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Associations of self-reported sleep quality and duration with dietary eating behaviours: a cross-sectional study of 27,263 UK adults

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ABSTRACT

Sub-optimal sleep, whether insufficient, excessive, or poor-quality, is an independent risk factor for obesity, largely through influencing energy intake via altered appetite and reward processing. Less is known about its influence on real-world dietary behaviours. We examined associations of self-reported sleep quality and duration with dietary eating behaviours in a large UK adult cohort. 27,263 adults (median (interquartile range): age, 51.0 (16.0) years; BMI, 25.2 (5.3) kg/m^2; 40.5 % female) completed a standardised health assessment, including self-reported sleep quality (1–10 scale) and duration. Thirteen eating behaviours broadly reflecting emotional/reward-driven eating, dietary disinhibition, food preferences, and meal patterns were assessed via questionnaire. Regression models examined associations between sleep characteristics and eating behaviours, adjusting for age, sex, socioeconomic status, assessment year, and region. Odds ratios (OR) are presented for ordinal/binary outcomes and rate ratios (RR) for count outcomes. Poor sleep quality and short sleep duration were associated with an eating profile suggestive of heightened emotional/reward-driven eating and reduced dietary restraint. This included higher odds/frequency of eating out of boredom, stress, or anger, overeating, skipping meals, and consuming energy-dense foods (OR/RR range: 1.08–3.50, $P \leq 0.018$). Long sleep duration was linked to higher emotional eating (OR range: 1.16–1.19, $P < 0.001$) but showed fewer signs of impulsivity or disinhibited intake. Some behaviours, like adding sugar to food and snacking, were not consistently related to sleep characteristics. In conclusion, short and poor-quality sleep are associated with eating patterns that may increase obesity risk. Interventions targeting sleep extension and quality could support healthier dietary behaviours and appetite regulation.

1. Introduction

Sleep is a dynamic and metabolically active state characterised by intricate behavioural and physiological processes (The Lancet Diabetes & Endocrinology, 2024). In modern society, both sleep quality and duration are increasingly compromised by behavioural, environmental, and occupational disruptors, including stress, inactivity, irregular schedules and excessive exposure to artificial (blue) light. From a health perspective, these two sleep characteristics consistently demonstrate the strongest associations to date with obesity and other non-communicable diseases, with obesity underpinning many chronic conditions (Chaput et al., 2023; Chaput & Stranges, 2024). The relationship between sleep and obesity is U-shaped (Grandner et al., 2015), with greater obesity risk seen in those who sleep too little or too much compared to optimal recommendations (7–8 h per night) (Heslop et al., 2002).

The link between sub-optimal sleep and obesity, whether due to

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insufficient, excessive, or poor-quality sleep, is fundamentally driven by disruptions to energy balance. Energy balance refers to the relationship between energy intake and energy expenditure, with mismatches leading to weight change. While sleep disturbance minimally impacts energy expenditure (Chaput et al., 2023), it may exert a pronounced effect on energy intake. Meta-analyses indicate that insufficient sleep increases energy intake between ~250 and 385 kcal per day (Al Khatib et al., 2017; Zhu et al., 2019). Experimental evidence suggests that links between disrupted sleep and increased energy intake may relate to altered appetite, including homeostatic (metabolic-driven) and hedonic (pleasure- or reward-related) components (Chaput et al., 2023). In tightly controlled laboratory settings, both restricted (Hanlon et al., 2016; Spiegel et al., 2004) and fragmented sleep (Gonnissen et al., 2013) have been shown to increase subjective appetite perceptions and reduce satiety. Moreover, insufficient sleep may elevate circulating levels of ghrelin (Spiegel et al., 2004), an appetite-stimulating hormone, and lower circulating levels of leptin (Mullington et al., 2003; Spiegel et al., 2004) and peptide-YY (Hibi et al., 2017), appetite-suppressing hormones.

The risk of overconsumption may be amplified by insufficient sleep shifting eating behaviour toward a more reward-driven pattern, accompanied by reduced cognitive control. In response to experimental sleep restriction, functional magnetic resonance imaging studies demonstrate heightened activation of reward-related brain regions (e.g. putamen, amygdala, striatum, insula, orbitofrontal cortex) in response to food cues (Benedict et al., 2012; St-Onge et al., 2012). Sleep disruption may therefore make the brain more sensitive to the sight or thought of foods, especially those which are highly palatable and energy dense. This response may be linked to augmented endocannabinoid signalling (Hanlon et al., 2016), which enhances the hedonic value of food. In parallel, insufficient sleep impairs executive functions, including judgement, impulse control, and decision-making (Khan & Al-Jahdali, 2023). This may reduce dietary restraint, increase impulsivity, and raise the likelihood of snacking, emotional eating and poor food choices. Emerging evidence also links sleep disturbance with binge eating behaviours (Kim et al., 2010; Trace et al., 2012) and broader disordered eating, supporting the view that this relationship is bi-directional (Christensen & Short, 2021). These findings suggest that impaired self-regulation may extend beyond everyday overeating to more severe forms of loss-of-control eating. Collectively, these bio-psychological responses may weaken appetite control and increase the risk of weight gain.

Despite growing evidence that sleep disruption alters hormonal, neural, and psychological processes related to appetite, a critical research gap remains. Specifically, it is not fully understood how these responses translate into changes in real-world dietary eating behaviours. This is important as eating behaviours impact diet quality, energy balance and weight management. Further research is needed to investigate the behavioural pathways through which sub-optimal sleep promotes obesity risk, particularly with regards to sleep duration and sleep quality.

Therefore, using data from a large and unique population-based cohort of UK adults, this study examined the associations of self-reported sleep quality and duration with dietary and eating behaviours. We hypothesised that poor sleep quality would be related to eating and dietary behaviours typically associated with poor diet quality and risk of overconsumption. Moreover, this profile would be similar in people reporting too little and excessive sleep.

2. Methods

2.1. Data source and study population

This study is a secondary, cross-sectional analysis of anonymised data provided by a UK-based independent healthcare charity. Data were collected between 2012 and 2016 from 27,386 adults aged 18–91 years who attended a standardised 1–3 h health assessment, including a structured physical examination, designed to evaluate general health and wellbeing. Assessments were conducted by medical doctors and/or health and wellbeing physiologists across multiple UK sites, including hospitals, medical centres, fitness and wellbeing gyms, and corporate settings. The purpose of the assessments was for preventative health, with participants undergoing anthropometric and cardiovascular measures, as well as the assessment of metabolic and biochemical blood markers. Further details of the health measures collected are described below and in previous research using this cohort (Alruwaili et al., 2024). Participants attended assessments for various reasons, including general health screening, management of a medical concern, lifestyle coaching, or as part of an occupational requirement. Prior to assessment, participants were invited to complete a comprehensive pre-assessment questionnaire capturing key demographic and lifestyle information such as dietary intake and behaviours, sleep patterns, and exercise habits. Ethical approval for this secondary data analysis was obtained from the Loughborough University Ethics Review Sub-Committee (project ID: 15414, September 30, 2022), and all participants provided informed consent for the use of their anonymised data in future research. The study methods and results adhere to the updated Strengthening the Reporting of Observational Studies in Epidemiology – Nutritional Epidemiology (STROBE-nut) reporting guidelines for cross-sectional studies (Lachat et al., 2016).

2.2. Outcome variables

The primary outcomes were 13 eating and dietary behaviours which were assessed via self-reported frequency items from the pre-assessment questionnaire. Of these, seven behaviours were evaluated using ordinal Likert-type scales with 3–5 response options, reflecting frequency of engagement from least to most frequent. Four behaviours were measured using count-based responses, indicating the number of times per day or days per week the behaviour occurred. The remaining two items utilised nominal or binary response formats, with answer options including ‘yes’, ‘no’, or ‘it varies’. These outcomes were chosen because they capture aspects of eating behaviour, such as meal timing, appetite control, and preferences for rewarding or energy-dense foods, that are thought to be influenced by sleep duration and quality (Chaput et al., 2023; St-Onge et al., 2012). A full list of the eating and dietary behaviour items, along with their corresponding response formats and eating behaviour constructs, is presented in Table 1.

2.3. Exposure variables

The pre-assessment questionnaire gathered detailed information on participants’ lifestyle behaviours. The study’s co-primary exposure variables were self-reported habitual sleep quality and duration. Sleep quality was assessed using a 1 to 10 Likert scale with the question ‘Do you feel good about the quality of your sleep?’, where 1 indicated ‘Almost never’ and 10 indicated ‘Almost always’. Sequential pairs of number ratings were then combined to form five sleep quality categories: ‘Very poor (1–2)’, ‘Poor (3–4)’, ‘Average (5–6)’, ‘Good (7–8)’ and ‘Very good (9–10)’. As a concept, sleep quality is defined as an individual’s overall satisfaction with their entire sleep experience, including the duration, latency, efficiency, and wake after sleep onset (Nelson et al., 2022). Sleep duration was calculated in hours from self-reported sleep and wake times on a normal day (including weekdays and weekend days) and subsequently stratified into the following categories: ‘Short (<7 h)’, ‘Average (7–8 h)’, and ‘Long (>8 h)’. The >8 h threshold for long sleep was selected as an alternative to current recommendations (>9 h) for two key reasons. First, this approach preserved sufficient statistical power for more reliable estimates, as only a small proportion of the present sample reported sleeping >9 h (~2 %). Second, several large-scale meta-analyses of observational studies have demonstrated that sleep durations >8 h are consistently associated with

Table 1
The eating and dietary behaviour questions and response options included in the pre-assessment questionnaire and used as outcome variables in the present study.

Question	Response type	Response options	Regression model
1. Do you ever treat yourself to food as a reward or to cheer yourself up?	Ordinal (Likert scale)	1. Never 2. Now and then 3. Yes, often	Multinomial logistic (sleep quality)/Ordinal logistic (sleep duration)
2. Do you eat out of boredom, frustration, anger or stress, even when you are not actually hungry?	Ordinal (Likert scale)	1. Never 2. Now and then 3. Yes, often	Multinomial logistic (sleep quality)/Ordinal logistic (sleep duration)
3. Looking back over the last few weeks have you found yourself overeating?	Categorical	1. No 2. Yes	Binary logistic
4. How many meals do you eat each day during the week? Also include any snacks you eat between main meals.	Count	___ meals per day	Poisson
5. How many days a week do you eat something sweet between meals?	Count	___ days per week	Poisson
6. How often do you snack between main meals?	Ordinal (Likert scale)	1. (Almost) never 2. Less than once a week 3. Once a week. 4. Several times a week 5. (Almost) every day	Ordinal logistic
7. How often do you go longer than 3 h without food?	Ordinal (Likert scale)	1. Never 2. Sometimes 3. Regularly	Ordinal logistic
8. Do you find it hard to leave something on your plate?	Categorical	1. No 2. It varies 3. Yes	Multinomial logistic
9. How often do you skip meals?	Ordinal (Likert scale)	1. Never 2. Less than once to three times a month 3. Once to three times a month 4. At least once a week	Ordinal logistic
10. How often do you add salt to your food?	Ordinal (Likert scale)	1. (Almost) never 2. Occasionally 3. (Almost) always	Ordinal logistic
11. How often do you add sugar to your food?	Ordinal (Likert scale)	1. (Almost) never 2. Occasionally 3. (Almost) always	Ordinal logistic
12. How many days a week do you eat something sweet for dessert after a meal?	Count	___ days per week	Poisson
13. On average how many times per week do you eat fried food?	Count	___ times per week	Poisson

adverse health outcomes, and have frequently adopted >8 h as an alternative threshold for long sleep (Jike et al., 2018; Liu et al., 2017; Yin et al., 2017). In accordance with data cleaning approaches in large-scale epidemiological datasets (e.g. NHANES (CDC, 2024)), we excluded participants reporting sleep durations <3 h or >14 h to remove implausible self-reports.

2.4. Covariates

Several covariates were adjusted for, including age, sex, socioeconomic status (SES), year of assessment, and the UK region in which the health assessment took place. Age was calculated as the time between each participant's date of birth and the date of their assessment. Sex was self-reported as male or female. SES was assessed using the relevant national Index of Multiple Deprivation: the English Index of Multiple Deprivation (IMD (Ministry of Housing & L. G, 2019, September 26)), the Scottish Index of Multiple Deprivation (SIMD (ScottishGovernment, 2020)) or the Welsh Index of Multiple Deprivation (WIMD (Welsh Government, 2025)). Each index is constructed from multiple separate indicators grouped into common domains, including income, employment, health, education and skills training, crime, barriers to housing and services, and the living environment. Scores are calculated at the level of small geographic units within each country (lower-layer super output areas in England and Wales; data zones in Scotland) and are ranked according to relative deprivation within each nation. To harmonise deprivation scores across UK nations, each participant was assigned a deprivation decile (ranging from 1 to 10) based on the location of their home address. UK assessment region was represented as a categorical variable with 11 regions covering England (9 regions), Scotland (single region) and Wales (single region). Moderate-to-vigorous exercise levels were calculated in minutes per week by combining the frequency and duration of self-reported moderate- and vigorous-intensity exercise sessions performed in a typical week.

2.5. Statistical analyses

Data were analysed using SPSS version 29 (SPSS Inc., Chicago, Illinois). Normality of the data was determined using Kolmogorov-Smirnov tests and visual inspection of histograms. Participant characteristics are presented as median (interquartile range) for continuous variables or number [percentage] for categorical variables. Where appropriate, Kruskal-Wallis tests and Chi-square tests were used to assess differences between the study cohort stratified by their respective sleep quality and duration categories. The associations of sleep quality and duration with the different eating and dietary behaviours were examined using generalised linear models with robust standard errors. For count outcomes, Poisson regression was used, whereas for binary outcomes, binary logistic regression was used. For ordinal outcomes, ordinal logistic regression was used. However, where the proportional odds assumption was violated or for nominal outcomes, multinomial logistic regression was used, and estimates are presented for individual categories. Models were performed both unadjusted and with adjustment for age (continuous), sex (binary), SES (ordinal), assessment year (ordinal), and UK region of assessment (nominal). Data are presented as odds ratios (OR) and corresponding 95 % confidence intervals (CI), or rate ratios (RR) and corresponding 95 % CI for Poisson regression. The reference group (i.e., an OR or RR = 1.00) was assigned as 'Very good (9–10)' for sleep quality and 'Average (7–8 h)' for sleep duration. Exact *P*-values are presented for each outcome to facilitate interpretation alongside estimates and 95 % CI. Null hypothesis testing against traditional significance thresholds was not performed in line with guidance from the

Table 2
Participant characteristics of the study cohort stratified by self-reported sleep quality.

	Sleep quality (1–10); $n = 27,263$				
	Very poor (1–2) $n = 1909$	Poor (3–4) $n = 2916$	Average (5–6) $n = 8664$	Good (7–8) $n = 8376$	Very good (9–10) $n = 5398$
Age (years)	40.0 (17.0)	41.0 (16.0)	41.0 (16.0)	41.0 (16.0)	41.0 (16.0)
Sex					
Female [%]	737 [38.6]	1194 [40.9]	3499 [40.4]	3361 [40.1]	2260 [41.9]
Male [%]	1172 [61.4]	1722 [59.1]	5165 [59.6]	5015 [59.9]	3138 [58.1]
SES (decile)	4 (4)	4 (4)	4 (4)	4 (4)	4 (4)
BMI (kg/m^2)	25.2 (5.2)	25.1 (5.2)	25.2 (5.3)	25.3 (5.3)	25.3 (5.3)
Obesity (BMI ≥ 30.0 kg/m^2)					
Yes [%]	297 [15.6]	438 [15.0]	1303 [15.0]	1234 [14.7]	850 [15.7]
No [%]	1612 [84.4]	2478 [85.0]	7361 [85.0]	7142 [85.3]	4548 [84.3]
Moderate-to-vigorous exercise (mins/wk)[a]	160 (225)	175 (210)	180 (210)	190 (200)	200 (225)
Eating and dietary behaviours					
1. Do you ever treat yourself to food as a reward or to cheer yourself up?					
Never [%]	717 [37.6]	1054 [36.2]	3291 [38.0]	3564 [42.6]	2588 [47.9]
Now and then [%]	884 [46.3]	1424 [48.8]	4321 [49.9]	4019 [48.0]	2351 [43.6]
Yes, often [%]	308 [16.1]	438 [15.0]	1052 [12.1]	793 [9.4]	459 [8.5]
2. Do you eat out of boredom, frustration, anger or stress, even when you are not actually hungry?					
Never [%]	749 [39.2]	1158 [39.7]	3947 [45.6]	4335 [51.7]	3131 [58.0]
Now and then [%]	778 [40.8]	1256 [43.1]	3589 [41.4]	3255 [38.9]	1809 [33.5]
Yes, often [%]	382 [20.0]	502 [17.2]	1128 [13.0]	786 [9.4]	458 [8.5]
3. Looking back over the last few weeks have you found yourself overeating?					
No [%]	1053 [55.2]	1647 [56.5]	5362 [61.9]	5571 [66.5]	3855 [71.4]
Yes [%]	856 [44.8]	1269 [43.5]	3302 [38.1]	2805 [33.5]	1543 [28.6]
4. How many meals do you eat each day during the week? Also include any snacks you eat between main meals.					
	4 (1)	4 (1)	3 (1)	3 (1)	3 (1)
5. How many days per week do you eat something sweet between meals?					
	3 (3)	3 (3)	3 (3)	3 (3)	2 (3)
6. How often do you snack between main meals?					
(Almost) never [%]	254 [13.3]	350 [12.0]	1048 [12.1]	1166 [14.0]	917 [17.0]
Less than once a week [%]	145 [7.6]	274 [9.5]	880 [10.1]	857 [10.2]	561 [10.4]
Once a week [%]	240 [12.6]	389 [13.3]	1235 [14.3]	1265 [15.1]	739 [13.7]
Several times a week [%]	689 [36.1]	1022 [35.0]	3036 [35.0]	2842 [33.9]	1746 [32.3]
(Almost) every day [%]	581 [30.4]	881 [30.2]	2465 [28.5]	2246 [26.8]	1435 [26.6]
7. How often do you go longer than 3 h without food?					
Never [%]	105 [5.5]	125 [4.3]	362 [4.2]	350 [4.2]	299 [5.5]
Sometimes [%]	705 [36.9]	1131 [38.8]	3406 [39.3]	3203 [38.2]	1972 [36.6]
Regularly [%]	1099 [57.6]	1660 [56.9]	4896 [56.5]	4823 [57.6]	3127 [57.9]
8. Do you find it hard to leave something on your plate?					
No [%]	560 [29.3]	746 [25.6]	2605 [30.1]	2488 [29.7]	1712 [31.7]
It varies [%]	348 [18.2]	572 [19.6]	1788 [20.6]	1818 [21.7]	1103 [20.4]
Yes [%]	1001 [52.4]	1598 [54.8]	4271 [49.3]	4070 [48.6]	2583 [47.9]
9. How often do you skip meals?					
Never [%]	662 [34.7]	1034 [35.4]	3264 [37.7]	3507 [41.9]	2586 [47.9]
Less than once to three times a month [%]	370 [19.4]	650 [22.3]	1925 [22.2]	2001 [23.9]	1180 [21.9]
Once to three times a month [%]	247 [12.9]	358 [12.3]	1102 [12.7]	1028 [12.2]	564 [10.4]
At least once a week [%]	630 [33.0]	874 [30.0]	2373 [27.4]	1840 [22.0]	1068 [19.8]
10. How often do you add salt to your food?					
(Almost) never [%]	833 [43.6]	1243 [42.6]	3707 [42.8]	3751 [44.8]	2461 [45.6]
Occasionally [%]	686 [35.9]	1138 [39.0]	3342 [38.6]	3173 [37.9]	1968 [36.4]
(Almost) always [%]	390 [20.4]	535 [18.4]	1615 [18.6]	1452 [17.3]	969 [18.0]
11. How often do you add sugar to your food?					
(Almost) never [%]	1676 [87.8]	2554 [87.6]	7563 [87.3]	7374 [88.0]	4777 [88.5]
Occasionally [%]	211 [11.1]	328 [11.2]	1006 [11.6]	920 [11.0]	569 [10.5]
(Almost) always [%]	22 [1.1]	34 [1.2]	95 [1.1]	82 [1.0]	52 [1.0]
12. How many days a week do you eat something sweet for dessert after a meal?					
	3 (3)	3 (2)	3 (2)	3 (2)	3 (3)
13. On average how many times per week do you eat fried food?					
	2 (2)	2 (2)	2 (2)	2 (1)	2 (1)

Data are presented as median (interquartile range) for continuous variables, or number [column percentage] for non-continuous variables.
[a] Moderate-to-vigorous exercise data are available for $n = 19,783$ only. BMI, body mass index; SES, socioeconomic status.

American Statistical Association and current practice in leading Epidemiology journals (Sterne, 2001; Wasserstein & Lazar, 2016).

Given that physical activity can also influence both the exposure and outcome variables (Dolezal et al., 2017; Joseph et al., 2011), a sensitivity analysis was performed in a sub-set of participants with additional adjustment for moderate-to-vigorous exercise levels (continuous). Furthermore, to explore whether associations differed across BMI groups, all adjusted main models were repeated stratified by BMI category (normal weight: <25 kg m^{-2}; overweight: 25.0–29.9 kg m^{-2}; obesity: ≥30.0 kg m^{-2}). In parallel, we formally assessed effect modification by BMI by including interaction terms between continuous BMI and sleep quality or duration in the adjusted main models. Interaction *P*-values were reported separately from the stratified results.

3. Results

Overall, 27,386 male and female participants had available data for the main study variables. Subsequently, 123 participants were excluded

Table 3
Participant characteristics of the study cohort stratified by self-reported sleep duration.

	Sleep duration; $n = 27,263$		
	Short (>7 h) $n = 6077$	Normal (7–8 h) $n = 17,152$	Long (>8 h) $n = 4034$
Age (years)	41.0 (17.0)	41.0 (16.0)	41.0 (16.0)
Sex			
Female [%]	2384 [39.2]	6999 [40.8]	1668 [41.3]
Male [%]	3693 [60.8]	10153 [59.2]	2366 [58.7]
SES (decile)	4 (4)	4 (4)	4 (4)
BMI (kg/m^2)	25.3 (5.2)	25.2 (5.3)	25.2 (5.3)
Obesity (BMI ≥ 30.0 kg/m^2)			
Yes [%]	939 [15.5]	2580 [15.0]	603 [14.9]
No [%]	5138 [84.5]	14572 [85.0]	3431 [85.1]
Moderate-to-vigorous exercise (mins/wk)[a]	180 (210)	180 (200)	180 (214)
Eating and dietary behaviours			
1. Do you ever treat yourself to food as a reward or to cheer yourself up?			
Never [%]	2558 [42.1]	7122 [41.5]	1534 [38.0]
Now and then [%]	2864 [47.1]	8186 [47.7]	1949 [48.3]
Yes, often [%]	655 [10.8]	1844 [10.8]	551 [13.7]
2. Do you eat out of boredom, frustration, anger or stress, even when you are not actually hungry?			
Never [%]	2871 [47.3]	8558 [49.9]	1891 [46.9]
Now and then [%]	2385 [39.2]	6716 [39.2]	1586 [39.3]
Yes, often [%]	821 [13.5]	1878 [10.9]	557 [13.8]
3. Looking back over the last few weeks have you found yourself overeating?			
No [%]	3662 [60.3]	11189 [65.2]	2637 [65.4]
Yes [%]	2415 [39.7]	5963 [34.8]	1397 [34.6]
4. How many meals do you eat each day during the week? Also include any snacks you eat between main meals.			
	3 (1)	3 (1)	3 (1)
5. How many days per week do you eat something sweet between meals?			
	3 (3)	3 (3)	3 (3)
6. How often do you snack between main meals?			
(Almost) never [%]	829 [13.6]	2371 [13.8]	535 [13.3]
Less than once a week [%]	591 [9.7]	1708 [10.0]	418 [10.4]
Once a week [%]	872 [14.3]	2410 [14.0]	586 [14.5]
Several times a week [%]	2099 [34.5]	5859 [34.2]	1377 [34.1]
(Almost) every day [%]	1686 [27.7]	4804 [28.0]	1118 [27.7]
7. How often do you go longer than 3 h without food?			
Never [%]	219 [3.6]	779 [4.5]	243 [6.0]
Sometimes [%]	2045 [33.7]	6688 [39.0]	1684 [41.7]
Regularly [%]	3813 [62.7]	9685 [56.5]	2107 [52.3]
8. Do you find it hard to leave something on your plate?			
No [%]	1665 [27.4]	5168 [30.2]	1278 [31.7]
It varies [%]	1214 [20.0]	3523 [20.5]	892 [22.1]
Yes [%]	3198 [52.6]	8461 [49.3]	1864 [46.2]
9. How often do you skip meals?			
Never [%]	2051 [33.8]	7296 [42.5]	1706 [42.3]
Less than once to three times a month [%]	1347 [22.2]	3915 [22.8]	864 [21.4]
Once to three times a month [%]	814 [13.4]	2026 [11.9]	459 [11.4]
At least once a week [%]	1865 [30.6]	3915 [22.8]	1005 [24.9]
10. How often do you add salt to your food?			
(Almost) never [%]	2705 [44.5]	7557 [44.1]	1733 [43.0]
Occasionally [%]	2283 [37.6]	6523 [38.0]	1501 [37.2]
(Almost) always [%]	1089 [17.9]	3072 [17.9]	800 [19.8]
11. How often do you add sugar to your food?			
(Almost) never [%]	5306 [87.3]	15107 [88.1]	3531 [87.5]
Occasionally [%]	715 [11.8]	1856 [10.8]	463 [11.5]
(Almost) always [%]	56 [0.9]	189 [1.1]	40 [1.0]
12. How many days a week do you eat something sweet for dessert after a meal?			
	3 (2)	3 (3)	3 (3)
13. On average how many times per week do you eat fried food?			
	2 (2)	2 (1)	2 (1)

Data are presented as median (interquartile range) for continuous variables, or number [column percentage] for non-continuous variables.
[a] Moderate-to-vigorous exercise data are available for $n = 19,783$ only. BMI, body mass index; SES, socioeconomic status.

for a self-reported sleep duration <3 h or >14 h; therefore, 27,263 participants were included in the main analyses. Moderate-to-vigorous exercise data were missing for $n = 7480$, thus 19,783 participants were included in the sensitivity analysis.

The characteristics of the main study cohort stratified by self-reported sleep quality and sleep duration are presented in Tables 2 and 3, respectively. When stratified by both sleep quality and duration, age, sex, IMD, BMI and obesity status were similar across the different sleep quality and duration categories (all $P \geq 0.052$). However, median moderate-to-vigorous exercise levels were progressively lower with poorer sleep quality ($P < 0.001$). In contrast, despite identical median exercise levels across sleep duration categories, significant differences were indicated between groups ($P = 0.009$), likely reflecting differences in variability or skewness rather than central tendency alone.

3.1. Sleep quality

The adjusted and unadjusted associations of sleep quality with the dietary eating behaviours are presented in Fig. 1 and Supplementary Table S1, respectively. In the adjusted models, poorer sleep quality was

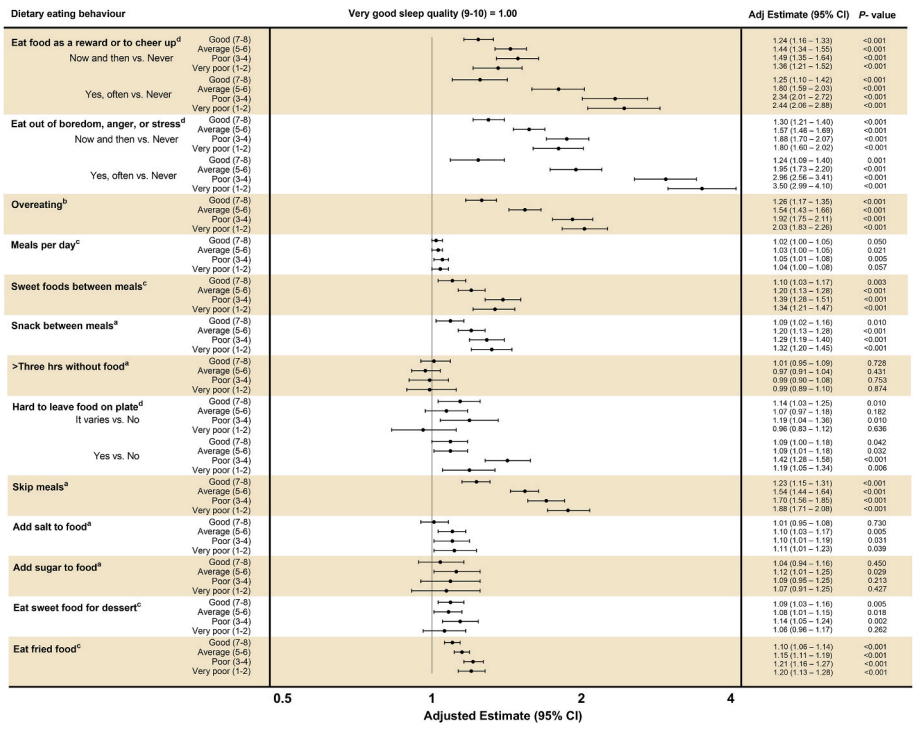

Fig. 1. Forest plot of the adjusted associations of sleep quality with the different dietary eating behaviours.
Generalised linear models with robust standard errors were adjusted for age, sex, SES, assessment year and UK region of assessment. Data are presented as adjusted odds ratios and 95 % CI for estimates from [a]ordinal logistic regression, [b]binary logistic regression and [d]multinomial logistic regression models, and as adjusted rate ratios and 95 % CI for estimates from [c]Poisson regression models. The 'Very good (9–10)' sleep quality category was assigned as the reference group (i.e., an adjusted odds ratio or rate ratio = 1.00 where appropriate). CI, confidence interval; SES, socioeconomic status

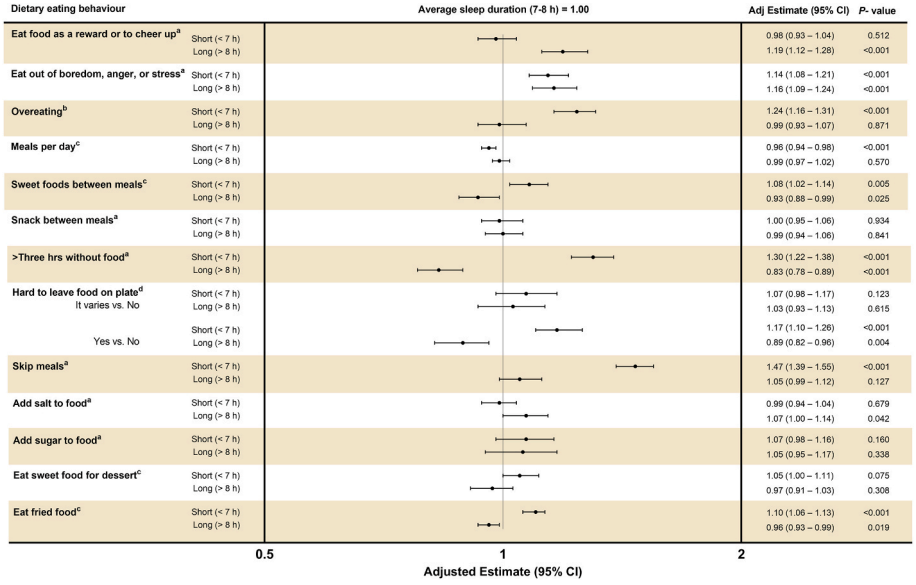

Fig. 2. Forest plot of the adjusted associations of sleep duration with the different dietary eating behaviours.
Generalised linear models with robust standard errors were adjusted for age, sex, SES, assessment year and UK region of assessment. Data are presented as adjusted odds ratios and 95 % CI for estimates from [a]ordinal logistic regression, [b]binary logistic regression and [d]multinomial logistic regression models, and as adjusted rate ratios and 95 % CI for estimates from [c]Poisson regression models. The 'Average (7–8 h)' sleep duration category was assigned as the reference group (i.e., an adjusted odds ratio or rate ratio = 1.00 where appropriate). CI, confidence interval; SES, socioeconomic status

progressively associated with higher odds of eating food as a reward or to cheer up (OR range: 1.25 to 2.44, $P < 0.001$), eating out of boredom, stress, or anger (OR range: 1.24 to 3.50, $P < 0.001$), overeating (OR range: 1.26 to 2.03, $P < 0.001$), snacking (OR range: 1.09 to 1.32, $P \leq 0.010$), and skipping meals (OR range: 1.23 to 1.88, $P < 0.001$). Furthermore, compared to participants with very good sleep quality, participants with poorer sleep quality had higher odds of finding it hard to leave food on their plate (OR range: 1.09 to 1.42, $P \leq 0.042$) and adding salt to food (OR range: 1.10 to 1.11, $P \leq 0.039$). Poorer sleep quality was also progressively associated with eating sweet foods

between meals (RR range: 1.10 to 1.39, $P \leq 0.003$) and eating fried foods (RR range: 1.10 to 1.21, $P < 0.001$) on more days per week. Additionally, with the exception of the very poor sleep quality category, poorer sleep quality was associated with consuming more meals per day (RR range: 1.02 to 1.05, $P \leq 0.050$) and eating sweet foods for dessert on more days per week (RR range: 1.08 to 1.14, $P \leq 0.018$) when compared to participants with very good sleep quality. No associations were observed between sleep quality and going more than 3 h without food, while associations with adding sugar to food were weak and inconsistent across sleep quality categories.

3.2. Sleep duration

The adjusted and unadjusted associations of sleep duration with the dietary eating behaviours are presented in Fig. 2 and Supplementary Table S2, respectively. In the adjusted models, short sleep duration (<7 h) was associated with higher odds of eating out of boredom, stress, or anger (OR = 1.14, $P < 0.001$), overeating (OR = 1.24, $P < 0.001$), going more than 3 h without food (OR = 1.30, $P < 0.001$), finding it hard to leave food on the plate (OR = 1.17, $P < 0.001$), and skipping meals (OR = 1.47, $P < 0.001$). Short sleep duration was also associated with eating sweet foods between meals (RR = 1.08, $P = 0.005$) and eating fried foods (RR = 1.10, $P < 0.001$) on more days per week. Furthermore, short sleepers consumed fewer meals per day (RR = 0.96, $P < 0.001$) when compared to participants with average sleep duration (7–8 h).

Long sleep duration (>8 h) was associated with higher odds of eating food as a reward or to cheer up (OR = 1.19, $P < 0.001$), eating out of boredom, stress, or anger (OR = 1.16, $P < 0.001$), and adding salt to food (OR = 1.07, $P = 0.042$). Furthermore, long sleepers had lower odds of going more than 3 h without food (OR = 0.83, $P < 0.001$) and finding it hard to leave food on their plate (OR = 0.89, $P = 0.004$) compared to participants with average sleep duration. Long sleep duration was also associated with eating sweet foods between meals (RR = 0.93, $P = 0.025$) and eating fried foods (RR = 0.96, $P = 0.019$) on fewer days per week. No associations were observed between sleep duration and snacking between meals, adding sugar to food, or eating sweet foods for dessert.

3.3. Sensitivity analysis

Including moderate-to-vigorous exercise as an additional covariate in a sub-set of participants did not fundamentally alter the pattern of results or interpretation of the models for either sleep quality or sleep duration. The overall direction and strength of associations remained consistent for most outcomes, with only a small number of associations differing from the main analyses (see Supplementary Tables S3 and S4 for the sleep quality and sleep duration sensitivity analyses, respectively).

The stratified analyses by BMI category are shown in Supplementary Tables S5-S7 for sleep quality and Supplementary Tables S8-S10 for sleep duration. Overall, the direction and magnitude of associations between sleep quality or duration and eating behaviours were broadly similar across BMI groups. While some individual estimates varied slightly in strength across BMI categories, particularly for emotional eating behaviours, there was no systematic divergence which suggested a distinct behavioural profile unique to any single BMI group. Formal interaction tests between continuous BMI and sleep quality or duration supported these observations, with non-significant interaction terms across 12 eating behaviours for sleep quality ($P \geq 0.185$) and 11 eating behaviours for sleep duration ($P \geq 0.157$). Significant interaction terms were found between BMI and sleep quality for eating fried food ($P = 0.036$) and between BMI and sleep duration for both eating out of boredom, stress, or anger ($P = 0.022$) and difficulty leaving food on the plate ($P = 0.026$).

4. Discussion

As hypothesised, the primary findings of the present study were that both poor sleep quality and short sleep duration were associated with a general pattern of eating behaviours suggestive of heightened hedonic drive, reduced dietary restraint, and disrupted meal patterns - behaviours commonly linked to overconsumption and poor diet quality. Conversely, long sleep duration was associated with a mixed behavioural profile, marked by some higher emotional or reward-driven eating behaviours but fewer indicators of impulsivity or irregular intake. These findings support the notion that poor sleep, whether in terms of quality or short duration, may contribute to dysregulated eating habits through shared neurocognitive and behavioural mechanisms. In contrast, long sleep duration may reflect distinct differences in underlying influences, such as psychological or health-related factors, rather than impaired behavioural control alone.

Poorer sleep quality was associated with eating behaviours related to emotional and reward-driven eating, and a preference for palatable foods. The most consistent findings were for emotional and hedonic eating, with clear dose-response relationships: poorer sleep quality was progressively linked to greater odds of eating for reward, eating out of boredom, stress or anger, snacking, and overeating. An increased tendency to eat sweet foods for dessert was also observed. These results align with existing evidence linking poor sleep quality to emotional eating (Konttinen, 2020; Zhou et al., 2024) and may reflect direct effects, via disrupted neural circuits involved in emotional regulation (Morris et al., 2001; Yoo et al., 2007) and reward processing (Benedict et al., 2012; St-Onge et al., 2012), or indirect effects, through shared underlying factors such as stress (Konttinen, 2020) or depression (Zhou et al., 2024). These findings offer new insights into the associations between sleep quality and real-world eating behaviours that could reflect emotional coping, reduced dietary control, and heightened responsiveness to food reward.

We also found poor sleep quality to be associated with eating behaviours characteristic of dietary disinhibition (i.e. a tendency to overeat in response to a stimuli) and impaired control of eating. Individuals with poorer sleep were more likely to report difficulty leaving food uneaten and a greater tendency to skip meals. While meal skipping can sometimes reflect intentional restraint or effective self-regulation of intake, it may also represent irregular or unstructured eating patterns that disrupt appetite regulation (Alhussain et al., 2016) and increase the likelihood of rebound overeating later in the day (Leidy & Campbell, 2011). Despite this, poorer sleep quality was not related to spending more than 3 h without food. This pattern supports the notion of more fragmented eating habits - skipping structured meals but compensating through grazing or unstructured snacking across the day, resulting in similar overall intervals between eating occasions. Given our cross-sectional design, it is not possible to determine whether meal skipping in this sample reflects successful restriction or contributes to later overconsumption. When considered alongside greater odds of overeating, these behaviours may indicate reduced cognitive control and a shift away from structured, goal-directed eating in those with poorer sleep. Alternatively, for some individuals, restriction may reflect an effort to compensate for previous overconsumption or a form of goal-directed restraint. Future work should explore both possibilities, including whether restriction contributes to overeating or exerts independent effects on appetite and energy regulation.

Poor sleep quality may also impair executive function (Sen & Tai, 2023), reducing inhibitory control, weakening decision-making, and increasing impulsivity around food (Dohle et al., 2018). This can make it harder to resist food cues or regulate intake once eating begins, contributing to difficulties leaving food uneaten and greater susceptibility to opportunistic or emotionally driven eating. Additionally, poor sleep disrupts appetite-related hormones, increasing ghrelin (Spiegel et al., 2004) and decreasing leptin (Mullington et al., 2003; Spiegel et al., 2004), promoting heightened hunger and reduced satiety. Together,

these cognitive and hormonal changes may intensify the drive to eat beyond physiological need, particularly in environments rich in palatable foods.

Our analyses also showed that poorer sleep quality was associated with eating behaviours reflecting a preference for energy-dense, salty and sweet foods. Dose-response relationships were observed for greater consumption of fried foods and sweet snacks between meals. Individuals with poorer sleep had higher odds of adding salt to food, though associations with adding sugar were inconsistent; possibly due to cultural habits such as adding sugar to tea and coffee in the UK. These findings align with a recent systematic review reporting that poor sleep quality is linked to less healthy dietary patterns, characterised by higher intakes of sugar, saturated fat, and processed food, and lower micronutrient intake (Godos et al., 2021). Our results extend this work by identifying specific eating behaviours which may underlie the less healthy dietary patterns among individuals with poor sleep quality.

Beyond sleep quality, short (<7 h) and long (>8 h) sleep durations were differentially associated with eating behaviours, with short sleep displaying a more consistently adverse profile. Short sleepers exhibited patterns suggestive of heightened hedonic drive, reduced dietary restraint, and disrupted intake. Specifically, they had higher odds of eating in response to negative emotions (e.g., boredom, stress, or anger), overeating, difficulty leaving food uneaten, and skipping meals. Short sleep was also associated with greater consumption of fried and sweet foods between meals, and irregular meal patterns, including fewer meals per day and longer intervals without eating. This profile closely resembled that seen with poor sleep quality, likely reflecting overlapping mechanisms given that sleep duration is a key component of sleep quality. Together, these behaviours suggest that insufficient sleep may compromise self-regulatory control of eating and promote more impulsive, reward-driven choices. Therefore, targeting short sleep through sleep extension interventions could promote healthier eating behaviours and potentially better weight management.

In contrast, long sleep duration (>8 h) was associated with a more mixed behavioural profile. While long sleepers had higher odds of eating in response to negative emotions, or as a reward, they did not exhibit the same behaviours suggestive of disinhibition or greater intake seen with short sleepers. Compared with the average sleep duration (7–8 h), long sleep was linked with lower odds of going extended periods without food and lower consumption of fried and sweet foods between meals. These findings suggest that although some hedonic tendencies may exist, long sleep is not strongly related to impaired appetite control or impulsive eating.

While this eating behaviour profile could appear 'healthier' or more structured than that of short sleepers, it is also possible that, rather than poor behavioural control, underlying psychological or lifestyle factors, such as low mood, depression, chronic fatigue, or subclinical illness (e.g. disordered/restrictive eating) (Lee et al., 2015; Ohayon et al., 2013; Patel et al., 2006), could contribute to both excessive sleep and reduced food intake. Unlike short sleep, which disrupts executive function (Sen & Tai, 2023) and appetite-related hormones (Mullington et al., 2003; Spiegel et al., 2004), long sleep may not elicit the same physiological or cognitive vulnerabilities that lead to the same eating patterns as poor quality or insufficient sleep. The associations observed for long sleep could also be slightly attenuated by our use of a shorter threshold than current guidelines (>8 h vs. >9 h). However, previous large-scale analyses have frequently applied this cut-off when longer sleep durations are uncommon and have consistently linked >8 h with adverse health outcomes including all-cause mortality, stroke, and coronary heart disease (Jike et al., 2018; Liu et al., 2017; Yin et al., 2017). Thus, our approach reflects both methodological pragmatism and alignment with prior research.

These sleep profiles have important implications for clinical intervention and public health. Individuals with poor quality or short sleep may benefit from strategies targeting sleep hygiene and impulse control around food, whereas long sleepers may require broader assessment for underlying psychological or health conditions (e.g. poor mental health, low mood, fatigue, sub-clinical comorbidities) that influence both sleep and eating patterns. Beyond general sleep hygiene advice, evidence-based behavioural interventions such as sleep restriction, titration, and stimulus control may more directly target core mechanisms of poor sleep quality (Walker et al., 2022) and, in turn, promote healthier eating patterns, though this requires confirmation in future studies. This aligns with emerging research emphasising personalised sleep recommendations that consider individual sleep needs, chronotype and behavioural context to improve sleep health and related eating behaviours (Garbarino & Bragazzi, 2024). Screening for poor sleep or insufficient duration might help identify individuals at risk of suboptimal eating behaviours and weight gain. Given established links between sleep disruption and binge eating tendencies (Kim et al., 2010; Trace et al., 2012), screening for loss of control over eating may also be warranted. Prospective studies should now examine how long-term changes in sleep relate to eating behaviours and body weight, and clarify the mechanisms involved.

Although the average BMI of participants fell within the healthy range, the sample included individuals across the weight spectrum. This context is important, as the observed associations between suboptimal sleep and maladaptive eating behaviours may represent early behavioural pathways relevant to obesity prevention and risk mitigation. In the present analyses, stratification by BMI category and formal interaction tests indicated that these relationships were broadly similar across BMI categories. Although interactions were detected for eating fried food, eating out of boredom, and difficulty leaving food on the plate - with slightly weaker associations in obesity - their magnitudes were small and did not form a coherent pattern across behaviours. These findings suggest that behavioural pathways linking sleep and eating appear largely consistent irrespective of BMI status. Furthermore, the presence of these maladaptive eating patterns even in individuals with normal weight could suggest that such behaviours arise early, highlighting opportunities for early identification and intervention to mitigate future weight gain and obesity development.

Key strengths of this study include its large, population-based sample of UK adults and the use of a unique dataset capturing a wide-range of real-world eating behaviours. However, several limitations should be acknowledged. First, the cross-sectional design limits causal inference, and self-reported measures of sleep and eating may introduce recall or reporting bias. Furthermore, with our cross-sectional design, individual differences in sleep need and changes in sleep behaviours over time could not be captured. Such variability may influence the observed associations, and longitudinal or experimental studies are needed to clarify how within-person changes in sleep affect eating behaviours. Relatedly, the questions assessing sleep quality and duration captured only 'average' responses across days, masking day-to-day variability in sleep. This is important, as inconsistent sleep patterns are linked to appetite dysregulation (Chaput et al., 2023). Consequently, individuals with more variable sleep may have been assessed less accurately, potentially weakening observed associations with eating behaviours. Although models were adjusted for key covariates, residual confounding from unmeasured factors (e.g. mental health, stress, or shift work) cannot be excluded and could independently influence both sleep and eating behaviours, suggesting that the observed associations may not be directly causal. Moreover, the possibility of bidirectional relationships cannot be excluded; for instance, emotionally-driven or irregular eating may also impair sleep. Sleep quality was assessed using a single, unvalidated item, which may not fully capture the complexity of sleep experiences, including pre-existing sleep disorders. Use of a validated tool, such as the Pittsburgh Sleep Quality Index (Buysse et al., 1989), could improve measurement reliability. Additionally, although some studies have defined long sleep as >8 h per night, this threshold is lower than other studies and may lead to misclassification of typical sleepers as long sleepers, thereby diluting observed associations. Finally, as participants were accessed from an independent healthcare provider, they likely

represent a more health-conscious and affluent cohort (similar to the UK Biobank (Keyes & Westreich, 2019)), which may limit generalisability to the general population.

In summary, both poor sleep quality and short sleep duration were consistently associated with real-world eating behaviour patterns related to overconsumption, including heightened emotional and reward-driven eating, reduced dietary restraint, and irregular intake patterns. In contrast, long sleep showed a more mixed behavioural profile, suggesting different underlying mechanisms. Collectively, these findings highlight the relevance of both sleep quality and quantity in shaping dietary behaviours and support recognising sleep as a modifiable factor in strategies to improve diet and reduce obesity risk. Future research should explore whether improving sleep leads to meaningful changes in eating patterns, potentially offering a novel, accessible target for obesity prevention and dietary intervention.

CRediT authorship contribution statement

Scott A. Willis: Writing – review & editing, Writing – original draft, Methodology, Data curation, Conceptualization. **Arwa Alruwaili:** Writing – review & editing, Formal analysis, Conceptualization. **Iuliana Hartescu:** Writing – review & editing, Methodology, Conceptualization. **Kevin Deighton:** Writing – review & editing, Methodology, Data curation. **Christopher Goodwin:** Writing – review & editing, Methodology, Data curation. **Joseph Henson:** Writing – review & editing, Methodology, Formal analysis. **Alice E. Thackray:** Writing – review & editing, Methodology, Formal analysis. **David J. Stensel:** Writing – review & editing, Resources, Funding acquisition. **James A. King:** Writing – review & editing, Writing – original draft, Project administration, Funding acquisition, Conceptualization.

Data statement

The data that support the findings of this study are not openly available due to reasons of commercial sensitivity and are available from the corresponding author upon reasonable request.

Ethics statement

All research procedures were performed in compliance with relevant laws and institutional guidelines and have been approved by the Loughborough University Ethics Advisory Committee (project ID: 15414; September 30, 2022).

The privacy rights of human subjects have been observed and informed consent was obtained before individuals took part in this research.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Glossary

BMI	Body Mass Index
OR	Odds Ratio
RR	Rate Ratio
CI	Confidence Interval
SES	Socioeconomic Status
IMD	Index of Multiple Deprivation
SIMD	Scottish Index of Multiple Deprivation
WIMD	Welsh Index of Multiple Deprivation
UK	United Kingdom
NHANES	National Health and Nutrition Examination Survey
SPSS	Statistical Package for the Social Sciences
fMRI	Functional Magnetic Resonance Imaging
STROBE-nut	Strengthening the Reporting of Observational Studies in Epidemiology – Nutritional Epidemiology
MVPA	Moderate-to-Vigorous Physical Activity

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2025.108428.

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