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# The Association of Food Shopping Frequency with Overall and Central Obesity Indicators: An Observational Study in a Public Health Setting from NHANES 2009-2010

**Leila Itani [1,†] and Marwan El Ghoch [2,*,†]**

[1] Department of Nutrition and Dietetics, Faculty of Health Sciences, Beirut Arab University, Riad El Solh, Beirut P.O. Box 11-5020, Lebanon; l.itani@bau.edu.lb
[2] Center for the Study of Metabolism, Body Composition and Lifestyle, Department of Biomedical, Metabolic and Neural Sciences, University of Modena and Reggio Emilia, 41125 Modena, Italy
* Correspondence: m.elghoch@unimore.it
† These authors contributed equally to this work.

## Highlights

**Public health relevance—How does this work relate to a public health issue?**

- Obesity is an escalating global crisis, with its prevalence projected to exceed 30% of the worldwide population by 2035.
- Identifying novel, modifiable behavioral strategies associated with a lower prevalence of obesity is a critical priority for public health.

**Public health significance—Why is this work of significance to public health?**

- Major food shopping frequency may be a modifiable household practice; whether changing it, for example, through low-cost education, affects adiposity remains to be tested in longitudinal and intervention studies.

**Public health implications—What are the key implications or messages for practitioners, policy makers and/or researchers in public health?**

- Researchers should conduct longitudinal and intervention studies to establish whether the association between major food shopping frequency and obesity is causal.
- Policy makers, practitioners, and educators can potentially collaborate to remove structural barriers to frequent major food shopping and incorporate food procurement habits into clinical counseling as a potential strategy for healthy weight management.

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## Abstract

Background and objectives: Food shopping frequency (FSF) has emerged as a key consumer behavior linked to health outcomes. We assessed the association between FSF and both overall and central obesity using multiethnic data from the National Health and Nutrition Examination Survey (NHANES). Methods: This cross-sectional study analyzed 4747 non-pregnant adults (aged ≥18) from the NHANES 2009–2010 cycle. Obesity was defined as BMI ≥ 30 kg/m²; central obesity as waist circumference ≥102 cm (men) and ≥88 cm (women). FSF, reported by one adult on behalf of the household, was categorized into four groups from >1 time/week (reference) to ≤1 time/month. Multivariable survey-weighted regression models adjusted for demographic, socioeconomic, food-access, and lifestyle covariates were used. Results: Obesity prevalence significantly increased from

the most to least frequent FSF category (29.1% to 42.5%; $p < 0.001$), as did central obesity (46.1% to 61.4%; $p = 0.002$). After full adjustment, each one-step decrease in FSF was independently associated with 16% higher odds of obesity (OR = 1.16; 95% CI = 1.03–1.29; $p$-trend = 0.015) and 21% higher odds of central obesity (OR = 1.21; 95% CI = 1.11–1.33; $p$-trend < 0.001). Conclusions: A lower FSF is independently associated with higher odds of overall and central obesity. If confirmed longitudinally, the effect of educational approaches promoting more frequent major food shopping on adiposity could be tested in intervention studies.

**Keywords:** food shopping frequency; central obesity; body mass index; waist circumference; NHANES; consumer behavior

## 1. Introduction

Obesity is currently considered one of the major public health problems worldwide. In 2022, about 16% of adults aged 18 years and older worldwide, more than 890 million people, were living with obesity, and the worldwide prevalence of adult obesity has more than doubled since 1990 [1,2]. This burden varies widely across the world reaching 40–50% in some countries of the Middle East and North Africa [3] and 40% in USA [4]. Obesity increases the burden of several medical and psychological comorbidities, such as type 2 diabetes, cardiovascular diseases, several types of cancer, and osteoarthritis [5–8] and depression [9] as well as impaired health-related quality of life (HRQoL) [10,11]. For these reasons, the identification of modifiable factors, such as behaviors and habits related to the food chain, that can be associated with a lower risk of obesity in the general population has become of vital importance and has important public health implications.

Among these factors, several consumer behaviors related to the way in which food is purchased, prepared, and consumed have attracted interest as potential determinants of body weight status. These include (i) eating out of the home, which has been positively associated with a higher energy and fat intake [12] and was positively associated with body weight in almost all prospective studies included in a systematic review [13]; (ii) the frequency of eating home-cooked meals, which has been linked to a better diet quality and a lower adiposity [14,15]; (iii) the use of nutrition labels, which has been associated with a higher intake of fruits, vegetables, and whole grains and a lower intake of sugar-sweetened beverages [16], while food labeling has been shown to reduce energy and fat intake and increase vegetable consumption [17]; and (iv) shopping with a grocery list, which has been associated with a healthier diet and a lower body mass index (BMI) [18].

In this context, a consumer behavior that deserves particular attention is food shopping frequency (FSF), which refers to how often a household does its major food shopping, since it shapes the foods that are available at home between one shopping trip and the next. Foremost FSF has been linked to diet quality in different populations. In fact, in the United States, FSF was associated with daily diet quality among non-Hispanic Black adults from NHANES 2007–2010, and it mediated the relationship between cooking frequency and the quality of the evening meal [19]. Similarly, more frequent grocery shopping was associated with a better home- and individual-level diet quality among low-income African American and Hispanic households with preschool-aged children [20], and with a higher likelihood of meeting fruit and vegetable recommendations among Burmese refugees [21]. Moreover, a representative sample of adults from Canada showed that more frequent shopping at food co-operatives was associated with a better diet quality, as was more frequent shopping at specialty shops and farmers' markets [22]. In addition,

this study reported that more frequent food shopping is also associated with a lower BMI and waist circumference (WC), though with no clear reference to obesity.

Therefore, to the best of our knowledge, the major part of the available literature on the topic focused on the association between FSF and diet quality rather than on body weight status [19–22]. Few studies that examined body weight assessed the frequency of shopping at specific types of stores, such as specialty shops and farmer's markets, and reported differences in mean BMI and WC rather than prevalence of obesity [22]. Whether the overall frequency of major household food shopping, regardless of type of store, is associated with overall or central obesity in a large national sample, with measured anthropometry, has not been examined.

In this context, FSF as a household practice rather than individual behavior makes food available to all the household members until the next trip. Hence, FSF can characterize the shared home food environment and consequently may affect the dietary intake and subsequent body weight status of household members. From this stems our hypothesis that a lower FSF can be associated with higher odds of having obesity, specifically central obesity with excessive adiposity, which carries cardiometabolic risk beyond BMI [23–25]. Based on these considerations, the current study aimed to examine the association between FSF and both overall obesity, assessed by BMI, and central obesity, assessed by WC as a surrogate measure, in a multiethnic sample of adults from the NHANES 2009–2010 cycle.

## 2. Materials and Methods

### *2.1. Participants and Design of the Study*

The current report involved a cross-sectional study based on the 2009–2010 cycle of the National Health and Nutrition Examination Survey (NHANES). NHANES uses a complex, stratified, multistage probability sampling design to obtain a representative sample of the civilian, non-institutionalized population of the United States, and combines a household interview with a standardized physical examination performed in a mobile examination center (MEC) [26]. Reporting follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement(Table S6) for cross-sectional studies [27].

Participants were included in the investigation if they fulfilled the following inclusion criteria: (i) an age of 18 years or more; (ii) completion of the MEC examination, with a valid examination sample weight; and (iii) a valid response to the question on FSF. On the other hand, the exclusion criteria were being pregnant at the time of the examination, reporting that they rarely make major shopping trips or rarely shop for food, and missing data on anthropometric measurements or on any of the covariates included in the regression models. Of the 6527 adults aged 18 years or more, 68 pregnant women, 167 participants without a MEC examination weight, 154 participants who reported only small shopping trips or rarely shopping for food, and 78 participants without a valid response on FSF were excluded. A further 353 participants had missing anthropometric data, and 960 had missing data on one or more covariates (Table S6), mainly the income–poverty ratio and/or alcohol consumption (n = 909). Of these, 955 lacked at least one Model 4 covariate, so that 4752 participants were eligible for Model 4, and only 5 lacked solely Model 5 variables, leaving a final analytic sample of 4747 adults. The same sample was used in all regression models, and the participant flow is shown in Figure 1.

The NHANES 2009–2010 protocol was approved by the NCHS Research Ethics Review Board (Continuation of Protocol #2005-06), and all participants gave their informed written consent. The present analysis used de-identified public-use data and therefore did not require additional ethical approval.

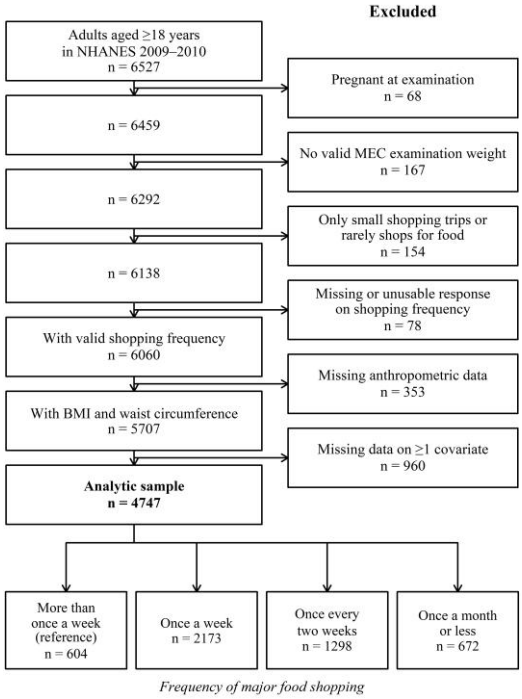



**Figure 1.** The flow of participants through the study, NHANES 2009–2010. MEC = mobile examination center; BMI = body mass index.

### *2.2. Food Shopping Frequency*

FSF was assessed in the consumer behavior questionnaire, which was administered at home through a computer-assisted personal interview to one adult family respondent per household. Item CBQ140 asks: "How often {do you/do you or someone else} do the major food shopping for {yourself/your family}? Please do not include times when {you buy/someone buys} only a few items." The response referred to the major food shopping of the household and was assigned to all examined adults in the family. Whether each participant was the main food shopper (DBQ940) of the household was recorded separately. The response options were more than once a week, once a week, once every two weeks, once a month or less, rarely making major shopping trips (only small trips), and rarely shopping for food. The first four options were retained as an ordered four-category exposure, and more than once a week, representing the most frequent shoppers, was used as the reference category. The last two options describe households that make no major shopping trips at all and therefore do not lie on the same continuum, so they were excluded from the main analysis, and were examined separately in a sensitivity analysis. For the trend analysis, the categories were also scored from 1 (more than once a week) to 4 (once a month or less), so that each unit increase represented one step toward less frequent major shopping.

### *2.3. Anthropometric Measurements*

Body weight, height, and WC were measured in the MEC by trained health technicians following the standardized NHANES anthropometry protocol. Body weight was measured with a digital scale with the participants in light clothing and without shoes, and height was measured with a fixed stadiometer. The BMI was calculated by dividing the body weight expressed in kilograms by the square of the height expressed in meters, and obesity was defined as a BMI ≥30 kg/m$^2$. WC was measured with a steel measuring tape just above the uppermost lateral border of the right ilium at the end of a normal

expiration. Central obesity was defined as an elevated WC of ≥102 cm in males and ≥88 cm in females [28,29]. Adult thresholds were also applied to participants aged 18–19 years, in line with the International Diabetes Federation recommendation to use adult criteria from 16 years of age [30]. BMI and WC were also analyzed as continuous variables.

### 2.4. Covariates

Covariates were selected a priori according to their assumed causal role, following the modified disjunctive cause criterion [31]. Variables thought to cause the exposure, the outcome, or both were eligible for adjustment; variables lying on the causal pathway were entered only in a separate model; and variables that were consequences of adiposity were not adjusted for. Demographic, socioeconomic, food-access and lifestyle factors were considered potential common causes of FSF and adiposity. Because all variables were measured at the same time, some covariates, such as food security, employment and physical activity, may also partly reflect prior adiposity. Covariates were entered in blocks. Demographic factors included age (years), sex, and race/ethnicity (Mexican American, other Hispanic, non-Hispanic White, non-Hispanic Black, and another race including multiracial). Socioeconomic and household factors included education (less than high school, high school or General Educational Development [GED], and more than high school), the family income-to-poverty ratio (continuous), marital status (married or living with a partner, widowed/divorced/separated, and never married), household size, the presence of children aged 17 years or younger in the household, household food security (full, marginal, and low or very low), receipt of Supplemental Nutrition Assistance Program (SNAP) benefits in the past 12 months, and employment status (working, looking for work, and not working).

Food-access factors included the self-reported one-way travel time to the grocery store, which was log-transformed as ln (1 + minutes) because of its skewed distribution; and whether the participant was the main food shopper in the household. Lifestyle factors included physical activity, sitting time, smoking, and alcohol consumption. Participants were classified as meeting the physical-activity guideline if their total activity from work, transport, and recreation reached at least 600 metabolic equivalent (MET)-minutes per week, corresponding to 150 min of moderate-intensity activity. Sitting time was expressed in hours per day. Smoking status was classified as never, former, or current, and alcohol consumption as none, >0–7, >7–14, and >14 drinks per week. Marital status was not collected for participants aged 18–19 years, and their smoking and alcohol use were assessed with a youth questionnaire not comparable with the adult items; these participants (n = 244) were therefore retained using a separate indicator category, which was not interpreted and was excluded from the Wald tests for these variables.

Finally, variables that may lie on the causal pathway between FSF and adiposity were considered as potential mediators. These included the home availability of fruit, dark-green vegetables, salty snacks, fat-free or low-fat milk, and soft drinks, each collapsed from five response options into three groups (Tables S1–S4), and the number of meals not prepared at home in the past 7 days, which was log-transformed as ln (1 + meals).

### 2.5. Statistical Analysis

All analyses accounted for the complex survey design of NHANES by using the MEC examination weight together with the masked variance pseudo-stratum and pseudo-primary sampling unit, with Taylor series linearization for variance estimation, in line with the NCHS analytic guidelines [26]. The analytical sample was analyzed as a subpopulation of the examined population, so that variance estimates reflect the complete design. Since the family members are nested within the primary sampling units, this approach also accounts for the correlation between adults of the same family sharing the same FSF

value. The design provides 16 degrees of freedom, and all Wald tests and confidence intervals were computed on these rather than on the sample size, which is the conservative approach recommended for NHANES. Descriptive statistics are reported as survey-weighted means and standard deviations (SDs) for continuous variables and as unweighted frequencies with weighted percentages for categorical variables. The characteristics of the participants were compared across the four FSF categories using the design-based Wald F test for continuous variables and the Rao–Scott chi-squared test for categorical variables.

Survey-weighted logistic regression models were used to estimate the odds ratios (ORs) and 95% confidence intervals (95% CIs) for obesity and central obesity, and survey-weighted linear regression models were used to estimate the β coefficients and 95% CIs for BMI and WC, across the FSF categories, with more than once a week as the reference. Five sequentially adjusted models were fitted: Model 1 was adjusted for age, sex, and race/ethnicity; Model 2 was further adjusted for education, income-to-poverty ratio, marital status, household size, children in the household, household food security, SNAP, and employment; Model 3 was further adjusted for travel time to the store and main food shopper status; and Model 4 was further adjusted for physical activity, sitting time, smoking, and alcohol consumption. Model 4 was considered the primary model. Model 5 was further adjusted for the potential mediators (home food availability and meals not prepared at home) and was considered exploratory and used only to assess the attenuation of the estimates.

The overall association between FSF and each outcome was tested with a design-based Wald test across the four categories. The linear trend was assessed by entering the FSF score (1–4) as a continuous variable in a separate model with the same covariates, and the resulting estimate was interpreted as the change in the odds, or in the mean value of the outcome, per one-step decrease in FSF. To account for multiple testing, the $p$ values of the overall and trend tests were corrected across the two outcomes of the same type (the two dichotomous and the two continuous outcomes) within each model, using the Benjamini–Hochberg false discovery rate, reported as q, and the more conservative Bonferroni correction [32]. Obesity and central obesity were the primary outcomes, and category-specific estimates were not corrected. As a sensitivity analysis, the stability of the estimates was examined across the five sequentially adjusted models. Additional sensitivity analyses of Model 4 included retaining participants who made only small trips or rarely shopped for food, further adjustment for food-related attitudes (importance of price and ease of preparation when buying food), home cooking and food spending, exclusion of participants trying to lose weight or following a special diet (both self-reported), restriction to adults aged ≥ 20 years, definition of obesity by BMI-for-age at 18–19 years and modeling of age as a natural cubic spline (Table S5). Additional analyses requested analyses during peer review, namely a comparison of included and excluded participants and of the analytical sample with all examined adults, refitting of Model 4 in the largest eligible sample and of Model 1 including the excluded participants, effect modification by main food shopper status, alternative scoring of FSF, adjusted prevalences, and separate estimates for participants making only small trips or rarely shopping for food, are reported in Supplementary Material S2 (Tables S6–S11).

The analysis was carried out on complete cases. All analyses were conducted with R version 4.5.2 (R Foundation for statistical Computing, Vienna Austria) and RStudio version 2026.07.1 (Posit Software, PBC, Boston, MA, USA) using the survey package version 4.5. The level of significance for all tests was set at $p < 0.05$.

## 3. Results

### 3.1. Characteristics of the Study Population

A total of 4747 adults were included in the analysis with a mean age of 46.2 years, and 50.1% being females. Participants who shopped less often were younger (43.2 vs. 50.3 years; $p < 0.001$), had a lower income-to-poverty ratio (2.25 vs. 3.27; $p < 0.001$), were less likely to be married or living with a partner (50.5% vs. 69.0%; $p < 0.001$) and were more likely to be non-Hispanic Black (28.3% vs. 5.1%; $p < 0.001$), to have low or very low food security (26.3% vs. 9.9%; $p < 0.001$), to receive SNAP benefits (30.6% vs. 11.0%; $p < 0.001$), and to be current smokers (30.3% vs. 16.1%; $p = 0.001$) and more likely to be the main food shopper (62.3% vs. 56.6%; $p = 0.014$) (Table 1). Household size, children in the household, travel time to the store, sitting time, and meeting the physical-activity guideline did not differ across groups. Among these, 604 reported an FSF of more than once a week, 2173 once a week, 1298 once every two weeks, and 672 once a month or less.

**Table 1.** The characteristics of the study population by food shopping frequency (FSF), NHANES 2009–2010.

| Characteristic | Total | More Than Once a Week | Once a Week | Once Every Two Weeks | Once a Month or Less | *p* Value |
|---|---|---|---|---|---|---|
| n (unweighted) | 4747 | 604 | 2173 | 1298 | 672 | |
| Age, years, mean (SD) | 46.24 (17.10) | 50.33 (17.22) | 47.20 (16.95) | 43.78 (16.75) | 43.22 (17.15) | <0.001 |
| Aged 18–19 years, % | 3.3% | 3.6% | 2.9% | 3.2% | 4.6% | 0.196 |
| Income-to-poverty ratio, mean (SD) | 3.02 (1.65) | 3.27 (1.72) | 3.23 (1.60) | 2.83 (1.60) | 2.25 (1.60) | <0.001 |
| Household size, mean (SD) | 3.04 (1.52) | 3.02 (1.54) | 3.13 (1.49) | 2.94 (1.48) | 2.95 (1.68) | 0.227 |
| Travel time to store, min, mean (SD) | 13.48 (12.37) | 12.16 (12.85) | 12.45 (9.51) | 15.19 (15.00) | 15.33 (14.93) | 0.282 |
| Sitting, h/day, mean (SD) | 5.81 (3.28) | 5.78 (3.24) | 5.86 (3.27) | 5.67 (3.27) | 5.98 (3.35) | 0.267 |
| Sex, % | | | | | | 0.046 |
| Male | 49.9% | 52.4% | 50.8% | 48.9% | 44.8% | |
| Female | 50.1% | 47.6% | 49.2% | 51.1% | 55.2% | |
| Race/ethnicity, % | | | | | | <0.001 |
| Mexican American | 8.3% | 8.6% | 8.1% | 8.8% | 8.1% | |
| Other Hispanic | 4.5% | 3.6% | 4.3% | 4.5% | 6.5% | |
| Non-Hispanic White | 71.0% | 73.9% | 76.3% | 67.8% | 51.8% | |
| Non-Hispanic Black | 10.5% | 5.1% | 5.8% | 14.2% | 28.3% | |
| Other race/multiracial | 5.7% | 8.7% | 5.6% | 4.7% | 5.3% | |
| Education, % | | | | | | 0.001 |
| Less than high school | 18.0% | 17.2% | 17.0% | 17.6% | 24.1% | |
| High school/GED | 23.6% | 16.9% | 23.3% | 26.1% | 26.2% | |
| More than high school | 58.4% | 65.9% | 59.7% | 56.2% | 49.7% | |
| Marital status, %‡ | | | | | | <0.001 |
| Married/living with partner | 64.9% | 69.0% | 69.2% | 61.0% | 50.5% | |
| Widowed/divorced/separated | 18.1% | 17.0% | 15.8% | 19.7% | 25.7% | |
| Never married | 17.0% | 13.9% | 15.0% | 19.3% | 23.8% | |
| Children ≤17 years in household, % | 39.6% | 36.8% | 40.2% | 40.7% | 38.1% | 0.694 |
| Household food security, % | | | | | | <0.001 |
| Full | 78.3% | 82.4% | 83.5% | 73.9% | 61.2% | |
| Marginal | 8.4% | 7.7% | 7.1% | 9.6% | 12.5% | |
| Low/very low | 13.3% | 9.9% | 9.4% | 16.6% | 26.3% | |
| SNAP, past 12 months, % | 13.6% | 11.0% | 9.6% | 15.1% | 30.6% | <0.001 |
| Employment, % | | | | | | <0.001 |
| Working/has a job | 63.8% | 57.8% | 66.9% | 65.2% | 54.0% | |
| Looking for work | 3.4% | 3.1%† | 2.9% | 4.1% | 4.6% | |
| Not working | 32.7% | 39.1% | 30.1% | 30.8% | 41.5% | |
| Main food shopper, % | 57.4% | 56.6% | 54.8% | 60.4% | 62.3% | 0.014 |
| Meets activity guideline, % | 64.8% | 67.3% | 65.7% | 62.6% | 63.1% | 0.321 |
| Smoking status, %‡ | | | | | | 0.001 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Never | 54.8% | 57.8% | 56.4% | 52.0% | 51.0% | |
| Former | 25.3% | 26.0% | 26.4% | 25.4% | 18.6% | |
| Current | 19.9% | 16.1% | 17.1% | 22.5% | 30.3% | |
| Alcohol, %‡ | | | | | | 0.069 |
| None | 25.0% | 24.6% | 23.7% | 25.4% | 30.5% | |
| >0–7 drinks/week | 59.1% | 55.2% | 61.7% | 59.4% | 51.1% | |
| >7–14 drinks/week | 9.5% | 12.5% | 9.1% | 8.4% | 10.3% | |
| >14 drinks/week | 6.4% | 7.7% | 5.4% | 6.8% | 8.1% | |

Values are unweighted n, survey-weighted means (SD) or survey-weighted percentages. *p* values: design-based Wald F test (continuous variables) and Rao–Scott F test (categorical variables) across FSF groups. ‡ Among participants aged ≥20 years (n = 4503); these questions were not asked of participants aged 18–19 years. † Unweighted cell count < 30; estimate may be unreliable. FSF, food shopping frequency; GED, General Educational Development; SNAP, Supplemental Nutrition Assistance Program.

### *3.2. Obesity*

The prevalence of obesity rose steadily as FSF declined, from 29.1% among participants who shopped more than once a week to 34.8% among those who shopped once a week, 39.1% among those who shopped once every two weeks, and 42.5% among those who shopped once a month or less ($p < 0.001$) (Table 2).

**Table 2.** Unadjusted distribution of adiposity indicators across food shopping frequency (FSF) groups.

| FSF | n | Obesity, n (%) | Central Obesity, n (%) | BMI, Mean (SD) | WC, Mean (SD), cm |
|---|---|---|---|---|---|
| More than once a week (reference) | 604 | 193 (29.1%) | 314 (46.1%) | 27.65 (5.86) | 95.77 (15.12) |
| Once a week | 2173 | 769 (34.8%) | 1195 (53.9%) | 28.51 (6.42) | 98.15 (16.10) |
| Once every two weeks | 1298 | 521 (39.1%) | 729 (55.0%) | 29.12 (6.88) | 98.76 (16.79) |
| Once a month or less | 672 | 304 (42.5%) | 425 (61.4%) | 29.80 (6.93) | 99.99 (16.64) |
| *p* value (crude) | | <0.001 | 0.002 | 0.005 | 0.012 |

n (weighted per cent) with each condition within each FSF group; survey-weighted means (SD). Crude Rao–Scott chi-square or design-based Wald F. Obesity = BMI ≥ 30 kg/m$^2$; central obesity = WC ≥ 102 cm (men)/≥88 cm (women).

In the fully adjusted model (Model 4), which accounted for sociodemographic, household, food-access, and lifestyle factors, the odds of obesity increased by 49% among participants who shopped once every two weeks (OR = 1.49; 95% CI = 1.11–1.99) and by 57% among those who shopped once a month or less (OR = 1.57; 95% CI = 1.06–2.31), compared to those who shopped more than once a week. The association in the once-a-week group was in the same direction but did not reach significance (OR = 1.30; 95% CI = 0.96–1.75) (Table 3). The trend analysis showed that the odds of obesity increased by 16% with each step down in FSF (OR = 1.16; 95% CI = 1.03–1.29; *p* for trend = 0.015), which remained significant after Bonferroni correction ($p = 0.029$), although the overall test across the four groups was of borderline significance ($p = 0.063$).

**Table 3.** Food shopping frequency (FSF) and dichotomous adiposity outcomes: odds ratios (95% CI) from survey-weighted logistic regression.

| FSF | Model 1 | Model 2 | Model 3 | Model 4 (Primary) | Model 5 |
|---|---|---|---|---|---|
| Obesity (BMI ≥30 kg/m²) | | | | | |
| More than once a week (reference) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Once a week | 1.33 (1.02–1.74) * | 1.34 (1.01–1.77) * | 1.35 (1.02–1.77) * | 1.30 (0.96–1.75) | 1.30 (0.99–1.72) |
| Once every two weeks | 1.59 (1.25–2.02) * | 1.55 (1.19–2.02) * | 1.56 (1.20–2.03) * | 1.49 (1.11–1.99) * | 1.47 (1.13–1.92) * |
| Once a month or less | 1.71 (1.22–2.38) * | 1.62 (1.13–2.32) * | 1.63 (1.14–2.33) * | 1.57 (1.06–2.31) * | 1.55 (1.10–2.18) * |
| Per step less frequent (trend) | 1.19 (1.08–1.31) * | 1.17 (1.05–1.30) * | 1.17 (1.05–1.30) * | 1.16 (1.03–1.29) * | 1.15 (1.04–1.27) * |
| Overall test | $p$ = 0.006; q = 0.006 * | $p$ = 0.019; q = 0.019 * | $p$ = 0.019; q = 0.019 * | $p$ = 0.063; q = 0.063 | $p$ = 0.040; q = 0.040 * |
| Trend test | $p$ = 0.002; q = 0.002 * | $p$ = 0.006; q = 0.006 * | $p$ = 0.005; q = 0.005 * | $p$ = 0.015; q = 0.015 * | $p$ = 0.008; q = 0.008 * |
| Bonferroni-corrected trend $p$ | 0.004 | 0.012 | 0.011 | 0.029 | 0.017 |
| Central obesity (WC ≥102 cm men/≥88 cm women) | | | | | |
| More than once a week (reference) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Once a week | 1.53 (1.21–1.94) * | 1.51 (1.21–1.88) * | 1.51 (1.21–1.87) * | 1.48 (1.17–1.87) * | 1.48 (1.17–1.87) * |
| Once every two weeks | 1.73 (1.46–2.05) * | 1.66 (1.40–1.96) * | 1.64 (1.38–1.94) * | 1.58 (1.33–1.87) * | 1.55 (1.31–1.85) * |
| Once a month or less | 2.24 (1.72–2.92) * | 2.07 (1.55–2.76) * | 2.05 (1.55–2.72) * | 2.00 (1.51–2.64) * | 1.95 (1.50–2.53) * |
| Per step less frequent (trend) | 1.26 (1.16–1.38)* | 1.23 (1.12–1.35)* | 1.23 (1.12–1.35)* | 1.21 (1.11–1.33)* | 1.20 (1.10–1.30)* |
| Overall test | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * |
| Trend test | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * |
| Bonferroni-corrected trend $p$ | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |

The values are odds ratios with 95% confidence intervals from survey-weighted regression. Reference = more than once a week; per step = one category less frequent. Model 1: age, sex, race/ethnicity. Model 2: + education, income-to-poverty ratio, marital status, household size, children in household, household food security, SNAP, employment. Model 3: + travel time to store, main food shopper. Model 4 (primary): + physical-activity guideline, sitting time, smoking, alcohol. Model 5: + home availability of fruit, dark-green vegetables, salty snacks, low-fat milk and soft drinks and meals not prepared at home; these lie on the possible causal pathway and are shown for attenuation only. * $p$ < 0.05. q = Benjamini–Hochberg false discovery rate across the two outcomes of the same type within each model; Bonferroni-corrected trend $p$ = trend p multiplied by two. Obesity = BMI ≥ 30 kg/m²; central obesity = WC ≥ 102 cm (men)/≥88 cm (women).

The linear regression showed the same pattern. Mean BMI rose from 27.65 ± 5.86 kg/m² among the most frequent shoppers to 28.51 ± 6.42 kg/m² among those who shopped once a week, 29.12± 6.88 kg/m² among those who shopped every two weeks, and 29.80 ± 6.93 kg/m² among the least frequent shoppers (Table 2). After full adjustment, BMI was higher by 1.21 kg/m² among participants who shopped once every two weeks (β = 1.21; 95% CI = 0.45–1.98) and by 1.54 kg/m² among those who shopped once a month or less (β = 1.54; 95% CI = 0.44–2.64), compared to those who shopped more than once a week, whereas the difference in the once-a-week group was not significant (β = 0.78; 95% CI = −0.03–1.59). BMI increased by 0.50 kg/m² with each step down in FSF (β = 0.50; 95% CI = 0.17–0.82; p for trend = 0.005) (Table 4).

**Table 4.** Food shopping frequency (FSF) and continuous adiposity measures: β coefficients (95% CI) from survey-weighted linear regression.

| FSF | Model 1 | Model 2 | Model 3 | Model 4 (Primary) | Model 5 |
|---|---|---|---|---|---|
| BMI, kg/m² | | | | | |
| More than once a week (reference) | 0 | 0 | 0 | 0 | 0 |
| Once a week | 0.94 (0.17–1.71) * | 0.91 (0.12–1.69) * | 0.91 (0.13–1.68) * | 0.78 (−0.03–1.59) | 0.79 (0.03–1.54) * |
| Once every two weeks | 1.49 (0.75–2.24) * | 1.39 (0.62–2.17) * | 1.38 (0.61–2.15) * | 1.21 (0.45–1.98) * | 1.18 (0.46–1.90) * |
| Once a month or less | 1.92 (0.86–2.99) * | 1.71 (0.62–2.79) * | 1.70 (0.63–2.77) * | 1.54 (0.44–2.64) * | 1.50 (0.50–2.50) * |
| Per step less frequent (trend) | 0.62 (0.29–0.95) * | 0.55 (0.22–0.89) * | 0.55 (0.22–0.88) * | 0.50 (0.17–0.82) * | 0.48 (0.17–0.78) * |
| Overall test | $p$ = 0.006; q = 0.006 * | $p$ = 0.013; q = 0.013 * | $p$ = 0.013; q = 0.013 * | $p$ = 0.027; q = 0.027 * | $p$ = 0.021; q = 0.021 * |
| Trend test | $p$ = 0.001; q = 0.001 * | $p$ = 0.003; q = 0.003 * | $p$ = 0.003; q = 0.003 * | $p$ = 0.005; q = 0.005 * | $p$ = 0.004; q = 0.004 * |
| Bonferroni-corrected trend $p$ | 0.002 | 0.006 | 0.006 | 0.011 | 0.008 |

WC, cm

| | | | | | |
|---|---|---|---|---|---|
| More than once a week (reference) | 0 | 0 | 0 | 0 | 0 |
| Once a week | 3.04 (1.24–4.83) * | 2.95 (1.15–4.74) * | 2.95 (1.15–4.74) * | 2.63 (0.70–4.56) * | 2.65 (0.86–4.44) * |
| Once every two weeks | 4.37 (2.81–5.92) * | 4.05 (2.47–5.63) * | 4.02 (2.44–5.60) * | 3.54 (1.98–5.10) * | 3.42 (1.94–4.90) * |
| Once a month or less | 5.78 (3.35–8.22) * | 5.08 (2.64–7.53) * | 5.06 (2.63–7.50) * | 4.61 (2.14–7.08) * | 4.46 (2.18–6.75) * |
| Per step less frequent (trend) | 1.78 (1.06–2.50) * | 1.56 (0.86–2.27) * | 1.55 (0.85–2.26) * | 1.40 (0.71–2.08) * | 1.33 (0.68–1.97) * |
| Overall test | $p$ <0.001; q <0.001 * | $p$ <0.001; q = 0.001 * | $p$ <0.001; q = 0.001 * | $p$ = 0.002; q = 0.003 * | $p$ = 0.001; q = 0.002 * |
| Trend test | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q <0.001 * | $p$ <0.001; q = 0.001 * | $p$ <0.001; q <0.001 * |
| Bonferroni-corrected trend $p$ | <0.001 | <0.001 | <0.001 | 0.001 | <0.001 |

The values are β coefficients with 95% confidence intervals from survey-weighted regression. Reference = more than once a week; per step = one category less frequent. Model 1: age, sex, race/ethnicity. Model 2: + education, income-to-poverty ratio, marital status, household size, children in household, household food security, SNAP, employment. Model 3: + travel time to store, main food shopper. Model 4 (primary): + physical-activity guideline, sitting time, smoking, alcohol. Model 5: + home availability of fruit, dark-green vegetables, salty snacks, low-fat milk and soft drinks and meals not prepared at home; these lie on the possible causal pathway and are shown for attenuation only. * $p < 0.05$. q = Benjamini–Hochberg false discovery rate across the two outcomes of the same type within each model; Bonferroni-corrected trend p = trend p multiplied by two.

### *3.3. Central Obesity*

The prevalence of central obesity (WC ≥102 cm in males and ≥88 cm in females) followed the same gradient, at 46.1%, 53.9%, 55.0%, and 61.4% from the most to the least frequent shopping group ($p$ = 0.002) (Table 2).

In the fully adjusted model, compared to participants who shopped more than once a week, the odds of central obesity increased by 48% among those who shopped once a week (OR = 1.48; 95% CI = 1.17–1.87) and by 58% among those who shopped once every two weeks (OR = 1.58; 95% CI = 1.33–1.87), and doubled among those who shopped once a month or less (OR = 2.00; 95% CI = 1.51–2.64) (Table 3). The odds increased by 21% with each step down in FSF (OR = 1.21; 95% CI = 1.11–1.33; p for trend < 0.001).

When WC was analyzed as a continuous measure, the mean values rose from 95.77 ± 15.12 cm to 99.99 ± 16.64 cm across the groups (Table 2). After full adjustment, WC was higher than in the reference group by 2.63 cm among those who shopped once a week (β = 2.63; 95% CI = 0.70–4.56), by 3.54 cm among those who shopped once every two weeks (β = 3.54; 95% CI = 1.98–5.10), and by 4.61 cm among those who shopped once a month or less (β = 4.61; 95% CI = 2.14–7.08), amounting to 1.40 cm per step down in FSF (β = 1.40; 95% CI = 0.71–2.08; p for trend < 0.001) (Table 4).

### *3.4. Sensitivity Analysis*

To assess the robustness of the findings, we examined the stability of the estimates across the five sequentially adjusted models and applied two corrections for multiple testing, namely the Benjamini–Hochberg false discovery rate and a Bonferroni correction of the trend test. Across all models and all four outcomes, the direction of the association was consistent, with less frequent shopping associated with greater adiposity. All trend tests remained significant after both corrections (Tables 3 and 4).

For obesity, the odds ratios were modestly attenuated from Model 1 to Model 4, with the excess odds in the least frequent shopping group decreasing from 71% (OR = 1.71; 95% CI = 1.22–2.38) to 57% (OR = 1.57; 95% CI = 1.06–2.31), and the per-step trend from 1.19 (95% CI = 1.08–1.31) to 1.16 (95% CI = 1.03–1.29). The once-every-two-weeks and once-a-month-or-less groups remained significant in all models, whereas the once-a-week group was significant in Models 1–3 (OR = 1.33–1.35) and lost significance after adjustment for lifestyle factors in Model 4 (OR = 1.30; 95% CI = 0.96–1.75). Similarly, the overall test across the four groups was significant in Models 1–3 ($p$ = 0.006–0.019), borderline in Model 4 ($p$ = 0.063), and significant again in Model 5 ($p$ = 0.040), while the trend test remained significant in all models ($p$ = 0.002–0.015). For central obesity, all three shopping categories and

the trend remained significant in every model (p for trend < 0.001), and the odds ratio in the least frequent group ranged from 2.24 in Model 1 to 2.00 in Model 4.

The linear regression estimates followed the same pattern. From Model 1 to Model 4, the per-step difference decreased by approximately one-fifth for both BMI (from 0.62 to 0.50 kg/m²) and WC (from 1.78 to 1.40 cm), with all trend tests remaining significant ($p \leq 0.005$). The only change in significance involved BMI in the once-a-week group, which was significant in Models 1–3, became non-significant in Model 4 (β = 0.78; 95% CI = −0.03–1.59), and was significant again in Model 5 (β = 0.79; 95% CI = 0.03–1.54). This reflects a lower confidence limit close to zero rather than a meaningful change in the size of the effect.

After the Benjamini–Hochberg correction across the two outcomes of the same type within each model, all trend tests remained significant in every model ($q \leq 0.015$). Under the more conservative Bonferroni correction, the trend also remained significant in every model for obesity ($p = 0.004$–$0.029$), central obesity ($p < 0.001$), BMI ($p = 0.002$–$0.011$), and WC ($p \leq 0.001$) (Tables 3 and 4).

Finally, the exploratory adjustment for home food availability and meals not prepared at home (Model 5), which may lie on the causal pathway, produced minimal attenuation across all outcomes. For example, the odds ratio in the least frequent shopping group changed from 1.57 to 1.55 for obesity and from 2.00 to 1.95 for central obesity, while the per-step β changed from 0.50 to 0.48 kg/m² for BMI and from 1.40 to 1.33 cm for WC. The full estimates for all covariates in Models 1–5 are presented in Supplementary Tables S1–S4. The associations were consistent across all sensitivity analyses including retaining participants who reported only small trips or rarely shopping for food, further adjustments for food-related attitudes, home cooking and food spending, restriction to adults≥ 20 years and modeling age as natural cubic spline and defining obesity by BMI-for-age for participants aged 18–19 years (Table S5); however, after excluding participants who were trying to lose weight or following a special diet, only the estimate of obesity was attenuated and no longer significant, whereas the associations with BMI, WC and central obesity remained significant (Table S5). Moreover, participants excluded because of missing covariates had similar distributions of FSF to those included, and the estimates were similar when Model 4 was refitted in the largest eligible sample (n = 4752) and when Model 1 included the excluded participants (Tables S6 and S7). Overall, the sensitivity analyses did not change the main inference. The results of the additional analyses requested during peer review are reported in Supplementary Material S2 (Tables S6–S11).

## 4. Discussion

### *4.1. Findings and Concordance with Previous Studies*

In this study, which aimed to assess the association between FSF and both overall and central obesity in a large national, multiethnic sample of adults from the United States, we found that the prevalence of obesity and central obesity increased progressively from the most to the least frequent shoppers. Moreover, after adjustment for potential confounding variables, a lower FSF remained significantly associated with higher odds of both obesity and central obesity, and each one-step decrease in FSF was associated with an increase of 16% and 21% in the odds of obesity and central obesity, respectively. The same pattern emerged when BMI and WC were analyzed as continuous variables, since the least frequent shoppers displayed a BMI higher by 1.54 kg/m² and a WC larger by 4.61 cm than the most frequent shoppers. The association with central obesity is relevant from a public health perspective, since WC is a marker of central adiposity, which is correlated with visceral fat and is associated with cardiometabolic risk beyond that captured by BMI, and it is a simple and low-cost measure [23,24,33]. A greater visceral adipose tissue mass

has also been independently associated with sarcopenic obesity, a phenotype with a particularly adverse health profile [34].

In general, our findings are in line with the previous literature that linked FSF to diet quality. For instance, among non-Hispanic Black adults from NHANES 2007–2010, FSF was associated with daily diet quality [19], while in low-income African American and Hispanic households with preschool-aged children, a more frequent grocery shopping was associated with a better diet quality both at home and at the individual level [20]. Similarly, more frequent shopping was associated with a higher likelihood of meeting the fruit and vegetable recommendations among Burmese refugees [21]. More specifically, our findings extend those of the Canadian NEWPATH study, in which more frequent shopping at specialty shops and farmers' markets was associated with a lower BMI and WC [22], by showing that the overall FSF, regardless of the type of store, is associated with measured adiposity in a large national sample. Similarly, among customers of farmers' markets and roadside produce stands in the Southern United States, those who shopped two or more times per week displayed a significantly lower BMI than those who shopped less frequently [35]. Moreover, it could be argued that a lower FSF merely reflects a poorer access to food stores, since individuals living in urban food deserts who traveled further to shop were found to shop less often and to have a higher BMI [36]. However, in our study, the travel time to the grocery store did not differ across the FSF categories, and its inclusion in the models only minimally changed the estimates, suggesting that the association between FSF and obesity is not explained by travel time to food stores, although other dimensions of food access, such as transport, food prices and store options were not assessed. The mechanisms underlying the association between FSF and obesity are complex, and due to the cross-sectional nature of our research, we were not in the position to clarify them. However, we speculate that households that shop less frequently may rely to a greater extent on shelf-stable and energy-dense foods that can be stored for long periods, while perishable foods, such as fruits and vegetables, may run out between one shopping trip and the next. Some of these shelf-stable products are ultra-processed, although a longer shelf life does not in itself imply ultra-processing, and a higher consumption of ultra-processed foods has been associated with obesity and abdominal obesity [37,38]. In a randomized controlled trial, an ultra-processed diet caused excess energy intake and weight gain [39]. A comparable cycle has been described among participants in the Supplemental Nutrition Assistance Program (SNAP), who were increasingly more likely to report a day with no eating occurrences as the benefit month progressed [40] and whose spending on fresh produce dropped by 38% at the end of the month [41]. Notably among food stamp households that conducted their major grocery shopping only once a month, food energy intake dropped significantly by the fourth week after benefit receipt, whereas it remained stable in those who shopped more often [42]. In the current study, the exploratory adjustment for the home availability of fruit, dark-green vegetables, salty snacks, low-fat milk, and soft drinks, as well as for the number of meals not prepared at home, changed the association estimates little, in line with a previous study in which the association between the frequency of farmers' market shopping and BMI was not mediated by fruit and vegetable consumption [35]. This suggests that other pathways, such as the amount and composition of the food purchased at each trip, or eating behaviors that were not captured by these measures, may be involved. However, these variables are limited proxies of what people actually eat and were measured at the same time as adiposity, so mediation cannot be ruled out and the mechanism remains open for investigation.

It is important to note here that less frequent shoppers had a lower income and food security, more often received SNAP benefits and were more often non-Hispanic Black (Table 1). Although the association was maintained after adjustment for these factors, FSF may also partly reflect broader household constraints, such as economic resources and

access to transport, which could not be fully captured by the models. Moreover, the weighted characteristics of the analytical sample were similar to those of all the examined adults (Table S6D). Hence, FSF should not be interpreted as a standalone determinant of obesity, but as a household practice that may partly reflect broader socioeconomic and organizational conditions, and the current data cannot separate these two roles.

From a theoretical perspective, ecological models describe eating behavior as shaped by nested individual, social (including home), physical (including food retail) and macro-level environments [43], and the home food environment as a setting in which these influences converge on dietary behavior and the development of obesity [44]. In this context, FSF can be viewed as the household behavior linking the store, where food is acquired, with the home, where it is consumed. The association was largely independent of travel time to store and the home availability of selected foods, suggesting that the rhythm of food acquisition may itself be relevant. This proposition requires confirmation in longitudinal studies with data on food purchases and diet.

### *4.2. Study Strengths and Limitations*

This study has certain strengths. To the best of our knowledge, it is the first to investigate the association between the overall FSF and the most widely used surrogate measures of adiposity in a large national, multiethnic sample of adults. In addition, body weight, height, and WC were measured by trained health technicians following a standardized protocol, and the complex survey design of NHANES was taken into account in all analyses. However, our paper also has several limitations. First, the cross-sectional design can be considered a limitation, since the association found does not provide information regarding any causality between a lower FSF and obesity; in fact, reverse causation cannot be excluded, as individuals with obesity may shop less frequently, for instance because of reduced mobility. Second, FSF was self-reported by one adult respondent on behalf of the whole household, and assigned to all its adult members, so that a household practice was related to individual measures of adiposity, and the question referred only to major food shopping, so that smaller top-up trips were not captured and some misclassification is possible. Third, the analyzed data were collected in 2009–2010, and since then the food retail landscape and consumer purchasing behaviors have undergone profound structural changes. Notably, the COVID-19 pandemic significantly accelerated the adoption of online grocery shopping, home delivery services, and digital meal-planning platforms. Because contemporary food procurement habits differ substantially from those in 2009–2010, the associations observed in this historical cohort may not fully reflect modern behavioral patterns. Consequently, caution should be exercised when generalizing these findings to the current public health and food environment landscape. In particular, whether the observed associations have a similar strength and nature in the current shopping environment is unknown and should be examined using more recent data. Fourth, households that reported making only small shopping trips or rarely shopping for food were excluded, although they were included in the sensitivity analysis, yet this group was small and our findings cannot be extended to them. In addition, FSF categories are not equally spaced and the per-step estimate should be interpreted as an average across categories. Fifth, obesity and central obesity were defined by means of BMI and WC, which are not direct measures of total and visceral fat. Sixth, the public-use NHANES data do not include the geographic location of the participants, and access to food stores was therefore captured only by the self-reported travel time rather than by the actual distance to the nearest store; transport, food prices, store options and delivery services were not assessed and may contribute to residual confounding. Seventh, although a wide range of potential confounders was considered, residual confounding by unmeasured factors

cannot be ruled out. Finally, although the NHANES was designed to be nationally representative, the complete-case sample may not fully represent the U.S. adult population.

### *4.3. Public Health Implications and New Directions for Future Research*

The current findings suggest that FSF, a simple household practice that is easy to assess, is worth studying as part of the home food environment. In the clinical setting, stimulus control, which aims to modify the environmental cues that lead to eating, is one of the core procedures of the cognitive-behavioral treatment of obesity [45], and whether FSF could be a component of interventions addressing the home food environment is a proposition that requires confirmation. However, for some families, additional trips may be burdensome without changing the foods purchased, and before any recommendation can be made, prospective and intervention studies measuring shopping opportunities, purchases, diet and later adiposity are needed. Future research should also clarify the underlying mechanisms by assessing the amount and composition of the food purchased and the diet quality of the participants; consider the barriers that may limit the possibility of doing major food shopping more frequently, such as travel time and access to transportation; and assess whether the association persists in more recent populations, in which online grocery shopping has become more common.

## 5. Conclusions

In this NHANES 2009–2010 sample, less frequent major household food shopping was associated with higher BMI and waist circumference and with higher odds of both overall and central obesity. These associations persisted after correction for potential confounders. Whether changing shopping frequency changes adiposity remains an open question that should be addressed in future longitudinal and intervention studies.

**Supplementary Materials:** The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/ijerph23111389/s1, Table S1: Full survey-weighted logistic regression models for obesity (BMI ≥30 kg/m$^2$): odds ratios (95% CI) for all covariates, Models 1–5; Table S2: Full survey-weighted logistic regression models for central obesity (waist circumference ≥102 cm in males and ≥88 cm in females): odds ratios (95% CI) for all covariates, Models 1–5; Table S3: Full survey-weighted linear regression models for BMI (kg/m$^2$): β coefficients (95% CI) for all covariates, Models 1–5; Table S4: Full survey-weighted linear regression models for waist circumference (cm): β coefficients (95% CI) for all covariates, Models 1–5; Table S5: Sensitivity analyses: per-step association between food shopping frequency and adiposity indicators; Table S6: STROBE Statement—Checklist of items that should be included in reports of cross-sectional studies. Supplementary Material S2 (additional analyses requested during peer review): Table S7: Comparison of participants included in and excluded from the analysis because of missing covariate data, distribution of missing data, and comparison of the analytic sample with all examined adults, NHANES 2009–2010; Table S8: Missing data sensitivity analyses: association between food shopping frequency and adiposity indicators under alternative approaches to the participants excluded for missing covariate data; Table S9: Association between food shopping frequency and adiposity indicators by main food shopper status; Table S10: Association between food shopping frequency and adiposity indicators under alternative scoring of the exposure; Table S11: Adjusted prevalence of obesity and central obesity, and prevalence differences, by food shopping frequency; Table S12: Association of the small-trip and rarely shopping groups with adiposity indicators, entered as separate categories.

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**Informed Consent Statement:** Written informed consent was obtained from all NHANES participants by the National Center for Health Statistics; no additional consent was required for this secondary analysis.

**Data Availability Statement:** The original data presented in the study are openly available on the following website: https://wwwn.cdc.gov/nchs/nhanes/Default.aspx (accessed on 10 June 2026).

**Conflicts of Interest:** The authors declare no conflicts of interest.

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