

Timing of Energy Intake and Ultra-Processed Food Consumption Are Associated With Obesity in Adults in the United Kingdom: A Pooled Cross-Sectional Analysis of the National Diet and Nutrition Survey (2008-2019)



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ABSTRACT

Background The distribution of energy intake and types of food consumed throughout the day may influence health.

Objective This study investigated the association of energy intake and ultra-processed food (UPF) consumption in the morning, at midday, and in the evening with indicators of obesity.

Design A pooled cross-sectional analysis of the National Diet and Nutrition Survey (2008-2019) of adults residing in England, Wales, Scotland, and Northern Ireland was conducted. Food consumption was assessed using 4-day food diaries. UPFs intake was assessed based on the Nova food classification. The 3 time periods were classified as morning (5:00 AM to 10:59 AM), midday (11:00 AM to 4:59 PM), and evening (5:00 PM to 4:59 am).

Participants/Setting This study included 5749 adults aged 19 to 64 years residing in private households in the United Kingdom.

Main Outcome Measures The main outcome measures were overweight, obesity, and abdominal obesity. Body mass index (calculated as kg / m^2) values ≥ 25 and ≥ 30 were used to classify overweight (including obesity) and obesity, respectively. Abdominal obesity was defined as a waist circumference ≥ 102 cm for men and ≥ 88 cm for women.

Statistical Analyses Performed Multivariable logistic regression assessed the associations between the percentage of energy intake and the percentage of energy intake from UPFs in the morning, at midday, and in the evening, and indicators of obesity. Models were adjusted for sociodemographic variables (ie, sex, age, ethnicity, region, year of the survey, and social class occupation), behavioral variables (ie, physical activity, smoking status, frequency of alcohol consumption, sleep duration, and weight-loss diet), and variables related to food consumption.

Results The highest percentage of energy intake in the morning (third tertile) was associated with a 19% reduction in the odds of being overweight (95% CI, 0.68 to 0.96), and the highest percentage in the evening was associated with a 21% higher odds of being overweight (95% CI, 1.01 to 1.44). A 10% increase in the percentage of energy intake from UPFs at midday and in the evening was associated with an 11% (95% CI, 1.02 to 1.20) and 10% (95% CI, 1.02 to 1.18) higher odds of overweight, respectively. The highest percentage of energy intake from UPFs in the morning, at midday, and in the evening (third tertile) was associated with a 26%, 25%, and 45% higher odds of obesity, respectively. A 10% increase in the percentage of energy intake from UPFs in the evening was associated with a 12% (95% CI, 1.03 to 1.22) higher odds of abdominal obesity.

Conclusions The timing of energy intake was associated with overweight, and lower consumption of UPFs at all times of day was associated with obesity. The strength of the association between UPFs consumption and indicators of obesity was greater in the evening compared with the morning and midday.

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OBESITY AFFECTS ALL COUNTRIES, AND THE NUMBER of people with overweight or obesity is expected to continue rising over the current decade.¹ According to the 2023 World Atlas of Obesity, projections estimate that by 2035, approximately 24% of the population 5 years and older will be living with overweight or obesity.¹

In high-income countries, one of the primary factors contributing to the obesity epidemic is believed to be the increased availability and affordability of ultra-processed foods (UPFs).² Findings from the National Diet and Nutrition Survey (NDNS) in the United Kingdom revealed that 56.8% of dietary calories came from UPFs, and higher consumption of these foods was associated with higher body mass index (BMI), increased waist circumference (WC), and a greater likelihood of obesity in adults and older adults.^{3,4} Previous researchers have also reported that higher consumption of UPFs was associated with obesity indicators.⁵⁻⁸ This indicates a strong association (odds ratio [OR] 1.55; 95% CI, 1.36 to 1.77) between higher consumption of UPFs and an increased risk of adverse health outcomes, particularly obesity.⁸ These findings emphasized the need to develop and evaluate public health strategies aimed at reducing dietary exposures to UPFs, which may contribute to improved population health outcomes.

Emerging research underscores the potential impact of the timing of food consumption on obesity risk alongside other characteristics of foods.⁹ Recent studies suggested that the timing and distribution of energy intake throughout the day may play a role in influencing weight control.^{10,11} The timing of food consumption may influence physiological functions, as it is associated with circadian rhythms, which regulate various metabolic processes, including energy metabolism, appetite, digestion, and absorption.^{12,13}

The impact of the timing of food consumption on obesity remains poorly understood, and emerging epidemiologic evidence suggests that irregular and concentrated eating patterns, particularly at the end of the day, may adversely affect weight control.¹⁴ Studies among adults have suggested that a higher percentage of energy intake at night was associated with an increased likelihood of being overweight or obese.^{10,15} However, further studies are needed to examine this hypothesis. A systematic review with meta-analysis found no significant association between BMI and evening energy intake, although the authors noted significant heterogeneity among studies and a high risk of bias as limitations.¹⁶ Understanding these associations may help generate hypotheses for future studies and provide insights that could eventually support the refinement of dietary guidance.¹⁷

To the best of our knowledge, some previous studies have provided information on the distribution of UPFs consumption throughout the day and its association with adiposity indicators. Therefore, the aim of this study was to assess the association of energy intake and UPFs consumption at different times of the day with indicators of obesity in the adult population in the United Kingdom (2008-2019). The study hypothesis was that higher energy intake and UPFs consumption in the evening, compared with lower intake during this time of day, are associated with higher odds of being overweight, obese, and having abdominal obesity.

RESEARCH SNAPSHOT

Research Question: What is the association between energy intake and ultra-processed food consumption at different times of the day (morning, midday, and evening) and indicators of obesity (overweight, obesity, and abdominal obesity)?

Key Findings: In a pooled cross-sectional analysis (2008-2019) of 5749 adults in the United Kingdom, higher energy intake in the morning (5:00 AM to 10:59 AM) was significantly associated with lower odds of being overweight, and higher energy consumption in the evening (5:00 PM to 4:59 AM), was significantly associated with higher odds of overweight. The highest percentage of energy intake from ultra-processed food in the morning, midday, and evening was significantly associated with 26%, 25%, and 45% higher odds of obesity, respectively.

METHODS

This was a cross-sectional analysis using data from the NDNS spanning the years 2008 to 2019. The NDNS is a continuous program of cross-sectional surveys designed to evaluate the diet, nutrient intake, and overall nutritional status of individuals aged 1.5 years and older residing in private households across England, Wales, Scotland, and Northern Ireland.¹⁸⁻²¹

Data across the years 2008 to 2019 were aggregated in this study to maximize the sample size. Households were randomly selected from a comprehensive list of all residential addresses in the United Kingdom, based on UK postcode data. To improve cost-effectiveness, addresses were first grouped into primary sampling units—small geographical areas based on postcode sectors—randomly drawn from across the United Kingdom. Within each primary sampling unit, a list of addresses was randomly selected. At each selected address, interviewers enumerated the households, and if more than 1 was present, randomly chose 1 to participate. From the chosen household, the interviewer randomly selected up to 1 adult (aged 19 years or older) and 1 child (aged 1.5-18 years) to participate in the survey. Details of the sample and sampling are described in previous publications.¹⁸⁻²¹

For this study, we included all participants aged 19-64 years ($n = 5767$) who had complete data on weight and height and at least 3 food records. It has been suggested that aging is accompanied by attenuated circadian rhythms and altered sleep patterns. For this reason, we excluded older adults from the sample (65 years and older).²² Individuals with implausible energy intakes (<1 st or >99 th percentiles across diary days²³; $n = 13$) and pregnant or breastfeeding women ($n = 5$) were also excluded. The final analytical sample included 5749 adults with valid weight and height data, which were used to define overweight and obesity status. Of these, $>98\%$ completed all 4 food diary days. A subsample of 4244 adults with valid WC measurements was used to assess abdominal obesity.

Data files for the present study were obtained under license from the UK Data Archive. Ethical approval for the study was obtained from the Oxfordshire A Research Ethics Committee and from the Cambridge South National Research

Ethics Service Committee thereafter. All adults aged 16 years and older completed and signed the adult consent form.

The NDNS aimed to maintain consistency in data collection and analysis methods over time. The processing and analytical procedures remained largely unchanged; however, when modifications were necessary, calibration studies were conducted to ensure the results remained comparable over the years.²⁰

Dietary Assessment

To collect food consumption data, participants were instructed to complete 4 consecutive food diaries within each 24-hour period. The study provided adults with a diary in paper format.

The survey was designed so that all days of the week were evenly represented. The food diary could start on any day of the week and run for 4 consecutive days. The participants were asked to record all food and drink consumed both inside and outside the home, including the timing of food intake. Portion sizes were estimated using a food photography atlas illustrating a range of portion sizes for commonly consumed foods. To validate the estimates of energy intake from food diaries, the NDNS Rolling Programme included a sub-study with participants aged 4 years and older using doubly labeled water.²⁴

The completed diaries were reviewed by interviewers with the respondents, and any entries lacking details regarding the quantity or food preparation method were clarified or completed during the interview. Although the completed diaries were reviewed with respondents, some details could not be retrieved because participants were unable to recall exact portion sizes, brand names, or preparation methods. Consequently, during dietary data processing, missing information was handled using standardized procedures, such as assigning default codes or estimating portion sizes based on other diary days, age-appropriate averages, or similar foods. Where reliable information was not available for some nutrients, values for such foods were obtained by extrapolating from data for similar foods. For homemade dishes and manufactured products, nutrients were calculated from their constituents using the Diet In, Nutrients Out (DINO) system, version 2005,²⁵ which allows adjustments to be made for weight and vitamin losses during cooking.²⁶⁻²⁹

Dietary data were processed using the DINO system,²⁵ with nutrient intakes estimated based on the NDNS Nutrient Databank, updated for each survey year.^{30,31} The DINO system's time-related database updates analytic data while maintaining nutrient profiles consistent with the version used for data collection. Details on the annual updates to the Nutrient Databank and on missing data handling are published for each NDNS survey.²⁶⁻²⁹ For example, in year 10 (2017-2018), the reviews of manufacturers' and label data focused on soft drinks, breakfast cereals, biscuits, buns, cakes, pastries, fruit pies, and dairy desserts. In addition, sodium values were updated for products such as bread, soups, baked beans, and crisps.²⁹ Food composition values are checked for accuracy and quality, including the validity of the analytical method used, before being incorporated into the DINO system. Further details of the system were published by Fitt and colleagues.²⁵ The DINO system contains 54 nutrient values and energy for a wide range of almost 6000

foods²⁵ and enables the detailed input of individual foods and complex recipes. For manufactured products not present in DINO, nutrient information was obtained from supermarkets, manufacturer websites, or direct contact with producers before creating new food codes and portion weights.²⁹

All recorded food items were categorized by trained researchers according to the Nova food classification system,^{32,33} which categorizes foods based on the nature, extent, and purpose of their industrial processing. This classification system³² comprises 4 groups: (1) unprocessed or minimally processed foods; (2) processed culinary ingredients; (3) processed foods; and (4) UPFs—the primary focus of this study. UPFs are products resulting from the processing of various foods, made predominantly from food-derived substances and cosmetic additives, with minimal or no whole foods.³³ The processing methods used for these foods typically involve salting, the addition of sugar, and industrial techniques such as extrusion, molding, and pre-frying. In addition, additives are incorporated to enhance the palatability or hyperpalatability of the final product.³³ These foods are often packaged in synthetic materials and designed to be durable, affordable, convenient, and visually appealing.³³ Examples of UPFs include soft drinks, packaged snacks, biscuits, instant noodles, sausages, fast food, and ready-made or preprepared frozen meals.³³ Further details regarding food categorization methods can be found in Rauber and colleagues.^{4,34} The categorization was followed by a review of these classifications by other experts within the research group. These classifications were then extensively discussed in periodic meetings with the team, as well as with a group of British researcher-partners—who are co-authors of this study—with expertise in local foods.

The dietary data were divided into time periods: morning (5:00 AM to 10:59 AM), midday (11:00 AM to 4:59 PM), and evening (5:00 PM to 4:59 AM). Then, the mean percentage of energy intake and the percentage of energy intake from UPFs (as a percentage of total daily energy intake) from the 4 food diaries for each time period and for each individual were calculated. These time slots were chosen based on circadian patterns of food intake, appetite, digestion, and metabolism, which are influenced by the light-dark cycle.^{12,35} The evening was defined as starting at 5:00 PM, aligning with the end of the workday for most adults in the United Kingdom, where the main meal (dinner or supper) is typically consumed in the early evening.³⁶ This timeframe also considers individuals who may have late-night snacks and meals. Previous researchers have also defined the start of evening eating habits as 05:00 PM.^{15,37,38}

Outcomes Assessments

Weight and height were measured on 1 occasion by trained researchers using a portable stadiometer and scales. For weight and height measurements, participants stood facing forward, with their feet together, arms at their sides, and heads positioned according to the Frankfort plane.³⁹ WC was measured at the midpoint between the iliac crest and the last rib.⁴⁰ The BMI was calculated by dividing weight by height squared (kg / m^2), and values ≥ 25 and ≥ 30 were classified as overweight and obesity, respectively, according to World Health Organization criteria.⁴¹ Abdominal obesity

was defined as a WC \geq 102 cm for males and \geq 88 cm for females.⁴²

Covariates

Participants completed interviews that involved recording sociodemographic variables and characteristics related to health behaviors.

Sociodemographic characteristics included in analyses were: sex (male and female), age (19-34 years, 35-49 years, 50-64 years), ethnicity (White, Black, Asian, mixed [including White and Black Caribbean, White and Black African, White and Asian], and other ethnic groups, which referred to ethnicities not included in the listed categories), region (England North, England Central/Midlands, England South [including London], Scotland, Wales, Northern Ireland), year of the survey (2008-2019) and social class occupation. The social class occupation was reported according to the National Statistics Socio-Economic Classification⁴³ (routine and manual occupations, intermediate occupations, lower managerial and professional occupations, higher managerial and professional occupations). The health behaviors were: physical activity assessed by the Recent Physical Activity Questionnaire⁴⁴ (hours per day of moderate or vigorous physical activity⁴⁵ classified by quartile, where the first quartile representing the least physically active individuals and the fourth quartile representing the most physically active), smoking status (nonsmoker, smoker), frequency of alcohol consumption (\geq 3 times/wk, 1-2 times/wk, $<$ 1 time/wk, never), sleep duration (hours per day, classified as $<$ 7 h/d, 7-8 h/d, $>$ 8 h/d), weight-loss diet (yes, no), and total energy intake (kilocalories per day) derived from the food diaries.

The selection of covariates was based on a previous study conducted using the same sample (2008-2016), which aimed to evaluate the association between overall daily UPFs consumption and obesity. Alcohol consumption was included as a covariate due to its association with late chronotype and related unhealthy behaviors reported in previous studies.⁴⁶

Multiple imputation by chained equations⁴⁷ was performed with 10 imputed copies of data for social class occupation (2.7% missing), ethnicity (0.1%), physical activity (10.7%), frequency of alcohol consumption (8.6%), sleep duration (3.9%), smoking status (0.3%), and weight-loss diet (16.6%). Sensitivity analysis was conducted comparing findings from imputed data and complete case analysis.

Exposure variables included the percentage of energy intake and the percentage of energy intake from UPFs (as a percentage of total energy intake) at each time period of the day. The outcomes assessed were overweight, obesity, and abdominal obesity (yes, no). A separate model was run for each time period of the day.

Statistical Analysis

Descriptive Analyses. Categorical variables were summarized as relative frequencies with SEs, and quantitative variables as means with SE. Differences in the prevalence of overweight, obesity, and abdominal obesity according to sociodemographic and behavioral variables were assessed using the χ^2 test.

Differences in the mean percentage of energy intake and energy from UPFs during morning, midday, and evening according to sociodemographic and behavioral variables were examined using univariate linear regression. Although prevalence, mean values, and SEs are presented for descriptive purposes, *P* values were derived from regression models accounting for the complex survey design.

Primary Analyses. Percentages of total energy intake and energy from UPFs within each time slot were categorized into tertiles (low, medium, high). Multivariable logistic regression estimated the odds of overweight, obesity, or abdominal obesity in the highest vs lowest tertile. Linear trend was tested by modeling tertiles as ordinal variables. In additional analyses, exposures were modeled as continuous variables, representing a 10% increase in the percentage of energy or UPFs intake per time period.

Collinearity among the independent variables was assessed using tolerance and variance inflation factor values. All tolerance values were $>$ 0.2, and all variance inflation factors were $<$ 2.5, indicating no evidence of multicollinearity.⁴⁸

Multivariable Modeling Strategy

Models for Percentage of Total Energy Intake. A forward selection strategy was used to build the multivariable models in conceptual blocks:

- Model 1: sociodemographic variables (sex, age, ethnicity, region, year, social class occupation)
- Model 2: model 1 plus behavioral variables (physical activity, smoking, alcohol frequency, sleep duration, weight-loss diet)
- Model 3 (final): model 2 plus total daily energy intake

Model 3 was considered the final model of interest because it best represents these associations (including all the adjustment variables) and also to verify this relationship independent of the total energy intake consumed, as carried out by other studies.^{10,49,50}

Sensitivity analyses were also conducted:

- Model 4: model 2 plus the percentage of total energy from UPFs throughout the entire day
- Model 5: model 3 plus the percentage of total energy from UPFs throughout the entire day
- Model 6: model 3 plus percentage energy from sugar, percentage energy from saturated fat, and daily fruit/vegetable intake (in grams).

Models for Percentage of Energy From UPFs. For the analyses with percentage of energy from UPFs as exposure, models followed a similar sequence:

- Model 1 and 2: as above
- Model 3 (final): Model 2 plus percentage of UPFs energy from other time periods (eg, for morning, UPFs percentage from midday plus evening)

Model 3 was defined as the final model of interest because it best represents these associations and allows for verification of the relationship independent of the percentage of

Table 1. Prevalence of overweight, obesity, and abdominal obesity according to sociodemographic and behavioral variables of the UK population (aged 19 to 64 years), NDNS^a 2008-2019 (n = 5749)

Characteristic	Total sample, unweighted n	All, %	Prevalence of		
			overweight	obesity	abdominal obesity
			←—————weighted % ^b (SE)—————→		
Total	—	100	61.3 (0.8)	24.7 (0.7)	35.9 (0.9)
Sex					
Male	2371	49.9	66.8 (1.1)***	23.8 (1.0)	31.1 (1.3)***
Female	3378	50.1	55.7 (1.1)	25.7 (0.9)	40.7 (1.2)
Age group					
19-34 y	1684	34.8	46.6 (1.5)***	16.9 (1.1)***	21.2 (1.4)***
35-49 y	2176	34.6	65.9 (1.3)	24.8 (1.1)	34.1 (1.4)
50-64 y	1889	30.5	72.8 (1.3)	33.6 (1.4)	52.2 (1.5)
Ethnicity					
White	5228	86.8	61.4 (0.9)	25.0 (0.7)	36.4 (1.0)
Black	137	3.3	62.5 (4.9)	32.3 (4.5)	34.7 (5.7)
Asian	235	6.6	63.1 (3.4)	20.9 (3.1)	33.5 (3.8)
Mixed ^c	56	1.3	50.0 (8.1)	21.9 (5.5)	22.6 (5.8)
Any other group ^d	86	2.0	53.9 (6.2)	15.8 (4.2)	29.1 (6.7)
Missing	7	0.1	96.5 (4.2)	11.7 (11.1)	0
Region					
England North	1000	22.8	65.0 (1.6)***	27.0 (1.5)***	39.8 (1.8)***
England Central/Midlands	738	16.3	66.8 (2.0)	28.9 (2.0)	37.3 (2.5)
England South (including London)	1742	45.1	56.9 (1.3)	20.8 (1.1)	31.0 (1.3)
Scotland	826	8.5	60.6 (2.5)	28.7 (2.2)	43.3 (2.9)
Wales	657	4.6	65.3 (2.5)	29.7 (2.2)	43.1 (2.5)
Northern Ireland	786	2.8	63.2 (1.9)	25.8 (1.8)	42.7 (2.8)
Social class occupation^e					
Higher managerial and professional occupations	962	18.9	55.6 (1.9)**	18.4 (1.5)***	29.9 (1.8)***
Routine and manual occupations	1983	32.1	63.1 (1.5)	28.5 (1.3)	40.4 (1.7)
Intermediate occupations	1159	19.6	63.1 (1.7)	25.7 (1.6)	37.9 (1.9)
Lower managerial and professional occupations	1476	26.8	62.8 (1.6)	23.8 (1.4)	33.7 (1.7)
Missing	169	2.7	50.4 (4.8)	25.6 (4.4)	34.9 (5.9)
Physical activity^f					
First quartile	1423	22.4	66.6 (1.7)**	32.5 (1.5)	47.1 (2.0)***
Second quartile	1338	22.3	57.9 (1.7)	23.8 (1.5)	35.3 (1.7)
Third quartile	1183	22.3	57.9 (1.8)	20.1 (1.5)	31.7 (1.7)
Fourth quartile	1138	22.3	62.9 (1.7)	21.9 (1.4)	30.2 (1.8)
Missing	667	10.7	60.6 (2.7)	25.9 (2.3)	36.5 (3.0)
Smoking status					
Nonsmoker ^g	4304	77.5	62.7 (0.9)**	25.2 (0.8)	36.2 (1.0)
Smoker	1434	22.2	56.6 (1.7)	23.1 (1.4)	34.9 (1.8)
Missing	11	0.3	38.6 (1.6)	14.9 (13.5)	13.7 (12.5)

(continued on next page)

Table 1. Prevalence of overweight, obesity, and abdominal obesity according to sociodemographic and behavioral variables of the UK population (aged 19 to 64 years), NDNS^a 2008-2019 (n = 5749) (continued)

Characteristic	Total sample, unweighted n	All, %	Prevalence of overweight	Prevalence of obesity	Prevalence of abdominal obesity
Frequency of alcohol consumption					
≥3 times/wk	1217	22.3	61.9 (1.7)	20.3 (1.4)***	33.6 (1.8)***
1-2 times/wk	1706	29.3	59.2 (1.6)	22.8 (1.3)	31.8 (1.6)
<1 time/wk	1781	28.6	62.9 (1.5)	30.1 (1.4)	40.6 (1.7)
Never	637	11.2	64.0 (2.4)	28.5 (2.4)	44.4 (2.9)
Missing	408	8.6	57.2 (2.5)	20.0 (2.1)	30.6 (2.9)
Sleep duration					
<7 h/d	1871	31.8	68.3 (1.3)***	30.8 (1.3)***	42.6 (1.6)***
7-8 h/d	2689	47.4	59.8 (1.2)	21.8 (0.9)	32.6 (1.2)
>8 h/d	980	16.9	52.5 (2.1)	21.9 (1.6)	33.4 (2.1)
Missing	209	3.9	59.8 (4.2)	24.1 (3.7)	30.1 (5.0)
Weight-loss diet					
No	3735	67.4	56.0 (1.0)***	20.2 (0.8)***	31.2 (1.1)***
Yes	937	16.0	85.4 (1.4)	44.3 (2.0)	56.7 (2.3)
Missing	1077	16.6	59.5 (1.8)	24.2 (1.8)	35.2 (2.1)

^aNDNS = National Diet and Nutrition Survey.

^bAll percentages are weighted using NDNS survey weights to account for sampling design.

^cWhite and Black Caribbean, White and Black African, White and Asian.

^dEthnicities not included in the listed categories.

^eRoutine and manual occupations: jobs that involve repetitive tasks and are often regulated by a basic labor contract; intermediate occupations: are considered to be more difficult conceptually than routine manual and nonmanual jobs, but less difficult than managerial or professional jobs (clerical, sales, services); lower managerial and professional occupations: positions that have an attenuated form of service relationship. Employees in these groups generally plan and supervise operations on behalf of the employer under the direction of senior managers; higher managerial and professional occupations: positions that involve general planning and supervision of operations, and that require specialized educational training.⁴³

^fFirst quartile represents the least physically active individuals, and the fourth quartile represents the most physically active.

^gFormer cigarette smoker and never regular cigarette smoker.

** χ^2 test, $P < .010$.

*** χ^2 test. $P < .001$.

energy intake from UPFs consumed during other periods of the day.

Sensitivity analyses also conducted:

- Model 4: model 2 plus total daily energy intake
- Model 5: model 3 plus total daily energy intake
- Model 6: model 3 plus percentage energy from sugar, percentage energy from saturated fat, and daily fruit and vegetable intake

Temporal Interactions. Interaction terms between exposures (both energy and UPF) and survey year tested potential temporal variation.

Additional Analyses. To investigate whether the timing of energy intake is a critical factor associated with obesity indicators, we performed additional multivariable logistic regression analyses. We calculated the ratio of energy consumed in the evening to that consumed in the morning and midday, categorized as <1.0 (reference), 1.00 to 1.49, 1.50 to 1.99, and ≥2.0. The regression was adjusted for socio-demographic variables, behavioral variables, and daily energy intake. The same approach was applied using UPFs' energy ratios.

All statistical analyses were performed using *Stata* software, version 16.1.⁵¹ Survey weights provided by NDNS were applied in all analyses to account for differential probabilities, ensuring nationally representative estimates. P value < .05 was considered statistically significant.

Because standard goodness-of-fit tests (eg, Hosmer–Lemeshow) are limited for multiply imputed complex survey data, model adequacy was assessed based on the stability of ORs across imputations. The consistency of these estimates supports the robustness of the models.

RESULTS

Approximately one-half of the sample were women (50.1%), aged 19 to 34 years (34.8%), White (86.8%), from the South of England (45.1%), and working in routine and manual occupations (32.1%). Regarding behavioral habits, physical activity levels were fairly evenly distributed across quartiles, with a slightly higher proportion in the first quartile (22.4%); most participants were nonsmokers (77.5%), consumed alcohol once or twice per week (29.3%), slept 7 to 8 hours/d (47.4%), and did not follow a weight-loss diet (67.4%) (Table 1).

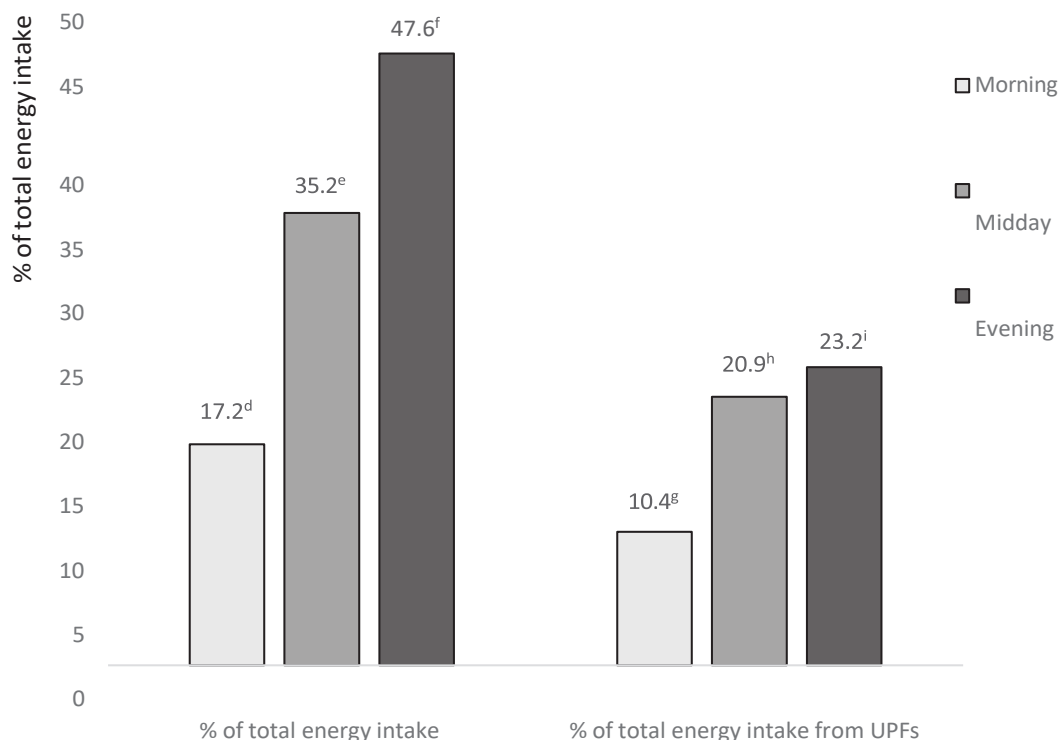


Figure. Mean proportions of energy intake and ultra-processed intake (% of total daily energy intake) consumed in three periods of the day^a (morning, midday and evening) in the UK^b population aged 19 to 64 years (NDNS^c, 2008–2019) (n = 5 749).

^aMorning (5:00 am to 10:59 am), Midday (11:00 am to 4:59 pm), Evening (5:00 pm to 4:59 am) ^bUnited Kingdom; ^cNational Diet and Nutrition Survey ^dMorning 95% CI (16.9; 17.4%) ^eMidday 95% CI (34.8; 35.6%) ^fEvening 95% CI (47.2; 48.1) ^gMorning 95% CI (10.2; 10.6%) ^hMidday 95% CI (20.6; 21.2%) ⁱEvening 95% CI (22.7; 23.6%)

UK adults had mean (SD) daily energy intake of 1856 (9.5) negligible linear trend was observed (OR 1.21; 95% CI, 1.01 to 1.44). The results for overweight remained similar in the sensitivity analysis (models 4, 5, and 6) (Table 4, available at www.jandonline.org).

The prevalence of overweight was higher in men, older individuals, individuals of lower social class, those who had lower levels of physical activity, nonsmokers, and adults following a weight-loss diet. Obesity was more prevalent among those who were older and followed a weight-loss diet. The prevalence of abdominal obesity was higher in women, older adults, those with lower levels of physical activity, and adults following a weight-loss diet (Table 1).

The percentage of energy intake and energy intake from UPFs were highest in the evening, followed by midday and morning (Figure). This information, according to characteristics of the sample, is presented in Table 2 (available at www.jandonline.org).

For overweight (Table 3), the highest percentage of energy intake in the morning was associated with lower odds of overweight and showed a significant linear trend (OR 0.81; 95% CI, 0.68 to 0.96). A 10% increase in the percentage of energy intake in the morning was associated with a reduction of 11% in the odds of overweight (OR 0.89; 95% CI, 0.82 to 0.96). For midday, there was no evidence of a significant association between energy intake and overweight. In evening consumption, the highest percentage of energy intake was associated with greater odds of overweight, and a

Regarding UPFs and overweight (Table 3), a 10% increase in the percentage of energy intake from UPFs at midday was associated with 11% higher odds of overweight (OR 1.11; 95% CI, 1.02 to 1.20). The highest percentage of energy from UPFs in the evening was associated with a higher odds of overweight, and a significant linear trend was also observed (OR 1.31; 95% CI, 1.08 to 1.60). The relationship remained significant when the variable was analyzed as continuous (OR 1.10; 95% CI, 1.02 to 1.18) (Table 3). The results for overweight persisted in the sensitivity analysis (models 4, 5, and 6) (Table 4).

For obesity (Table 5), no evidence of significant association was found for the percentage of energy intake during the 3 periods of the day. In the sensitivity analysis (models 4, 5, and 6), the results were consistent with model 3 (Table 6, available at www.jandonline.org). Considering the UPFs (Table 5), a significant linear trend was observed for the association between tertile of energy consumption from UPFs in the morning and midday and obesity in model 3 (OR 1.26; 95% CI, 1.04 to 1.53; OR 1.25; 95% CI, 1.04 to 1.51, respectively). For these models, a similar result was observed when the variable was treated as continuous. Considering the evening period, the highest percentage of energy intake from UPFs was associated with higher odds of having obesity

Table 3. OR^a (95% CI) of the association between tertiles and a 10% increase in energy intake and energy intake from ultra-processed foods across daytime periods,^b and overweight status^c in UK adults (aged 19-64 years), NDNS^d 2008-2019 (n = 5749)

Variable	Energy Consumption (% of Total Energy) in Each Period of the Day				P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^e			OR (95% CI)		
	First	Second	Third			
Period of the day						
Morning						
Unadjusted model	1	0.94 (0.80 to 1.11)	1.00 (0.86 to 1.17)		.948	0.99 (0.92 to 1.06)
Model 1 ^{g,h}	1	0.87 (0.74 to 1.04)	0.89 (0.76 to 1.04)		.154	0.93 (0.86 to 1.00)
Model 2 ^{g,i}	1	0.85 (0.71 to 1.01)	0.81 (0.68 to 0.96)		.014	0.89 (0.82 to 0.96)
Model 3 ^{g,j}	1	0.87 (0.72 to 1.04)	0.81 (0.68 to 0.96)		.015	0.89 (0.82 to 0.96)
Midday						
Unadjusted model	1	0.70 (0.60 to 0.83)	0.76 (0.65 to 0.90)		.001	0.94 (0.89 to 0.99)
Model 1 ^{g,h}	1	0.83 (0.70 to 0.98)	0.92 (0.78 to 1.09)		.372	0.99 (0.94 to 1.06)
Model 2 ^{g,i}	1	0.85 (0.71 to 1.01)	0.95 (0.80 to 1.13)		.614	1.00 (0.94 to 1.07)
Model 3 ^{g,j}	1	0.87 (0.73 to 1.03)	0.96 (0.81 to 1.15)		.693	1.00 (0.94 to 1.07)
Evening						
Unadjusted model	1	1.13 (0.96 to 1.33)	1.22 (1.04 to 1.43)		.014	1.06 (1.00 to 1.12)
Model 1 ^{g,h}	1	1.13 (0.95 to 1.36)	1.15 (0.97 to 1.36)		.099	1.04 (0.98 to 1.10)
Model 2 ^{g,i}	1	1.20 (0.99 to 1.44)	1.21 (1.01 to 1.45)		.034	1.06 (0.99 to 1.13)
Model 3 ^{g,j}	1	1.21 (1.01 to 1.46)	1.21 (1.01 to 1.44)		.037	1.06 (0.99 to 1.13)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k			OR (95% CI)		
	First	Second	Third			
Period of the day						
Morning						
Unadjusted model	1	0.89 (0.76 to 1.05)	1.02 (0.86 to 1.20)		.832	1.02 (0.92 to 1.12)
Model 1 ^{l,h}	1	0.87 (0.74 to 1.02)	0.93 (0.79 to 1.10)		.403	0.95 (0.86 to 1.06)
Model 2 ^{l,i}	1	0.82 (0.69 to 0.98)	0.87 (0.73 to 1.03)		.111	0.91 (0.82 to 1.02)
Model 3 ^{l,m}	1	0.85 (0.72 to 1.01)	0.93 (0.77 to 1.12)		.444	0.96 (0.86 to 1.08)
Midday						
Unadjusted model	1	0.78 (0.67 to 0.93)	0.94 (0.79 to 1.11)		.452	1.00 (0.94 to 1.07)
Model 1 ^{l,h}	1	0.86 (0.72 to 1.02)	1.12 (0.94 to 1.34)		.198	1.08 (1.00 to 1.16)
Model 2 ^{l,i}	1	0.89 (0.74 to 1.07)	1.17 (0.97 to 1.41)		.094	1.10 (1.01 to 1.19)
Model 3 ^{l,n}	1	0.89 (0.74 to 1.07)	1.19 (0.98 to 1.44)		.068	1.11 (1.02 to 1.20)
Evening						
Unadjusted model	1	0.99 (0.83 to 1.16)	1.17 (0.99 to 1.39)		.069	1.05 (0.99 to 1.11)
Model 1 ^{l,h}	1	1.01 (0.85 to 1.20)	1.28 (1.07 to 1.53)		.008	1.08 (1.02 to 1.15)

(continued on next page)

Table 3. OR^a (95% CI) of the association between tertiles and a 10% increase in energy intake and energy intake from ultra-processed foods across daytime periods,^b and overweight status^c in UK adults (aged 19-64 years), NDNS^d 2008-2019 (n = 5749) (continued)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k				
	First	Second	Third		
Model 2 ^{l,i}	1	1.04 (0.87 to 1.25)	1.29 (1.06 to 1.56)	.011	1.09 (1.01 to 1.16)
Model 3 ^{l,o}	1	1.04 (0.87 to 1.25)	1.31 (1.08 to 1.60)	.008	1.10 (1.02 to 1.18)

^aOR = odds ratio.

^bMorning: 5:00 AM to 10:59 AM, midday: 11:00 AM to 4:59 PM, evening: 5:00 PM to 4:59 AM.

^cOverweight: body mass index ≥ 25 .

^dNDNS = National Diet and Nutrition Survey.

^eThe tertiles were categorized based on cutoff points for energy consumption: Morning: first tertile: $\leq 13.1\%$ of total energy intake; second tertile: 13.2%-20.6% of total energy intake; third tertile: $\geq 20.7\%$ of total energy intake. Midday: first tertile: $\leq 30.7\%$ of total energy intake; second tertile: 30.8%-39.6% of total energy intake; third tertile: $\geq 39.7\%$ of total energy intake. Evening: first tertile: $\leq 42.8\%$ of total energy intake; second tertile: 42.9%-52.1% of total energy intake; third tertile: $\geq 52.2\%$ of total energy intake.

^fP value for linear trend across tertiles of dietary contribution.

^gAdjustment model for energy consumption.

^hModel 1: adjusted for sex, age, region, survey year, and social class occupation.

ⁱModel 2: Model 1 and physical activity, smoking, sleep duration, following a weight-loss diet, and frequency of alcohol consumption.

^jModel 3: Model 2 and total energy intake.

^kFor ultra-processed foods intake: Morning: first tertile: $\leq 7.2\%$ of total energy intake; second tertile: 7.3%-12.6% of total energy intake; third tertile: $\geq 12.7\%$ of total energy intake. Midday: first tertile: $\leq 16.3\%$ of total energy intake; second tertile: 16.4%-24.5% of total energy intake; third tertile: $\geq 24.6\%$ of total energy intake. Evening: first tertile: $\leq 17.1\%$ of total energy intake; second tertile: 17.2%-27.1% of total energy intake; third tertile: $\geq 27.2\%$ of total energy intake.

^lAdjustment model for ultra-processed foods consumption.

^mModel 3: Model 2 and percentage of energy from ultra-processed foods in the midday and evening.

ⁿModel 3: Model 2 and percentage of energy from ultra-processed foods in the morning and evening.

^oModel 3: Model 2 and percentage of energy from ultra-processed foods in the morning and midday.

(OR 1.45; 95% CI, 1.20 to 1.76), and a significant linear trend was observed. Furthermore, a 10% increase in the percentage of energy intake from UPFs in the evening was associated with 16% higher odds of overweight (OR 1.16; 95% CI, 1.07 to 1.26) (Table 5).

The magnitude of the effect of the highest percentage of energy intake from UPFs on obesity was greatest in the evening compared with midday and morning, with corresponding increases in the odds of obesity of 45% (OR 1.45; 95% CI, 1.20 to 1.76), 25% (OR 1.25; 95% CI, 1.04 to 1.51), and 26% (OR 1.26; 95% CI, 1.04 to 1.53), respectively (Table 5).

In sensitivity analysis (Table 6), the association between percentage energy intake from UPFs and obesity remained significant only for the evening period after adjusting for total energy in model 4.

In relation to abdominal obesity (Table 7), no association was observed for the percentage of energy intake during the periods of the day analyzed. In the sensitivity analysis, the results were consistent with model 3 (Table 8, available at www.jandonline.org). When considering the percentage energy intake from UPFs (Table 7), a statistically significant association was observed for the evening period only (OR 1.31; 95% CI, 1.07 to 1.61), with a significant linear trend observed. A 10% increase in the percentage of energy intake from UPFs in the evening was associated with 12% higher odds of abdominal obesity (OR 1.12; 95% CI, 1.03 to 1.22) (Table 7). The results for abdominal obesity remained similar in the sensitivity analysis (Table 8).

After testing for interaction between the percentage of energy intake and from UPFs during the periods of the day and the year of data collection, no significant interaction was observed (data not shown).

Sensitivity analysis performed, including complete cases only, indicated that the results of the multiple imputations did not differ significantly from the complete case analysis (data not shown).

A positive association was observed between the highest category of energy intake timing ratio and overweight (OR 1.34; 95% CI, 1.09 to 1.66). Similarly, regarding UPFs intake, participants with an evening-to-morning/midday energy ratio from UPFs >2.0 had higher odds of both obesity (OR 1.22; 95% CI, 1.03 to 1.47) and overweight (OR 1.22; 95% CI, 1.03 to 1.46) (data not shown in tables).

DISCUSSION

We examined the association between the dietary percentage of energy intake and the percentage of energy intake from UPFs during the morning, midday, and evening with indicators of adiposity. Three notable findings emerged from the analyses: (1) higher UPFs intake at any mealtime is associated with higher odds of obesity; (2) higher UPFs intake in the evening was linked to greater odds of obesity compared with other times, and it was also linked to overweight and abdominal obesity; (3) energy intake in the morning, regardless of the level of food processing, was associated with a lower likelihood of overweight, and the opposite was observed for the evening period.

These findings suggest that higher energy intake in the morning is associated with a reduced likelihood of overweight. A clinical trial investigating the effect of redistributing total energy intake on weight loss reported greater weight loss in women with overweight and obesity when more energy was consumed in the morning compared with the evening.⁵²

Table 5. OR^a (95% CI) of the association between tertiles and a 10% increase in energy intake and energy intake from ultra-processed foods, across daytime periods,^b and obesity status^c in UK adults (aged 19-64 years), NDNS^d 2008-2019 (n = 5749)

Variable	Energy Consumption (% of Total Energy) in Each Period of the Day				P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^e			OR (95% CI)		
	First	Second	Third			
Period of the day						
Morning						
Unadjusted model	1	0.97 (0.82 to 1.16)	1.17 (0.98 to 1.40)		.082	1.06 (0.98 to 1.14)
Model 1 ^{g,h}	1	0.91 (0.76 to 1.08)	1.07 (0.90 to 1.29)		.427	1.01 (0.93 to 1.10)
Model 2 ^{g,i}	1	0.88 (0.73 to 1.06)	1.00 (0.82 to 1.21)		.984	0.98 (0.90 to 1.06)
Model 3 ^{g,j}	1	0.89 (0.74 to 1.07)	1.00 (0.82 to 1.21)		.978	0.98 (0.90 to 1.06)
Midday						
Unadjusted model	1	0.78 (0.65 to 0.93)	0.77 (0.64 to 0.93)		.006	0.95 (0.89 to 1.03)
Model 1 ^{g,h}	1	0.85 (0.71 to 1.02)	0.87 (0.72 to 1.05)		.149	0.99 (0.91 to 1.06)
Model 2 ^{g,i}	1	0.87 (0.72 to 1.05)	0.86 (0.70 to 1.05)		.125	0.97 (0.90 to 1.05)
Model 3 ^{g,j}	1	0.88 (0.73 to 1.06)	0.86 (0.70 to 1.05)		.138	0.98 (0.91 to 1.05)
Evening						
Unadjusted model	1	1.01 (0.84 to 1.21)	1.12 (0.93 to 1.35)		.220	1.01 (0.95 to 1.08)
Model 1 ^{g,h}	1	0.99 (0.83 to 1.21)	1.09 (0.90 to 1.31)		.382	1.01 (0.94 to 1.08)
Model 2 ^{g,i}	1	1.08 (0.89 to 1.32)	1.17 (0.97 to 1.43)		.107	1.03 (0.97 to 1.11)
Model 3 ^{g,j}	1	1.09 (0.89 to 1.32)	1.17 (0.96 to 1.43)		.115	1.03 (0.97 to 1.11)

Variable	Consumption of ultra-processed foods (% of total energy)				P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k			OR (95% CI)		
	First	Second	Third			
Period of the day						
Morning						
Unadjusted model	1	1.05 (0.89 to 1.25)	1.25 (1.06 to 1.49)		.009	1.16 (1.05 to 1.28)
Model 1 ^{l,h}	1	1.02 (0.86 to 1.22)	1.19 (0.86 to 1.22)		.049	1.12 (1.01 to 1.24)
Model 2 ^{l,i}	1	0.99 (0.83 to 1.19)	1.14 (0.94 to 1.37)		.173	1.09 (0.98 to 1.21)
Model 3 ^{l,m}	1	1.05 (0.87 to 1.25)	1.26 (1.04 to 1.53)		.021	1.17 (1.05 to 1.31)
Midday						
Unadjusted model	1	0.85 (0.71 to 1.02)	1.06 (0.89 to 1.27)		.514	1.03 (0.96 to 1.12)
Model 1 ^{l,h}	1	0.88 (0.73 to 1.07)	1.19 (0.99 to 1.43)		.061	1.08 (1.00 to 1.17)
Model 2 ^{l,i}	1	0.90 (0.74 to 1.09)	1.18 (0.98 to 1.43)		.082	1.08 (0.99 to 1.17)
Model 3 ^{l,n}	1	0.91 (0.75 to 1.11)	1.25 (1.04 to 1.51)		.020	1.11 (1.03 to 1.20)
Evening						
Unadjusted model	1	1.03 (0.86 to 1.23)	1.34 (1.12 to 1.60)		.001	1.10 (1.03 to 1.18)
Model 1 ^{l,h}	1	1.04 (0.87 to 1.25)	1.44 (1.19 to 1.73)		<.001	1.14 (1.06 to 1.23)

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Table 5. OR^a (95% CI) of the association between tertiles and a 10% increase in energy intake and energy intake from ultra-processed foods, across daytime periods,^b and obesity status^c in UK adults (aged 19-64 years), NDNS^d 2008-2019 (n = 5749) (continued)

Variable	Consumption of ultra-processed foods (% of total energy)			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k				
	First	Second	Third		
Model 2 ^{l,i}	1	1.07 (0.89 to 1.29)	1.40 (1.15 to 1.69)	.001	1.13 (1.05 to 1.22)
Model 3 ^{l,o}	1	1.07 (0.89 to 1.29)	1.45 (1.20 to 1.76)	<.001	1.16 (1.07 to 1.26)

^aOR = odds ratio.

^bMorning: 5:00 AM to 10:59 AM, midday: 11:00 AM to 4:59 PM, evening: 5:00 PM to 4:59 AM.

^cObesity: body mass index ≥ 30 .

^dNDNS = National Diet and Nutrition Survey.

^eThe tertiles were categorized based on cutoff points for energy consumption: Morning: first tertile: $\leq 13.1\%$ of total energy intake; second tertile: 13.2%-20.6% of total energy intake; third tertile: $\geq 20.7\%$ of total energy intake. Midday: first tertile: $\leq 30.7\%$ of total energy intake; second tertile: 30.8%-39.6% of total energy intake; third tertile: $\geq 39.7\%$ of total energy intake. Evening: first tertile: $\leq 42.8\%$ of total energy intake; second tertile: 42.9%-52.1% of total energy intake; third tertile: $\geq 52.2\%$ of total energy intake.

^fP value for linear trend across tertiles of dietary contribution.

^gAdjustment models for energy consumption.

^hModel 1: adjusted for sex, age, region, survey year, and social class occupation.

ⁱModel 2: Model 1 and physical activity, smoking, sleep duration, following a weight-loss diet, and frequency of alcohol consumption.

^jModel 3: Model 2 and total energy intake.

^kFor ultra-processed foods intake: Morning: first tertile: $\leq 7.2\%$ of total energy intake; second tertile: 7.3%-12.6% of total energy intake; third tertile: $\geq 12.7\%$ of total energy intake. Midday: first tertile: $\leq 16.3\%$ of total energy intake; second tertile: 16.4%-24.5% of total energy intake; third tertile: $\geq 24.6\%$ of total energy intake. Evening: first tertile: $\leq 17.1\%$ of total energy intake; second tertile: 17.2%-27.1% of total energy intake; third tertile: $\geq 27.2\%$ of total energy intake.

^lAdjustment models for ultra-processed foods consumption.

^mModel 3: Model 2 and percentage of energy from ultra-processed foods in the midday and evening.

ⁿModel 3: Model 2 and percentage of energy from ultra-processed foods in the morning and evening.

^oModel 3: Model 2 and percentage of energy from ultra-processed foods in the morning and midday.

In line with the hypotheses, we found that a higher proportion of energy intake in the evening was associated with overweight. However, no association was observed between the percentage of energy intake assessed during the morning and evening periods and obesity or abdominal obesity. Conversely, other researchers reported an association with BMI or overweight and obesity classified based on BMI.^{10,49} In a cohort study, during a 6-year follow-up period, participants who consumed $\geq 48\%$ of their total energy intake at dinner were twice as likely to develop obesity compared with participants who consumed $< 33\%$ of their total energy intake at dinner.⁵³ A previous study among Korean adults found that morning eating was associated with a decreased prevalence of abdominal obesity among women, but not in men.⁵⁰

By contrast, Longo Silva and colleagues⁵⁴ found no statistically significant differences between early and late dinner eaters concerning obesity in Brazilian adults. A systematic review¹⁶ aimed at investigating the association between evening energy intake and weight in adults reported that only 4 of 10 studies found a significant association with obesity. The authors noted significant heterogeneity among the studies, and many trials had an unknown or high risk of bias.¹⁶

We found that the percentage of energy intake from UPFs in the 3 periods of the day was associated with obesity. In addition, there was an association between the percentage of energy intake from UPFs at midday and in the evening with overweight, and the evening percentage was also associated with abdominal obesity. To date, according to the best of our knowledge, no published articles have analyzed this association stratified by periods of the day, and therefore, the present findings cannot be compared with previous studies. UPFs are known to be high in energy, saturated fats, sugars, and free

sugars, and higher consumption of these foods is associated with an increased risk of adiposity.^{3,4,55,56} A previous study using data from the UK NDNS found that higher consumption of UPFs was associated with a 1.66 higher mean BMI, a 3.56-cm larger mean WC, and a 90% higher odds of obesity compared with lower consumption.⁴

Possible explanations for the observed results are related to satiety hormones such as leptin or ghrelin. Higher consumption in the morning may reduce hunger, cravings for fat and sweets, and also decrease postprandial ghrelin concentrations, which may prevent susceptibility to weight gain.^{57,58} Studies have shown that earlier intakes are associated with higher thermogenesis, increased total energy expenditure, and lower glycemic responses.^{11,53,59} Conversely, later intake is linked to reduced insulin sensitivity, lower efficiency of the thermic effect of food, and decreased glucose tolerance.⁶⁰⁻⁶²

The higher mean proportion of UPFs intake in the evening (23.2%) compared with 20.9% and 10.4% at midday and in the morning, respectively, may partially account for the observed association. Furthermore, the magnitude of the association between the percentage of energy intake from UPFs and obesity was greater in the evening compared with other periods of the day. These results might be attributed to the potential association between individuals with evening chronotypes and a greater appetite for high-energy-dense foods, including processed foods and UPFs.⁶³ Chronic sleep deprivation is common among individuals with evening chronotypes, as they tend to delay their routines to later hours, while still meeting social and professional demands earlier in the day.^{64,65} Consequently, this sleep deprivation may lead to increased ghrelin secretion and decreased leptin secretion,

Table 7. OR^a (95% CI) of the association between tertiles and a 10% increase in total energy intake and energy intake from ultra-processed foods, across daytime periods,^b and abdominal obesity status^c in UK adults (aged 19-64 years), NDNS^d 2008-2019 (n = 4244)

Variable	Energy Consumption (% of Total Energy) in Each Period of the Day				P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^e			OR (95% CI)		
	First	Second	Third			
Period of the day						
Morning						
Unadjusted model	1	1.00 (0.84 to 1.20)	1.17 (0.98 to 1.40)		.081	1.05 (0.97 to 1.14)
Model 1 ^{g,h}	1	0.88 (0.73 to 1.07)	1.00 (0.83 to 1.20)		.996	0.97 (0.89 to 1.06)
Model 2 ^{g,i}	1	0.87 (0.71 to 1.06)	0.95 (0.79 to 1.16)		.669	0.95 (0.87 to 1.04)
Model 3 ^{g,j}	1	0.88 (0.72 to 1.07)	0.96 (0.79 to 1.16)		.676	0.95 (0.87 to 1.04)
Midday						
Unadjusted model	1	0.78 (0.65 to 0.93)	0.83 (0.64 to 0.93)		.048	0.95 (0.89 to 1.03)
Model 1 ^{g,h}	1	0.87 (0.73 to 1.05)	0.96 (0.79 to 1.16)		.228	0.99 (0.92 to 1.07)
Model 2 ^{g,i}	1	0.88 (0.73 to 1.07)	0.95 (0.78 to 1.16)		.592	0.98 (0.91 to 1.06)
Model 3 ^{g,j}	1	0.89 (0.73 to 1.08)	0.95 (0.78 to 1.16)		.613	0.98 (0.91 to 1.06)
Evening						
Unadjusted model		0.98 (0.82 to 1.19)	1.11 (0.92 to 1.34)		.275	1.01 (0.95 to 1.08)
Model 1 ^{g,h}	1	0.99 (0.82 to 1.19)	1.12 (0.93 to 1.36)		.228	1.03 (0.96 to 1.10)
Model 2 ^{g,i}	1	1.03 (0.85 to 1.25)	1.16 (0.95 to 1.42)		.147	1.04 (0.97 to 1.12)
Model 3 ^{g,j}	1	1.04 (0.86 to 1.26)	1.16 (0.95 to 1.42)		.153	1.04 (0.97 to 1.12)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k			OR (95% CI)		
	First	Second	Third			
Period of the day						
Morning						
Unadjusted model	1	0.97 (0.82 to 1.15)	1.14 (0.96 to 1.35)		.137	1.07 (0.96 to 1.19)
Model 1 ^{l,h}	1	0.92 (0.77 to 1.11)	1.07 (0.89 to 1.28)		.474	1.02 (0.91 to 1.14)
Model 2 ^{l,i}	1	0.92 (0.76 to 1.11)	1.05 (0.87 to 1.27)		.602	1.01 (0.90 to 1.14)
Model 3 ^{l,m}	1	0.94 (0.78 to 1.14)	1.12 (0.92 to 1.36)		.255	1.06 (0.94 to 1.20)
Midday						
Unadjusted model	1	0.73 (0.61 to 0.87)	0.89 (0.74 to 1.07)		.200	0.97 (0.89 to 1.05)
Model 1 ^{l,h}	1	0.78 (0.64 to 0.94)	1.09 (0.90 to 1.33)		.423	1.05 (0.96 to 1.14)
Model 2 ^{l,i}	1	0.77 (0.64 to 0.94)	1.09 (0.89 to 1.34)		.449	1.05 (0.96 to 1.15)
Model 3 ^{l,n}	1	0.78 (0.64 to 0.95)	1.13 (0.92 to 1.38)		.283	1.07 (0.98; 1.17)
Evening						
Unadjusted model	1	0.96 (0.80 to 1.14)	1.16 (0.96 to 1.40)		.126	1.05 (0.98 to 1.13)
Model 1 ^{l,h}	1	0.99 (0.83 to 1.19)	1.38 (1.14 to 1.68)		.001	1.13 (1.05 to 1.23)

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Table 7. OR^a (95% CI) of the association between tertiles and a 10% increase in total energy intake and energy intake from ultra-processed foods, across daytime periods,^b and abdominal obesity status^c in UK adults (aged 19-64 years), NDNS^d 2008-2019 (n = 4244) (continued)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k				
	First	Second	Third		
Model 2 ^{li}	1	0.99 (0.83 to 1.20)	1.29 (1.05 to 1.58)	.016	1.11 (1.02 to 1.20)
Model 3 ^{lo}	1	0.99 (0.83 to 1.20)	1.31 (1.07 to 1.61)	.010	1.12 (1.03 to 1.22)

^aOR = odds ratio.

^bMorning: 5:00 AM to 10:59 AM, midday: 11:00 AM to 4:59 PM, evening: 5:00 PM to 4:59 AM.

^cAbdominal obesity: waist circumference ≥ 102 cm for men and ≥ 88 cm for women.

^dNDNS = National Diet and Nutrition Survey.

^eThe tertiles were categorized based on cutoff points for energy consumption: Morning: first tertile: $\leq 13.1\%$ of total energy intake; second tertile: 13.2%-20.6% of total energy intake; third tertile: $\geq 20.7\%$ of total energy intake. Midday: first tertile: $\leq 30.7\%$ of total energy intake; second tertile: 30.8%-39.6% of total energy intake; third tertile: $\geq 39.7\%$ of total energy intake. Evening: first tertile: $\leq 42.8\%$ of total energy intake; second tertile: 42.9%-52.1% of total energy intake; third tertile: $\geq 52.2\%$ of total energy intake.

^fP value for linear trend across tertiles of dietary contribution.

^gAdjustment model for energy consumption.

^hModel 1: adjusted for sex, age, region, survey year, and social class occupation.

ⁱModel 2: Model 1 and physical activity, smoking, sleep duration, following a weight-loss diet, and frequency of alcohol consumption.

^jModel 3: Model 2 and total energy intake.

^kFor ultra-processed foods intake: Morning: first tertile: $\leq 7.2\%$ of total energy intake; second tertile: 7.3%-12.6% of total energy intake; third tertile: $\geq 12.7\%$ of total energy intake. Midday: first tertile: $\leq 16.3\%$ of total energy intake; second tertile: 16.4%-24.5% of total energy intake; third tertile: $\geq 24.6\%$ of total energy intake. Evening: first tertile: $\leq 17.1\%$ of total energy intake; second tertile: 17.2%-27.1% of total energy intake; third tertile: $\geq 27.2\%$ of total energy intake.

^lAdjustment model for ultra-processed foods consumption.

^mModel 3: Model 2 and percentage of energy from ultra-processed foods in the midday and evening.

ⁿModel 3: Model 2 and percentage of energy from ultra-processed foods in the morning and evening.

^oModel 3: Model 2 and percentage of energy from ultra-processed foods in the morning and midday.

resulting in higher energy intake.⁶⁶ A study of Italian adults found that individuals classified as late eaters reported higher consumption of UPFs, suggesting that the degree of food processing could be one of the factors explaining the relationship between meal timing and impaired cardiometabolic outcomes.⁶⁷ Food processing affects both the nutritional composition and the architecture of food. UPFs are often unstructured (their natural physical form is heavily altered during manufacturing, resulting in uniform, refined products), fractionated, and frequently enriched with free glucose and sucrose, thereby increasing the availability of glucose for absorption.^{68,69} However, during the nighttime, there is reduced glucose tolerance, which could explain the increased likelihood of obesity indicators during this period of the day.⁷⁰

A study limitation included the utilization of cross-sectional data for the analyses, which precludes causal inference. The possibility of under-reporting food consumption cannot be disregarded, as it is a common issue across all dietary assessment methods and tends to increase with higher BMI.⁷¹ In addition, self-reported dietary intake may be influenced by social desirability or the desire for social approval, potentially impacting risk estimates in epidemiologic studies.⁷² Although 4 consecutive 24-hour food diaries were used, this approach has important limitations for estimating usual dietary intake. As highlighted by Kirkpatrick and colleagues,⁷³ characterizing usual intake is more complex when short-term assessments are collected over consecutive days, given that intake on consecutive days tends to be more correlated, potentially reducing day-to-day variability. Furthermore, despite interviewer review of food diaries, some information on portion sizes and food details remained missing and required imputation. Although standardized procedures were applied to

minimize bias, these imputations may have introduced a degree of measurement error.

The influence of chronotype and shift work data, which could affect the timing of food consumption,^{50,74} could not be examined due to the lack of information. It is plausible that categorizing food consumption into morning, midday, and evening may not accurately reflect long-term dietary habits subject to seasonal variations. The NDNS collects limited information on food processing, potentially leading to misclassification of food items.^{3,34} Although the percentage of energy from UPFs does not fully capture artificially sweetened beverages, it was used as it better reflects the energy density of UPF. Other studies assessing the association between the consumption of UPFs and obesity also use the percentage energy from UPF.^{4,5} Artificially sweetened beverages accounted for 3.9% of total food grams (data not shown), but non-nutritive sweeteners in other items may not be fully captured. Future studies should consider assessing UPFs in grams and their daily distribution in relation to obesity risk. A broader measure of overall dietary quality, such as the Healthy Eating Index, was not accounted for in the present study. Future research should explore whether total UPFs consumption and the timing of intake are linked to obesity risk independently of overall diet quality.⁷⁵

The study boasts several strengths, such as the use of a large, nationally representative sample of UK adults. Extensive adjustments for sociodemographic and behavioral factors, total energy intake, and energy from UPFs were included. The findings contribute to enhancing the understanding of the mechanisms underlying the relationship between meal timing and obesity indicators, which supports the need for further investigation into the timing of UPFs consumption and its

potential association with health outcomes. This represents a critical and clearly defined primary objective for public health, as it addresses both the prevailing epidemic of our era (obesity) and the primary driver of health care expenditures, affecting individuals at increasingly younger ages.⁷⁶ These may include the adoption of fiscal measures, regulation of advertising for these foods, implementation of front-of-package warning labels, and control of food environments related to access to such products.⁷⁷

CONCLUSIONS

The findings indicate an association between a higher percentage of energy intake in the morning and a lower odds of overweight, and consuming more of the day's total energy intake in the evening is linked to a higher likelihood of overweight. The strength of the association between UPFs consumption and indicators of obesity was notably higher in the evening compared with other times of the day. Future longitudinal studies, incorporating individuals' chronotypes, should be conducted to further assess causality.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

P. de Fragas Hinnig, F. Rauber, and R. Bertazzi Levy designed the research and methodology. P. de Fragas Hinnig performed data analysis and interpretation and wrote the original draft. F. Rauber and R. Bertazzi Levy assisted in data analysis and interpretation and revised and edited the manuscript. K. Chang and E. P. Vamos revised and edited the manuscript. All authors read and approved the final manuscript.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this work, the authors used ChatGPT in order to help make the paragraphs more concise, reduce the number of words, and refine the English grammar and style to improve overall readability. After using this tool, the authors reviewed and edited the content as needed. The authors take full responsibility for the content of the publication.

Table 2. Mean (SE) proportion of energy intake and UPF^a (% of total energy) consumed in the morning,^b midday,^c and evening^d according to sociodemographic and behavioral characteristics of the UK population (aged 19 to 64 years), NDNS^e 2008-2019 (n = 5749)

Characteristic	% of Total Energy Intake			% of Total Energy Intake From UPF		
	Morning	Midday	Evening	Morning	Midday	Evening
	←————— <i>mean (SE)</i> —————→					
Sex^f						
Male	17.0 (0.2)	34.3 (0.3)	48.7 (0.3)	10.6 (0.2)	21.0 (0.3)	24.2 (0.3)
Female	17.3 (0.2)	36.1 (0.2) ^{***}	46.6 (0.3) ^{***}	10.2 (0.1)	20.8 (0.2)	22.2 (0.3) ^{***}
Age group^f						
19-34 y	15.6 (0.3)	36.8 (0.4)	47.6 (0.4)	9.7 (0.2)	23.0 (0.3)	25.5 (0.4)
35-49 y	17.7 (0.2)	35.0 (0.3)	47.3 (0.4)	10.8 (0.2)	20.6 (0.2)	22.5 (0.3)
50-64 y	18.3 (0.3) ^{***}	33.6 (0.3) ^{***}	48.1 (0.3)	10.8 (0.2) ^{***}	18.8 (0.2) ^{***}	21.2 (0.3) ^{***}
Ethnicity^f						
White	17.1 (0.2)	35.0 (0.2)	47.9 (0.2)	10.5 (0.1)	21.4 (0.2)	23.8 (0.2)
Black	16.5 (1.0)	35.0 (1.4)	48.5 (1.6)	9.5 (0.7)	18.0 (1.0) ^{***}	18.7 (1.3) ^{***}
Asian	18.1 (0.7)	37.1 (0.9) [*]	44.7 (1.1) ^{**}	10.1 (0.5)	18.1 (0.8) ^{***}	19.8 (0.8) ^{***}
Mixed ^g	18.7 (1.1)	37.2 (1.7)	44.1 (1.9)	10.3 (0.8)	22.1 (1.7) ^{***}	20.9 (1.8) ^{***}
Any other group ^h	17.9 (1.2)	37.4 (1.5)	44.6 (1.8)	8.6 (0.8) [*]	15.2 (1.2) ^{***}	16.7 (1.4) ^{***}
Region^f						
England North	16.8 (0.3)	35.1 (0.4)	48.1 (0.4)	10.3 (0.3)	21.4 (0.4)	24.0 (0.4)
England Central/Midlands	16.9 (0.4)	35.3 (0.5)	47.8 (0.5)	10.4 (0.3)	21.9 (0.4)	24.5 (0.6)
England South (including London)	17.4 (0.2)	35.5 (0.3)	47.1 (0.4)	10.4 (0.2)	20.1 (0.3) ^{**}	21.8 (0.3) ^{****}
Scotland	17.2 (0.4)	33.5 (0.6) ^{***}	49.3 (0.7)	10.2 (0.3)	21.2 (0.5)	25.1 (0.7)
Wales	17.2 (0.5)	36.4 (0.5) ^{***}	46.4 (0.6) ^{***}	10.4 (0.3)	22.0 (0.5)	22.6 (0.7)
Northern Ireland	17.0 (0.4)	34.1 (0.4)	48.8 (0.5)	10.7 (0.3)	21.7 (0.4)	25.8 (0.4) ^{**}
Social class occupation^{ij}						
Higher managerial and professional occupations	17.3 (0.3)	35.4 (0.4)	47.3 (0.4)	10.2 (0.2) ^{**}	20.0 (0.3) ^{***}	20.9 (0.4) ^{***}
Routine and manual occupations	17.3 (0.3)	35.6 (0.3)	47.1 (0.4)	10.7 (0.2)	21.6 (0.3)	25.1 (0.4)
Intermediate occupations	17.1 (0.3)	34.9 (0.4)	48.0 (0.5)	10.5 (0.3)	21.0 (0.4)	22.5 (0.4)
Lower managerial and professional occupations	17.0 (0.3)	34.8 (0.4)	48.3 (0.5)	10.1 (0.2)	20.6 (0.3)	22.8 (0.5)
Physical activity^{ik}						
First quartile	16.6 (0.3)	36.2 (0.4)	47.2 (0.5)	10.1 (0.2)	21.4 (0.4)	23.7 (0.4)
Second quartile	17.3 (0.3)	35.5 (0.4)	47.2 (0.4)	10.3 (0.2)	21.0 (0.3)	22.6 (0.4)
Third quartile	16.3 (0.3)	35.1 (0.4)	48.5 (0.5)	9.8 (0.2)	20.5 (0.3)	23.0 (0.5)
Fourth quartile	18.4 (0.4) ^{**}	33.9 (0.4) ^{***}	47.6 (0.4)	11.5 (0.3) ^{**}	20.8 (0.4)	23.6 (0.4)
Smoking status^f						
Nonsmoker	17.7 (0.2)	35.3 (0.2)	47.0 (0.2)	10.8 (0.1)	20.5 (0.2)	22.1 (0.2)
Smoker	15.1 (0.3) ^{***}	35.0 (0.4)	49.9 (0.5) ^{***}	9.1 (0.2) ^{***}	22.3 (0.4) ^{***}	26.7 (0.5) ^{***}
Frequency of alcohol consumption^l						
≥ 3 times/wk	15.9 (0.3)	33.2 (0.4)	50.8 (0.4)	9.6 (0.2)	19.7 (0.3)	21.3 (0.3)
1 to 2 times/wk	17.1 (0.3)	35.6 (0.4)	47.3 (0.4)	10.6 (0.2)	21.2 (0.3)	23.3 (0.4)
< 1 time/wk	17.7 (0.3)	35.7 (0.4)	46.6 (0.4)	10.7 (0.2)	21.9 (0.3)	25.0 (0.4)

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Table 2. Mean (SE) proportion of energy intake and UPF^a (% of total energy) consumed in the morning,^b midday,^c and evening^d according to sociodemographic and behavioral characteristics of the UK population (aged 19 to 64 years), NDNS^e 2008-2019 (n = 5749) (continued)

Characteristic	% of Total Energy Intake			% of Total Energy Intake From UPF		
	Morning	Midday	Evening	Morning	Midday	Evening
Never	18.3 (0.5)***	36.8 (0.6)***	44.8 (0.8)***	10.6 (0.4)**	20.2 (0.6)**	21.7 (0.6)**
Sleep duration^f						
<7 h/d	17.8 (0.3)	34.4 (0.3)	47.8 (0.4)	10.9 (0.2)	20.6 (0.3)	23.4 (0.4)
7–8 h/d	17.3 (0.2)	35.0 (0.3)	47.6 (0.3)	10.4 (0.2)	20.7 (0.2)	22.6 (0.3)
> 8 h/d	15.4 (0.4)***	37.2 (0.5)***	47.4 (0.6)	9.3 (0.3)***	22.1 (0.5)**	24.1 (0.6)
Weight loss diet^f						
No	17.1 (0.2)	35.2 (0.2)	47.7 (0.2)	10.4 (0.1)	21.1 (0.2)	23.3 (0.2)
Yes	17.5 (0.3)	35.2 (0.5)	47.3 (0.5)	10.3 (0.2)	20.1 (0.4)***	22.5 (0.5)

^aUPF = ultra-processed food.

^bMorning: 5:00 AM to 10:59 AM.

^cMidday: 11:00 AM to 4:59 PM.

^dEvening: 5:00 PM to 4:59 AM.

^eNDNS = National Diet and Nutrition Survey.

^fUnivariate linear regression (first category of sociodemographic and behavioral variables that appear in the row as reference).

^gWhite and Black Caribbean, White and Black African, White and Asian.

^hEthnicities not included in the listed categories.

ⁱUnivariate linear regression for linear trend across categories.

^jRoutine and manual occupations: jobs that involve repetitive tasks and are often regulated by a basic labor contract; intermediate occupations: are considered to be more difficult conceptually than routine manual and nonmanual jobs, but less difficult than managerial or professional jobs (clerical, sales, services); lower managerial and professional occupations: positions that have an attenuated form of service relationship. Employees in these groups generally plan and supervise operations on behalf of the employer under the direction of senior managers; higher managerial and professional occupations: positions that involve general planning and supervision of operations, and that require specialized educational training.⁴⁵

^kFirst quartile represents the least physically active individuals, and the fourth quartile represents the most physically active.

* $P < .05$.

** $P < .01$.

*** $P < .001$.

Table 4. Sensitivity analyses describing ORs^a (95% CI) for the association between tertiles of total energy intake percentage and percentage of energy intake from ultra-processed foods, along with a continuous 10% increase, analyzed across 3 periods of the day,^b and overweight^c in the UK population (aged 19-64 years), NDNS,^d 2008-2019 (n = 5749)

Variable	Energy Consumption (% of Total Energy) in Each Period of the Day				
	Tertiles ^e			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
	← OR (95% CI) →				
Period of the day					
Morning					
Model 4 ^{gh}	1	0.86 (0.72 to 1.03)	0.82 (0.69 to 0.98)	.026	0.90 (0.83 to 0.97)
Model 5 ^{gi}	1	0.88 (0.73 to 1.05)	0.83 (0.70 to 0.98)	.030	0.90 (0.83 to 0.97)
Model 6 ^{gj}	1	0.89 (0.74 to 1.06)	0.84 (0.71 to 1.00)	.053	0.90 (0.83 to 0.98)
Midday					
Model 4 ^{gh}	1	0.84 (0.71 to 1.00)	0.94 (0.79 to 1.12)	.483	0.99 (0.93 to 1.06)
Model 5 ^{gi}	1	0.86 (0.73 to 1.03)	0.95 (0.79 to 1.13)	.546	0.99 (0.94 to 1.06)
Model 6 ^{gj}	1	0.88 (0.74 to 1.05)	0.96 (0.81 to 1.15)	.678	1.00 (0.94 to 1.07)
Evening					
Model 4 ^{gh}	1	1.20 (0.99 to 1.44)	1.21 (1.01 to 1.45)	.036	1.06 (0.99 to 1.13)
Model 5 ^{gi}	1	1.21 (1.01 to 1.46)	1.21 (1.01 to 1.44)	.041	1.06 (0.99 to 1.13)
Model 6 ^{gj}	1	1.20 (0.99 to 1.44)	1.18 (0.99 to 1.44)	.070	1.05 (0.99 to 1.12)
Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				
	Tertiles ^k			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
	← OR (95% CI) →				
Period of the day					
Morning					
Model 4 ^{lm}	1	0.83 (0.70 to 0.99)	0.87 (0.73 to 1.04)	.130	0.92 (0.83 to 1.02)
Model 5 ^{ln}	1	0.86 (0.73 to 1.02)	0.94 (0.78 to 1.14)	.536	0.97 (0.86 to 1.09)
Model 6 ^{lo}	1	0.85 (0.71 to 1.01)	0.89 (0.74 to 1.08)	.231	0.93 (0.83 to 1.05)
Midday					
Model 4 ^{lm}	1	0.91 (0.76 to 1.10)	1.19 (0.99 to 1.44)	.057	1.11 (1.02 to 1.20)
Model 5 ^{lp}	1	0.91 (0.76 to 1.10)	1.22 (1.01 to 1.47)	.038	1.12 (1.03 to 1.21)
Model 6 ^{lq}	1	0.88 (0.73 to 1.06)	1.14 (0.94 to 1.38)	.189	1.09 (1.01 to 1.19)
Evening					
Model 4 ^{lm}	1	1.07 (0.90 to 1.28)	1.31 (1.08 to 1.59)	.007	1.09 (1.02 to 1.17)

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Table 4. Sensitivity analyses describing ORs^a (95% CI) for the association between tertiles of total energy intake percentage and percentage of energy intake from ultra-processed foods, along with a continuous 10% increase, analyzed across 3 periods of the day,^b and overweight^c in the UK population (aged 19-64 years), NDNS,^d 2008-2019 (n = 5749) (continued)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)					Continuous (10% increase in the consumption), OR (95% CI)
	Tertiles ^k			P for trend ^f		
	First (reference)	Second	Third			
Model 5 ^l _r	1	1.07 (0.90 to 1.28)	1.34 (1.09 to 1.63)	.005	1.11 (1.03 to 1.19)	
Model 6 ^l _s	1	1.07 (0.89 to 1.28)	1.32 (1.06 to 1.64)	.012	1.10 (1.02 to 1.19)	

^aOR = odds ratio.

^bMorning: 5:00 AM to 10:59 AM, midday: 11:00 AM to 4:59 PM, evening: 5:00 PM to 4:59 AM.

^cOverweight: body mass index ≥ 25 .

^dNDNS = National Diet and Nutrition Survey.

^eThe tertiles were categorized based on cutoff points for energy consumption: Morning: first tertile: $\leq 13.1\%$ of total energy intake; second tertile: 13.2%-20.6% of total energy intake; third tertile: $\geq 20.7\%$ of total energy intake. Midday: first tertile: $\leq 30.7\%$ of total energy intake; second tertile: 30.8%-39.6% of total energy intake; third tertile: $\geq 39.7\%$ of total energy intake. Evening: first tertile: $\leq 42.8\%$ of total energy intake; second tertile: 42.9%-52.1% of total energy intake; third tertile: $\geq 52.2\%$ of total energy intake.

^fP value for linear trend across tertiles of dietary contribution.

^gAdjustment model for energy consumption.

^hModel 4: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of total energy from ultra-processed foods.

ⁱModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus energy intake and total energy from ultra-processed foods.

^jModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, total energy intake, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^kFor ultra-processed foods intake: Morning: first tertile: $\leq 7.2\%$ of total energy intake; second tertile: 7.3%-12.6% of total energy intake; third tertile: $\geq 12.7\%$ of total energy intake. Midday: first tertile: $\leq 16.3\%$ of total energy intake; second tertile: 16.4%-24.5% of total energy intake; third tertile: $\geq 24.6\%$ of total energy intake. Evening: first tertile: $\leq 17.1\%$ of total energy intake; second tertile: 17.2%-27.1% of total energy intake; third tertile: $\geq 27.2\%$ of total energy intake.

^lAdjustment model for ultra-processed foods consumption.

^mModel 4: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus total energy intake.

ⁿModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the midday and evening, and total energy intake.

^oModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the midday and evening plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^pModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the morning and evening, and total energy intake.

^qModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the morning and evening, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^rModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the morning and midday, and total energy intake.

^sModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the morning and midday, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

Table 6. Sensitivity analyses describing OR^a (95% CI) for the association between tertiles of total energy intake percentage and percentage of energy intake from ultra-processed foods, along with a continuous 10% increase, analyzed across 3 periods of the day,^b and obesity^c in the UK population (aged 19-64 years), NDNS^d 2008-2019 (n = 5749)

Variable	Energy Consumption (% of Total Energy) in Each Period of the Day				
	Tertiles ^e			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
	← OR (95% CI) →				
Period of the day					
Morning					
Model 4 ^{gh}	1	0.89 (0.74 to 1.08)	1.03 (0.85 to 1.25)	.733	0.99 (0.91 to 1.08)
Model 5 ^{gi}	1	0.91 (0.75 to 1.09)	1.03 (0.85 to 1.25)	.722	0.99 (0.91 to 1.08)
Model 6 ^{gj}	—	0.92 (0.76 to 1.11)	1.05 (0.86 to 1.27)	.619	0.99 (0.91 to 1.08)
Midday					
Model 4 ^{gh}	1	0.85 (0.71 to 1.03)	0.83 (0.70 to 1.02)	.070	0.96 (0.89 to 1.04)
Model 5 ^{gi}	1	0.87 (0.72 to 1.05)	0.84 (0.68 to 1.02)	.079	0.97 (0.89 to 1.04)
Model 6 ^{gj}	—	0.89 (0.74 to 1.08)	0.85 (0.70 to 1.04)	.111	0.97 (0.90 to 1.05)
Evening					
Model 4 ^{gh}	1	1.08 (0.88 to 1.31)	1.17 (0.96 to 1.43)	.111	1.04 (0.97 to 1.11)
Model 5 ^{gi}	1	1.08 (0.89 to 1.32)	1.17 (0.96 to 1.42)	.119	1.03 (0.97 to 1.11)
Model 6 ^{gj}	—	1.08 (0.89 to 1.32)	1.15 (0.95 to 1.40)	.153	1.03 (0.96 to 1.10)
Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				
	Tertiles ^k			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
	← OR (95% CI) →				
Period of the day					
Morning					
Model 4 ^{lm}	1	1.00 (0.84 to 1.20)	1.14 (0.95 to 1.37)	.162	1.09 (0.98 to 1.21)
Model 5 ^{ln}	1	1.06 (0.88 to 1.27)	1.27 (1.04 to 1.54)	.017	1.18 (1.05 to 1.32)
Model 6 ^{lo}	—	1.04 (0.87 to 1.25)	1.23 (1.01 to 1.49)	.040	1.15 (1.03 to 1.29)
Midday					
Model 4 ^{lm}	1	0.92 (0.75 to 1.11)	1.20 (0.99 to 1.44)	.061	1.08 (0.99 to 1.17)
Model 5 ^{lp}	1	0.92 (0.76 to 1.13)	1.27 (1.06 to 1.53)	.013	1.12 (1.03 to 1.21)
Model 6 ^{lq}	—	0.91 (0.75 to 1.11)	1.24 (1.03 to 1.50)	.032	1.11 (1.02 to 1.20)
Evening					
Model 4 ^{lm}	1	1.08 (0.90 to 1.30)	1.40 (1.16 to 1.70)	.001	1.13 (1.05 to 1.22)

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Table 6. Sensitivity analyses describing OR^a (95% CI) for the association between tertiles of total energy intake percentage and percentage of energy intake from ultra-processed foods, along with a continuous 10% increase, analyzed across 3 periods of the day,^b and obesity^c in the UK population (aged 19-64 years), NDNS^d 2008-2019 (n = 5749) (continued)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				
	Tertiles ^k			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
Model 5 ^l _r	1	1.08 (0.90 to 1.31)	1.47 (1.21 to 1.78)	<.001	1.16 (1.08 to 1.26)
Model 6 ^l _s	—	1.09 (0.90 to 1.32)	1.48 (1.21 to 1.81)	<.001	1.18 (1.08 to 1.28)

^aOR = odds ratio.

^bMorning: 5:00 AM to 10:59 AM, midday: 11:00 AM to 4:59 PM, evening: 5:00 PM to 4:59 AM.

^cObesity: body mass index ≥ 30 .

^dNDNS = National Diet and Nutrition Survey.

^eThe tertiles were categorized based on cutoff points for energy consumption: Morning: first tertile: $\leq 13.1\%$ of total energy intake; second tertile: 13.2–20.6% of total energy intake; third tertile: $\geq 20.7\%$ of total energy intake. Midday: first tertile: $\leq 30.7\%$ of total energy intake; second tertile: 30.8–39.6% of total energy intake; third tertile: $\geq 39.7\%$ of total energy intake. Evening: first tertile: $\leq 42.8\%$ of total energy intake; second tertile: 42.9–52.1% of total energy intake; third tertile: $\geq 52.2\%$ of total energy intake.

^fP value for linear trend across tertiles of dietary contribution.

^gAdjustment model for energy consumption.

^hModel 4: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of total energy from ultra-processed foods.

ⁱModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus energy intake and total energy from ultra-processed foods.

^jModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, total energy intake, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^kFor ultra-processed foods intake: Morning: first tertile: $\leq 7.2\%$ of total energy intake; second tertile: 7.3%–12.6% of total energy intake; third tertile: $\geq 12.7\%$ of total energy intake. Midday: first tertile: $\leq 16.3\%$ of total energy intake; second tertile: 16.4%–24.5% of total energy intake; third tertile: $\geq 24.6\%$ of total energy intake. Evening: first tertile: $\leq 17.1\%$ of total energy intake; second tertile: 17.2%–27.1% of total energy intake; third tertile: $\geq 27.2\%$ of total energy intake.

^lAdjustment model for ultra-processed foods consumption.

^mModel 4: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus total energy intake.

ⁿModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the midday and evening and total energy intake.

^oModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the midday and evening plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^pModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the morning and evening, and total energy intake.

^qModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the morning and evening, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^rModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the morning and midday, and total energy intake.

^sModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the morning and midday, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

Table 8. Sensitivity analyses describing OR^a (95% CI) for the association between tertiles of total energy intake percentage and percentage of energy intake from ultra-processed foods, along with a continuous 10% increase, analyzed across 3 periods of the day,^b and abdominal obesity^c in the UK population (aged 19-64 years), NDNS^d 2008-2019 (n = 4244)

Variable	Energy Consumption (% of Total Energy) in Each Period of the Day				
	Tertiles ^e			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
	← OR (95% CI) →				
Period of the day					
Morning					
Model 4 ^{gh}	1	0.88 (0.72 to 1.07)	0.97 (0.80 to 1.18)	.794	0.96 (0.88 to 1.05)
Model 5 ^{gi}	1	0.89 (0.72 to 1.08)	0.97 (0.80 to 1.18)	.808	0.96 (0.88 to 1.05)
Model 6 ^{gj}	1	0.90 (0.74 to 1.11)	0.99 (0.82 to 1.21)	.983	0.97 (0.88 to 1.06)
Midday					
Model 4 ^{gh}	1	0.87 (0.72 to 1.05)	0.94 (0.77 to 1.14)	.498	0.98 (0.90 to 1.06)
Model 5 ^{gi}	1	0.88 (0.73 to 1.07)	0.94 (0.77 to 1.15)	.516	0.98 (0.90 to 1.06)
Model 6 ^{gj}	1	0.90 (0.74 to 1.09)	0.94 (0.77 to 1.15)	.520	0.98 (0.90 to 1.06)
Evening					
Model 4 ^{gh}	1	1.03 (0.85 to 1.25)	1.16 (0.95 to 1.42)	.145	1.04 (0.97 to 1.12)
Model 5 ^{gi}	1	1.04 (0.86 to 1.25)	1.16 (0.95 to 1.42)	.151	1.04 (0.97 to 1.12)
Model 6 ^{gj}	1	1.03 (0.85 to 1.25)	1.14 (0.93 to 1.40)	.195	1.04 (0.96 to 1.12)
	← OR (95% CI) →				
Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				
	Tertiles ^k			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
	← OR (95% CI) →				
Period of the day					
Morning					
Model 4 ^{lm}	1	0.92 (0.77 to 1.11)	1.06 (0.87 to 1.28)	.574	1.01 (0.90 to 1.14)
Model 5 ^{ln}	1	0.95 (0.79 to 1.14)	1.13 (0.93 to 1.37)	.227	1.06 (0.94 to 1.20)
Model 6 ^{lo}	1	0.93 (0.77 to 1.13)	1.09 (0.90 to 1.33)	.389	1.04 (0.92 to 1.17)
Midday					
Model 4 ^{lm}	1	0.78 (0.64 to 0.95)	1.10 (0.90 to 1.35)	.389	1.05 (0.96 to 1.15)
Model 5 ^{lp}	1	0.79 (0.65 to 0.96)	1.14 (0.94 to 1.40)	.229	1.07 (0.99 to 1.17)
Model 6 ^{lq}	1	0.78 (0.64 to 0.95)	1.10 (0.90 to 1.35)	.409	1.06 (0.97 to 1.15)
Evening					
Model 4 ^{lm}	1	1.00 (0.83 to 1.20)	1.30 (1.06 to 1.59)	.013	1.11 (1.02 to 1.21)

(continued on next page)

Table 8. Sensitivity analyses describing OR^a (95% CI) for the association between tertiles of total energy intake percentage and percentage of energy intake from ultra-processed foods, along with a continuous 10% increase, analyzed across 3 periods of the day,^b and abdominal obesity^c in the UK population (aged 19-64 years), NDNS^d 2008-2019 (n = 4244) (*continued*)

Variable	Consumption of Ultra-Processed Foods (% of Total Energy)				
	Tertiles ^k			P for trend ^f	Continuous (10% increase in the consumption), OR (95% CI)
	First (reference)	Second	Third		
Model 5 ^l r	1	1.00 (0.83 to 1.21)	1.32 (1.08 to 1.62)	.008	1.12 (1.03 to 1.22)
Model 6 ^l s	1	1.00 (0.83 to 1.20)	1.30 (1.06 to 1.62)	.016	1.13 (1.03 to 1.23)

^aOR = odds ratio.

^bMorning: 5:00 AM to 10:59 AM, midday: 11:00 AM to 4:59 PM, evening: 5:00 PM to 4:59 AM.

^cAbdominal obesity: waist circumference \geq 102 cm for men and \geq 88 cm for women.

^dNDNS = National Diet and Nutrition Survey.

^eThe tertiles were categorized based on cutoff points for energy consumption: Morning: first tertile: \leq 13.1% of total energy intake; second tertile: 13.2%-20.6% of total energy intake; third tertile: \geq 20.7% of total energy intake. Midday: first tertile: \leq 30.7% of total energy intake; second tertile: 30.8%-39.6% of total energy intake; third tertile: \geq 39.7% of total energy intake. Evening: first tertile: \leq 42.8% of total energy intake; second tertile: 42.9%-52.1% of total energy intake; third tertile: \geq 52.2% of total energy intake.

^fP value for linear trend across tertiles of dietary contribution.

^gAdjustment model for energy consumption.

^hModel 4: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of total energy from ultra-processed foods.

ⁱModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus energy intake and total energy from ultra-processed foods.

^jModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, total energy intake, plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^kFor ultra-processed foods intake: Morning: first tertile: \leq 7.2% of total energy intake; second tertile: 7.3%-12.6% of total energy intake; third tertile: \geq 12.7% of total energy intake. Midday: first tertile: \leq 16.3% of total energy intake; second tertile: 16.4%-24.5% of total energy intake; third tertile: \geq 24.6% of total energy intake. Evening: first tertile: \leq 17.1% of total energy intake; second tertile: 17.2%-27.1% of total energy intake; third tertile: \geq 27.2% of total energy intake.

^lAdjustment model for ultra-processed foods consumption.

^mModel 4: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus total energy intake.

ⁿModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the midday and evening, and total energy intake.

^oModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the midday and evening plus percentage of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^pModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the morning and evening, and total energy intake.

^qModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the morning and evening, plus % of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.

^rModel 5: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, plus percentage of energy from ultra-processed foods in the morning and midday, and total energy intake.

^sModel 6: adjusted for sex, age, region, survey year, social class occupation, physical activity, smoking, sleep duration, following a weight-loss diet, frequency of alcohol consumption, percentage of energy from ultra-processed foods in the morning and midday, plus % of daily energy from sugar, percentage of daily energy from saturated fat, and daily fruit and vegetable intake in grams.