSATFAT among MA compared to NHB (42.79±0.65 compared to 44.85±0.49, respectively) and NHB compared to NHW (44.85±0.49 compared to 42.52±0.34, respectively.

Table 2

Mean dietary fat intake and waist circumference by race/ethnicity and sex

	Non-Hispanic Whites		Non-Hispanic Blacks		Mexican Americans	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
	n = 6396	**n** = 6303	**n** = 3469	**n** = 3626	**n** = 2813	**n** = 2777
Total Fat Intake (g)	104.02±0.86	73.02±0.55	97.92±1.34	75.13±0.84	96.95±1.39	72.97±1.09
Saturated Fat Intake (g)	34.64±0.30	24.16±0.20	30.78±0.41	23.58±0.31	31.45±0.51	23.58±0.43
Unsaturated Fat Intake (g)	60.17±0.53	42.52±0.34	58.33±0.90	44.85±0.49	56.51±0.82	42.79±0.65
Waist Circumference (cm)	101.93±0.29	95.71±0.30	97.99±0.38	101.51±0.40	100.14±0.47	97.96±0.48

Relationships between Dietary Fat Intake and Waist Circumference across Race/Ethnicity for Men

Table 3 contains the age, BMI, sex, and DFI by WC risk across race/ethnicity for men. As expected, men with a high-risk WC were found to be older and have a higher BMI. For NHW, there were more men with a high TOTFAT and a high-risk WC than men with a low TOTFAT (χ (1, *n* = 27057) = 68.22, p<0.0001). For NHW, there were more men with a high SATFAT and a high-risk WC than men with a low SATFAT (χ (1, *n* = 27057) = 46.08, p<0.0001). For NHW, there were more men with a high UNSATFAT and a high-risk waist circumference than men with a low UNSATFAT (χ (1, *n* = 27057) = 26.44, p<0.0001). For NHB, there were more men with a high TOTFAT and a high-risk WC than men with a low TOTFAT (χ (1, *n* = 27057) = 30.86, p<0.0001). For NHB, there were more men with a high SATFAT and a high-risk WC than men with a low SATFAT (χ (1, *n* = 27057) = 13.94, p=0.0002). For NHB, there were more men with a high UNSATFAT and a high-risk WC than men with a low UNSATFAT (χ (1, *n* = 27057) = 21.19, p<0.0001). For MA, there were more men with a high TOTFAT and a high-risk WC than men with a low TOTFAT (χ (1, *n* = 27057) = 16.21, p<0.0001). For MA, there were more men with a high SATFAT and a high-risk WC than men with a low SATFAT (χ (1, *n* = 27057) = 3.95, p=0.0470). For MA, there were more men with a high UNSATFAT and a high-risk WC than men with a low UNSATFAT (χ (1, *n* = 27057) = 6.52, p=0.0106).

Table 3

Categories of dietary fat intake by waist circumference risk for men within race/ethnicity groups

	Non-Hispanic Whites		**Non-Hispanic Blacks**		**Mexican Americans**	
	High-Risk	**Low-Risk**	**High-Risk**	**Low-Risk**	**High-Risk**	**Low-Risk**
	n = 2859	**n** = 3866	**n** = 1330	**n** = 2454	**n** = 1149	**n** = 1858
Age (Years)	46.30±0.29*	39.44±0.34	43.46±0.37*	38.12±0.36	39.76±0.50*	35.25±0.30
BMI (kg/m^2)	33.28±0.12*	25.26±0.07	35.53±0.16*	25.62±0.12	34.03±0.24*	26.25±0.12
Total Fat Intake						
High	1437 (49.75)*	1526 (50.25)	633 (40.98)*	907 (59.02)	450 (44.99)*	536 (55.01)
Low	1422 (38.16)	2340 (61.84)	697 (29.84)	1547 (70.16)	699 (35.05)	1322 (64.95)
Saturated Fat Intake						
High	1858 (47.64)*	2163 (52.36)	718 (38.28)*	1137 (61.72)	568 (40.60)*	804 (59.40)
Low	1001 (37.00)	1703 (63.00)	612 (30.55)	1317 (69.45)	581 (36.40)	1054 (63.60)
Unsaturated Fat Intake						
High	553 (53.05)*	514 (46.95)	295 (43.50)*	375 (56.50)	162 (44.95)*	187 (55.05)
Low	2306 (41.42)	3352 (58.58)	1035 (32.46)	2079 (67.54)	987 (37.52)	1671 (62.48)

*Note: *p <0.05*

Relationships between Dietary Fat Intake and Waist Circumference across Race/Ethnicity for Women

Table 4 contains the age, BMI, sex, and DFI by WC risk across race/ethnicity for women. As expected, women with a high-risk WC were found to be older and have a higher BMI. For NHW, there were more women with a high TOTFAT and a high-risk WC than women with a low TOTFAT (χ (1, n = 27057) = 68.22, p<0.0001). For NHW, there were more women with a high SATFAT and a high-risk WC than women with a low SATFAT (χ (1, n = 27057) = 42.91, p<0.0001). For NHW, there were more women with a high UNSATFAT and a high-risk WC than women with a low UNSATFAT (χ (1, n = 27057) = 5.77, p=0.0163). For NHB, there were more women with a high TOTFAT and a high-risk WC than women with a low TOTFAT (χ (1, n = 27057) = 5.19, p=0.0227). For NHB, there were no significant differences between SATFAT and WC risk, and there were no significant differences between UNSATFAT and WC risk. For MA, there were more women with a high TOTFAT and a high-risk WC than women with a low TOTFAT (χ (1, n = 27057) = 6.97, p=0.0083). For MA, there were no significant differences between SATFAT and WC risk, and there were no significant differences between UNSATFAT and WC risk.

Table 4

Categories of dietary fat intake by waist circumference risk for women within race/ethnicity groups

	Non-Hispanic Whites		**Non-Hispanic Blacks**		**Mexican Americans**	
	High-Risk	**Low-Risk**	**High-Risk**	**Low-Risk**	**High-Risk**	**Low-Risk**
	n = 3884	**n** = 2751	**n** = 2720	**n** = 1206	**n** = 2089	**n** = 891
Age (Years)	45.69±0.24*	39.50±0.35	42.52±0.36*	36.84±0.50	39.51±0.29*	34.43±0.47
BMI (kg/m^2)	32.56±0.16*	23.25±0.10	35.01±0.17*	26.06±0.28	32.90±0.19*	24.82±0.28
Total Fat Intake						
High	1821 (62.90)*	1082 (37.10)	1267 (71.46)*	512 (28.54)	848 (71.63)*	305 (28.37)
Low	2063 (53.77)	1669 (46.23)	1453 (67.59)	694 (32.41)	1241 (67.61)	586 (32.39)
Saturated Fat Intake						
High	2378 (61.85)*	1465 (38.15)	1397 (70.43)	601 (29.57)	1094 (69.85)	450 (30.15)
Low	1506 (52.36)	1286 (47.64)	1323 (68.21)	605 (31.79)	995 (68.43)	441 (31.57)
Unsaturated Fat Intake						
High	754 (62.03)*	452 (37.97)	619 (71.97)	238 (28.03)	325 (71.74)	118 (28.26)
Low	3130 (56.87)	2299 (43.13)	2101 (68.63)	968 (31.37)	1764 (68.72)	773 (31.28)

*Note:*p <0.05*

Association between Dietary Fat Intake and Waist Circumference for Men and Women

To examine the associations between DFI and WC risk, the crude and adjusted odds ratio (OR) by race/ethnicity, controlling for age, BMI, and total caloric intake were produced for each type of dietary fat. Results from the multivariable logistic regression can be found in Table 5 and 6. NHW men with a diet high in TOTFAT had 1.46 times the odds of having a high-risk WC compared to men with a diet low in TOTFAT, controlling age, BMI, and total caloric intake (OR: 1.46, 1.18 – 1.80). NHW men with a diet high in SATFAT had 1.49 times the odds of having a high-risk WC compared to men with a diet low in SATFAT, after controlling for age, BMI, and total caloric intake (OR: 1.49, 1.21 - 1.84). NHW men with a diet high in UNSATFAT had 1.38 times the odds of having a high-risk WC compared to men with a diet low in UNSATFAT after controlling for age, BMI, and total caloric intake (OR: 1.375, 1.09 – 1.74). There were no significant associations for NHB men and MA men among any of the types of dietary fats. For women, there were no significant associations between any of the DFI and WC among any of the race/ethnicity groups after controlling for age, BMI, and total caloric intake.

Table 5
Examining the association between dietary fat intake and waist circumference risk in men by race/ethnicity

	Model 1 (95% CI)	**Model 2 (95% CI)**
Total Fat Intake		
Non-Hispanic Whites	1.61 (1.43 – 1.80)	1.46 (1.18 -1.780)
Non-Hispanic Blacks	1.63 (1.37 – 1.95)	1.29 (0.97 – 1.71)

Mexican Americans	1.52 (1.24 – 1.85)	1.21 (0.92 – 1.59)
Saturated Fat Intake		
Non-Hispanic Whites	1.55 (1.36 – 1.76)	1.49 (1.21 – 1.84)
Non-Hispanic Blacks	1.41 (1.17 – 1.70)	1.14 (0.82 – 1.59)
Mexican Americans	1.19 (1.00 – 1.43)	1.05 (0.80 - 1.37)
Unsaturated Fat Intake		
Non-Hispanic Whites	1.60 (1.35 – 1.89)	1.38 (1.09 – 1.74)
Non-Hispanic Blacks	1.60 (1.31 – 1.96)	1.16 (0.87 – 1.55)
Mexican Americans	1.36 (1.08 – 1.72)	0.89 (0.59 – 1.34)

Model 1: Crude OR for each race/ethnicity
Model 2: Adjusted for age, BMI, and total caloric intake

Table 6
Examining the association between dietary fat intake and waist circumference risk in women by race/ethnicity

	Model 1 (95% CI)	**Model 2 (95% CI)**
Total Fat Intake		
Non-Hispanic Whites	1.46 (1.27 – 1.68)	1.01 (0.83 – 1.24)
Non-Hispanic Blacks	1.20 (1.02 – 1.41)	0.89 (0.72– 1.11)
Mexican Americans	1.21 (1.05 – 1.40)	0.86 (0.68 – 1.10)
Saturated Fat Intake		
Non-Hispanic Whites	1.48 (1.31 – 1.66)	1.01 (0.86 – 1.19)
Non-Hispanic Blacks	1.11 (0.93 – 1.32)	0.88 (0.70 – 1.10)
Mexican Americans	1.07 (0.88 – 1.30)	0.80 (0.61 – 1.05)
Unsaturated Fat Intake		
Non-Hispanic Whites	1.24 (1.04 – 1.48)	0.97 (0.77 – 1.23)

Non-Hispanic Blacks	1.17 (0.94 – 1.47)	0.84 (0.62 – 1.13)
Mexican Americans	1.16 (0.92 – 1.46)	0.86 (0.58 – 1.28)

Model 1: Crude OR for each race/ethnicity
Model 2: Adjusted for age, BMI, and total caloric intake

Relationships between Dietary Fat Intake and Body Shape across Race/Ethnicity for Men

Table 7 contains the age, BMI, sex, and DFI by body shape across race/ethnicity for men. There were no significant associations between body shape and age, across race/ethnicity. Associations between body shape and BMI were not significant except for MA men. For NHW, there were no significant associations between TOTFAT and body shape. For NHW, there were more men with a high SATFAT and an apple body shape than men with a low SATFAT (χ (1, *n* = 27057) = 10.61, p=0.0011). For NHW, there were no significant associations between UNSATFAT and body shape. For NHB, there were no significant associations between TOTFAT and body shape. For NHB, there were more men with a high SATFAT and an apple body shape than men with a low SATFAT (χ (1, *n* = 27057) = 6.38, p=0.0116). For NHB, there were no significant associations between UNSATFAT and body shape. There were no significant associations between any of the DFI categories by body shape among MA men.

Table 7
Categories of dietary fat intake by body shape for men within race/ethnicity groups

	Non-Hispanic Whites		**Non-Hispanic Blacks**		**Mexican Americans**	
	Apple Shape n = 1127	**Pear Shape n = 5598**	**Apple Shape n = 520**	**Pear Shape n = 3264**	**Apple Shape n = 618**	**Pear Shape n = 2389**
Age (Years)	42.94±0.45	42.30±0.28	41.02±0.72	39.78±0.34	36.56±0.46	37.06±0.33
BMI (kg/m^2)	28.92±0.18	28.79±0.12	28.99±0.24	29.13±0.16	28.46±0.22*	29.46±0.19
Total Fat Intake						
High	495 (17.61)	2468 (82.39)	226 (15.16)	1314 (84.84)	189 (15.30)	797 (84.70)
Low	632 (17.68)	3130 (82.32)	294 (13.47)	1950 (86.53)	429 (17.82)	1592 (82.18)
Saturated Fat Intake						
High	717 (18.93)*	3304 (81.07)	287 (15.81)*	1568 (84.19)	274 (16.17)	1098 (83.83)
Low	410 (15.75)	2294 (84.25)	233 (12.55)	1696 (87.45)	344 (17.69)	1291 (82.31)
Unsaturated Fat Intake						
High	190 (18.31)	877 (81.69)	90 (13.99)	580 (86.01)	66 (15.04)	283 (84.96)
Low	937 (17.52)	4721 (82.48)	430 (14.19)	2684 (85.81)	552 (17.23)	2106 (82.77)

*Note: *p<0.05*

Relationships between Dietary Fat Intake and Body Shape across Race/Ethnicity for Women

Table 8 contains the age, BMI, sex, and DFI by body shape across race/ethnicity for women. There was a significant association between age and body shape for NHW; however, these associations were not significant for the other race/ethnicities. As expected, women with an apple body shape were found to have a higher BMI. For NHW, there were no significant associations between TOTFAT and body shape. For NHW, there were more women with a high SATFAT and an apple body shape than women with a low SATFAT (χ (1, n = 27057) = 3.94, p=0.0473). For NHW, there were no significant associations between UNSATFAT and body shape. Among NHB women, there were no significant associations between any of the DFI categories and body shape. Similar results were found among MA women as well.

Table 8
Categories of dietary fat intake by body shape for women within race/ethnicity groups

	Non-Hispanic Whites		**Non-Hispanic Blacks**		**Mexican Americans**	
	Apple Shape n = 537	**Pear Shape n = 6098**	**Apple Shape n = 332**	**Pear Shape n = 3594**	**Apple Shape n = 357**	**Pear Shape n = 2623**
Age (Years)	44.84±0.67*	42.92±0.24	41.31±0.49	40.73±0.35	38.72±0.66	37.86±0.33
BMI (kg/m^2)	31.92±0.23*	28.52±0.15	34.35±0.43*	32.29±0.20	31.46±0.37*	30.43±0.20
Total Fat Intake						
High	249 (9.32)	2654 (90.68)	142 (8.46)	1637 (91.54)	147 (10.20)	1006 (89.80)
Low	288 (8.09)	3444 (91.91)	190 (9.15)	1957 (90.85)	210 (9.16)	1617 (90.84)
Saturated Fat Intake						
High	337 (9.39)*	3506 (90.61)	172 (9.29)	1826 (90.71)	200 (10.50)	1344 (89.50)
Low	200 (7.61)	2592 (92.39)	160 (8.35)	1768 (91.65)	157 (8.54)	1279 (91.46)
Unsaturated Fat Intake						
High	90 (7.80)	1116 (92.20)	65 (8.12)	792 (91.88)	56 (10.30)	387 (89.70)
Low	447 (8.84)	4982 (91.16)	267 (9.03)	2802 (90.97)	301 (9.43)	2236 (90.57)

*Note: *p <0.05*

Association between Dietary Fat Intake and Body Shape for Men and Women

To examine the association between DFI and body shape, the crude and adjusted OR by race/ethnicity controlling for age, BMI, and total caloric intake, were produced for each type of dietary fat. Results from the multivariable logistic regression can be found in Table 9 and 10. For men, there were no associations between any of the DFI and body shape among all race/ethnicity groups after controlling for age, BMI, and total caloric intake. For women, there were no associations found between any of the DFI and body shape among all race/ethnicity groups after controlling for age, BMI, and total caloric intake.

Table 9
Examining the association among dietary fat intake and body shapes in men by race/ethnicity

	Model 1 (95% CI)	**Model 2 (95% CI)**
Total Fat Intake		
Non-Hispanic Whites	1.00 (0.85 – 1.17)	0.88 (0.74 – 1.03)
Non-Hispanic Blacks	1.15 (0.89 – 1.48)	1.01 (0.79 – 1.29)
Mexican Americans	0.83 (0.62 – 1.12)	0.76 (0.58 – 1.01)
Saturated Fat Intake		
Non-Hispanic Whites	1.25 (1.09 – 1.43)	1.09 (0.95 – 1.26)
Non-Hispanic Blacks	1.31 (1.07 – 1.61)	1.16 (0.95 – 1.42)
Mexican Americans	0.90 (0.68 – 1.18)	0.79 (0.60 – 1.03)
Unsaturated Fat Intake		
Non-Hispanic Whites	1.06 (0.83 – 1.34)	0.97 (0.77 – 1.23)
Non-Hispanic Blacks	0.98 (0.75 – 1.29)	0.90 (0.689 – 1.17)

Mexican Americans	0.85 (0.58 – 1.24)	0.80 (0.55 – 1.17)

Model 1: Crude OR for each race/ethnicity
Model 2: Adjusted for age, BMI, and total caloric intake

Table 10
Examining the association among dietary fat intake and body shapes in women by race/ethnicity

	Model 1 (95% CI)	**Model 2 (95% CI)**
Total Fat Intake		
Non-Hispanic Whites	1.17 (0.97 – 1.41)	1.05 (0.85 – 1.31)
Non-Hispanic Blacks	0.92 (0.72 – 1.17)	0.81 (0.63 – 1.04)
Mexican Americans	1.13 (0.90 – 1.42)	1.01 (0.80 – 1.27)
Saturated Fat Intake		
Non-Hispanic Whites	1.26 (1.01 – 1.57)	1.14 (0.89 – 1.45)
Non-Hispanic Blacks	1.12 (0.86 – 1.46)	1.00 (0.76 – 1.33)
Mexican Americans	1.26 (0.90 – 1.74)	1.10 (0.78 – 1.56)
Unsaturated Fat Intake		
Non-Hispanic Whites	0.87 (0.66 – 1.16)	0.81 (0.60 – 1.09)
Non-Hispanic Blacks	0.89 (0.63 – 1.26)	0.81 (0.57 – 1.16)
Mexican Americans	1.10 (0.74 – 1.63)	1.00 (0.68 – 1.48)

Model 1: Crude OR for each race/ethnicity
Model 2: Adjusted for age, BMI, and total caloric intake

DISCUSSION

This study showed increasing linear trends in each category of race with MA having the largest increasing trend. A previous study in Minneapolis-St Paul showed decreasing linear trends in total fat percent intake from 1980-2009[11]. These results provide evidence that the US population's diet is slowly increasing in total fat, which could lead to increased development of risk factors for several chronic diseases.

Our main findings were that NHW men with a high TOTFAT were associated with having a high-risk WC compared to NHW men with a low TOTFAT, controlling for age, BMI, and total caloric intake. Similar results were found in another study assessing the associations between BMI categories and fat intake.[13] NHW Men with a high SATFAT were associated with having a high-risk WC compared to NHW men with a low SATFAT, controlling for age, BMI, and total caloric intake; however, this association was not found to be significant among women. These results were consistent with a study observing the effects of saturated fat intake on BMI; however, the previous study did not stratify the multivariable analyses by sex.[12] NHW Men with a high UNSATFAT were associated with having a high-risk WC compared to NHW men with a low UNSATFAT, controlling for age, BMI, and total caloric intake. The association between UNSATFAT and WC risk was not significant when analyzed among women. These results indicate there may be some sex and racial differences in how dietary fat intake influences an individual's body fat distribution. The associations between DFI and WC for men further conclude the importance of adhering to the recommended dietary guidelines.

For our body shape analysis through classification of A/G ratios, there were no associations between body shape and any of the dietary fats after controlling for confounders. The results of no association were consistent with that of another study done analyzing the associations between dietary fat and regional body fat distribution; however, the earlier study only included women.[14]

There were two different results when using different methods of measuring abdominal obesity. In our WC analysis, we found that men were associated with a higher odds of a high-risk WC when consuming a high total fat diet, saturated fat diet, or unsaturated fat diet; however, these associations were not found in women. Results suggest there are racial difference in effects of fat intake on WC. In our body shape analysis, we found that there were no associations between body shape and any type of dietary fat intake, which was not consistent with our WC analysis. A previous study has found significant correlations between android fat mass and waist circumference, which is not consistent with our results.[15] These inconsistencies could indicate that the assessments of abdominal obesity are capturing different information regarding the actual fat tissue.

Strengths of this study include the use of a large nationally representative sample of US adults. Anthropometric measurement methods were standardized and performed by trained investigators. This study includes DXA measures, which provide minimal measuring error.[16] Analysis consists of two methods for measuring regional body fat, as opposed to only assessing abdominal obesity through BMI measurements. Limitations to the present study include the cross-sectional study design, which prevents any temporal relationship to be determined between WC risk and dietary fat intake. Additionally, the self-reported dietary intake data collected via 24-hour recall may have introduced recall bias because people may have a hard time remembering what they had to eat the day before. The analysis was performed on day 1 dietary interview data. Measuring an individual's diet for a single day may not accurately account for day-to-day variation in the dietary intake.

In summary, Non-Hispanic White men with a diet high in total fat or any sub-type of fat was significantly associated with a high-risk WC while the other race/ethnicities had no associations. WC risk was not found to be significantly associated with dietary fat intake in women. Apple body shape was not significantly associated with diets high in total fat, saturated fat, or unsaturated fats. Findings from the WC analysis are consistent with the dietary recommendations while results from the DXA analysis were not. Inconsistencies between the two analyses suggest level of fat intake may not influence central body fat distribution. Considering the accuracy of DXA measurements, future studies may need to investigate the A/G ratio cut-off points for increased risk associated with chronic disease.

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