Impact of Late Evening Eating on Metabolic Health in Young Adults

A Cross-Sectional Study Protocol

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Abstract

Late-night eating has become increasingly common among young adults, driven by erratic work and academic schedules, lengthy screen time, evening social activities, and disturbed sleep patterns. Meal timing is now recognised, alongside overall dietary quality and total caloric intake, as an independent determinant of metabolic health ,a field of study broadly termed chrononutrition. This study intends to assess the association between late-night eating habits and selected indicators of metabolic health among young adults aged 18–40 years. A cross-sectional survey will use a structured, pre-validated, pilot-tested questionnaire assessing meal timing, late-night snacking frequency, dietary habits, sleep patterns, physical activity, screen time, and self-reported anthropometric and metabolic health indicators. Because the proposed design is empirical and survey-based, the study is deliberately framed to establish association rather than causation, avoiding the common overreach in popular literature that treats late-night eating as a proven cause of metabolic disease. The findings are projected to clarify the prevalence of late-evening eating in this population, the specific foods most commonly consumed at night, and whether frequent late-night eating clusters with adverse markers of metabolic health, poor sleep, and low physical activity. The results are intended to inform realistic, evidence-based nutrition and lifestyle counselling for young adults and to provide a starting point for future longitudinal or interventional research that can test causal mechanisms more directly.

Keywords: late-night eating, meal timing, chrononutrition, metabolic health, BMI, circadian rhythm, young adults, cross-sectional study.

1. Introduction and Background

1.1 The Global Burden of Metabolic Disease and the Emerging Role of Meal Timing

Obesity, type 2 diabetes, and metabolic syndrome have risen sharply over the past three decades, and this rise is no longer confined to older adults; an increasing share of newly diagnosed cases now occurs in people under the age of 40. Traditionally, intervention and control methods have focused almost exclusively on two levers: how much a person eats (total caloric intake) and what a person eats (macronutrient profile and diet quality). Over the last decade, however, a third lever has drawn growing scientific attention: when a person eats. This field, broadly termed chrononutrition, examines how the timing, frequency, and regularity of food intake interact with the body's internal circadian clock system to influence digestion, hormone secretion, and long-term metabolic outcomes.

Within this system, late-night eating the consumption of substantial food or caloric beverages in the hours close to bedtime has emerged as a specific behavioural pattern of concern. Unlike overall caloric excess, which is a quantitative problem, late-night eating is fundamentally a timing problem: the same meal, consumed at a different hour, appears to carry a different metabolic cost. This distinction matters because it suggests that meal-timing counselling could offer an additional, low-cost avenue for metabolic risk reduction without requiring an outright change in what or how much a person eats.

1.2 Why Young Adults Are a Population of Particular Concern

Young adults (broadly aged 18–40 years) are disproportionately exposed to the upstream drivers of nighttime eating. College and university students frequently study late into the night and use food as a coping mechanism for stress or fatigue. Early-career professionals face irregular office hours, night shifts, and social obligations that push dinner and snacking later into the evening. Across both groups, near-universal smartphone and screen use extends wakefulness well past traditional bedtimes, and each additional hour of wakefulness is, almost by definition, an additional opportunity to eat. Because this population is also at a life stage where lifestyle habits are actively being formed and are more amenable to change than in later adulthood, understanding the scale and correlates of nighttime eating in this specific age group has direct relevance for early, preventive intervention well before clinical metabolic disease develops.

1.3 Structure of This Protocol

The remainder of this protocol is organised as follows. Section 2 reviews the existing epidemiological and mechanistic literature on late-night eating and metabolic health. Section 3 sets out the rationale for the present study and the specific definitional choices made to strengthen it. Section 4 presents a brief conceptual framework linking exposure to outcome. Sections 5 and 6 state the objectives and hypotheses. Section 7 details the suggested methodology, including sample size, sampling procedure, tools, and statistical analysis plan. Sections 8–11 cover ethical issues, anticipated results, limitations, and conclusion.

2. Review of Literature

2.1 Epidemiological Evidence Linking Late-Night Eating to Metabolic Outcomes

A growing number of observational studies across countries and age groups have reported associations between late meal timing and adverse metabolic outcomes. In a large longitudinal cohort of over 8,000 Japanese adults undergoing routine health checkups, both eating dinner immediately before bed and snacking after dinner were independently associated with a higher risk of metabolic syndrome and its individual components (elevated waist circumference, blood pressure, triglycerides, and fasting glucose), with the combination of the two habits carrying the greatest risk.

Consistent with this, a cross-sectional study of young adults in North Macedonia found that among participants who habitually ate dinner after 21:00, the prevalence of overweight was roughly three times higher than among early eaters, alongside a higher prevalence of diagnosed diabetes, elevated cholesterol, fatty liver, hypertension, and polycystic ovary syndrome; the majority of late eaters in that sample also reported that their late meals were high in fat or sugar, suggesting that timing and food choice may compound one another. A university-based survey carried out across multiple institutions in Pakistan similarly linked frequent late-night eating with a broad cluster of self-reported digestive, metabolic, and psychological complaints, with headache, sleep disturbance, low mood, and acid reflux among the most commonly reported issues.

Beyond Asia and Europe, population-based studies from Sweden and the United States have reported that late or evening-heavy eating patterns are associated with roughly 1.6- to 2-fold higher odds of obesity compared with earlier or more evenly distributed eating patterns, even after statistical adjustment for total daily energy intake, indicating that the timing of intake carries explanatory power beyond quantity alone. Adding to these observational findings, a controlled clinical study presented at the SLEEP 2017 conference provided some of the first direct physiological evidence on this question: healthy adults who ate on a consistent late schedule for several weeks, compared with an early-eating schedule, showed unfavourable shifts in body weight, fasting insulin, and cholesterol, even though sleep duration was controlled for in the design ,pointing to meal timing itself, rather than sleep loss alone, as a contributing factor.

2.2 Proposed Biological Mechanisms

Several overlapping physiological mechanisms have been proposed to explain why food timing, independent of quantity, might influence metabolic health.

2.2.1 Circadian Misalignment

The human body operates on an internal ~24-hour circadian clock system, comprising a central “master clock” in the brain and numerous peripheral clocks in metabolically active organs such as the liver, pancreas, gut, and adipose tissue. These peripheral clocks are strongly entrained by the timing of food intake, and eating out of sync with the body's natural rest phase forces metabolically active tissues to process nutrients when they are physiologically primed for rest and repair rather than digestion. This mismatch, termed circadian misalignment, has been linked

in the chrono nutrition literature to impaired glucose tolerance, altered lipid handling, and reduced energy expenditure.

2.2.2 Appetite-Control Hormones

Key appetite hormones, including leptin (which signals satiety) and ghrelin (which stimulates hunger), follow their own diurnal rhythm. Disruption of this rhythm, for example, through irregular or delayed eating, or through insufficient sleep, has been associated with relatively higher ghrelin plus lower leptin signalling, which can increase subjective appetite and promote overeating, particularly of calorie-rich foods. These high-fat or high-sugar foods are already the most commonly reported late-night food choices in the survey literature described above.

2.2.3 Reduced Diet-Induced Thermogenesis and Slower Gastric Emptying

The thermic effect of food ,the energy the body expends digesting and metabolising a meal ,and the rate of gastric emptying both appear to be higher earlier in the day and slower in the evening. A meal eaten late at night may therefore be processed less efficiently and left partially undigested for longer, a pattern that chrono nutrition researchers have linked to poorer post-meal glucose handling.

2.2.4 Gut Microbiome Rhythms

The gut microbiome itself shows rhythmic, diurnal fluctuations in composition and activity, and the timing and regularity of food intake strongly affects these fluctuations. Animal and early human studies suggest that irregular feeding schedules can flatten or alter these microbial rhythms, changing the production of microbial metabolites (such as short-chain fatty

acids) that influence host metabolism, glucose regulation, and inflammation an emerging and still-developing area of chrono-nutrition research.

2.2.5 Interaction with Sleep

Late-night eating and poor sleep are closely intertwined and likely reinforce one another: eating close to bedtime can delay sleep onset and reduce sleep quality, while poor or insufficient sleep independently increases appetite and the likelihood of subsequent late-night snacking. Because of this two-way relationship, the present study treats sleep duration and quality as both a potential outcome and a potential confounder. They are therefore measured explicitly (see Section 7.6).

2.3 Behavioural and Social Determinants Specific to Young Adults

Beyond biology, the literature consistently points to behavioural and social drivers that are especially concentrated in young adulthood: irregular or rotating work and study schedules, breakfast skipping (which some studies suggest shifts caloric intake later in the day), high recreational screen time and social media use late at night, and social or peer-driven late-night eating occasions (e.g., after-work or after-class gatherings). These factors are not simply background noise; they are plausible upstream causes during late-night eating and are therefore incorporated into the present questionnaire as covariates rather than left unmeasured.

2.4 Gap in the Existing Literature

Despite this expanding evidence base, most existing studies fall into one of two categories: large occupational or clinical cohorts with objectively measured outcomes yet limited generalisability to the general young-adult population, or small, single-institution surveys with limited depth of metabolic assessment. There is still a need for a moderately sized, structured, self-report-based survey that (a) uses an explicit, literature-aligned operational definition for late-night eating, (b) captures a reasonably comprehensive set of metabolic health indicators rather than a single outcome such as BMI alone, and (c) explicitly measures the behavioural covariates (sleep, physical activity, screen time, work-shift pattern) that plausibly link late-night eating to metabolic outcomes. The present study is designed to fill this specific gap.

3. Rationale of the Study

The underlying topic is timely and relevant, given the rising prevalence of nighttime eating among young adults documented above; however, two deliberate refinements strengthen the scientific rigour of the first proposal.

First, because the proposed design is a cross-sectional survey rather than a longitudinal or experimental study, it can establish an association between late-night eating and metabolic health indicators. Still, it cannot establish causation that is, it cannot confirm that late-night eating causes metabolic problems, only that the two are statistically related in the sampled population at a single point in time. Reverse causation is equally plausible (for example, a person who already has disrupted metabolism or poor sleep may eat later as a consequence, rather than a cause). The study is therefore explicitly and consistently framed throughout this protocol in its

objectives, hypotheses, and expected discussion as an association study, and causal language is deliberately avoided.

Second, to make the study methodologically stronger, two definitional elements have been fixed in advance, before the questionnaire and statistical analysis plan were finalised, rather than left to be decided informally during analysis:

- A clear, literature-aligned operational definition of "late-night eating": regular consumption of food or caloric beverages after 10:00 PM (or within two hours of habitual bedtime), occurring at least three times per week over the preceding month.
- Clearly defined "metabolic health" indicators limited, for simplicity in a self-report survey, to BMI, waist circumference, and self-reported/clinician-diagnosed elevated blood glucose, dyslipidaemia, hypertension, or fatty liver.

Fixing these definitions in advance serves three purposes: it allows the questionnaire items to be written precisely rather than vaguely; it allows the statistical analysis plan (Section 7.9) to be specified before data collection, decreasing the risk of post-hoc, result-driven analytical choices; and it allows the eventual findings to be compared meaningfully against the existing studies cited in Section 2, which use broadly similar definitions.

4. Conceptual Framework

The proposed study is guided by a simple conceptual pathway, summarised below, which will also inform the choice of covariates to adjust for in the statistical analysis:

Upstream drivers (irregular work/study schedule, screen time, social occasions, stress) → **Late-night eating behaviour** (frequency, quantity, food type) → **Proposed mediating pathways** (circadian misalignment, altered appetite hormones, reduced thermogenesis, disrupted sleep, gut microbiome rhythm) → **Metabolic health indicators** (BMI, waist circumference, self-reported glucose/lipid/blood-pressure/liver markers).

Physical activity level and overall dietary pattern are treated as parallel covariates acting on the same outcome, since both are plausible confounders of the late-evening eating – metabolic health relationship. This system is descriptive rather than causal, and is intended only to guide variable selection and the interpretation of associations found in Section 7.9, not to imply a confirmed causal sequence.

5. Objectives

5.1 Main Objective

To assess the association between late-night eating habits and metabolic health among young adults.

5.2 Secondary Objectives

1. To determine the prevalence and frequency of late-evening eating among young adults.
2. To assess the relationship between late-night eating and BMI/waist circumference.

3. To examine the association between late-night eating, sleep patterns, and physical activity.
4. To identify commonly consumed foods in late-night eating.
5. To assess whether frequent late-night eating is associated with self-reported metabolic health concerns.

Each secondary objective pertains to a specific block of questionnaire items and a specific planned statistical test, as detailed in Section 7.6 and Section 7.9, so that every objective listed here is answerable directly from the collected data.

6. Hypotheses

Null Hypothesis (H_0)

There is no statistically significant association between late-night eating habits and metabolic health among young adults aged 18–40 years.

Alternative Hypothesis (H_1)

There is a statistically significant association between late-night eating habits and metabolic health among young adults aged 18–40 years.

The hypotheses were tested at a two-tailed significance level of $\boldsymbol{\alpha = 0.05}$. The analysis examined whether increasing frequency of late-night eating was associated with differences in BMI, waist circumference, and the occurrence of self-reported metabolic health concerns.

7. Methodology

7.1 Study Design

The study employed an **observational, analytical, cross-sectional design** to examine the association between late-night eating habits and metabolic health among young adults. Data were collected from each participant at a single point in time, with no longitudinal follow-up.

A structured, self-administered questionnaire was used to collect information regarding demographic characteristics, meal timing, nighttime eating frequency, dietary patterns, sleep duration and quality, physical activity, screen time, work/study schedules, anthropometric indicators, and metabolic health concerns.

Because of the cross-sectional nature of the study, the findings were interpreted in terms of **statistical association rather than causation**.

7.2 Study Setting and Duration

The study was conducted among young adults recruited from educational institutions, workplaces, and community settings within the study area. Recruitment across more than one setting was undertaken to obtain participants with different educational, occupational, and daily schedule patterns.

The study was completed over a six-month period. The initial phase involved finalisation of the research protocol and questionnaire, followed by pilot testing, participant recruitment and data collection, data cleaning, statistical analysis, and preparation of the research manuscript.

7.3 Study Population and Sampling

The study population consisted of adults aged **18–40 years** residing, studying, or working in the study area.

A **convenience/purposive sampling technique** was employed because of the practical and resource limitations associated with recruiting participants from multiple settings. Efforts were made to include participants with different occupational and educational backgrounds, living arrangements, and work/study schedules.

A total of **448 individuals were approached for participation**. Of these, 438 provided responses. Eight questionnaires were excluded because of substantial missing information or failure to satisfy the eligibility criteria. The final analytical sample therefore consisted of **430 participants**.

7.4 Participant Recruitment and Sample

Participants were recruited through educational institutions, workplaces, and community contacts. Potential participants received information regarding the purpose of the study,

eligibility requirements, voluntary nature of participation, and confidentiality of the information provided.

Participants were included if they were between 18 and 40 years of age, provided informed consent, were able to complete the questionnaire, and had been residing, studying, or working in the study area for at least three months.

Participants with diagnosed diabetes mellitus, thyroid or other endocrine conditions currently under treatment, as well as pregnant or breastfeeding individuals, were excluded in accordance with the study protocol. Individuals who were unwilling or unable to provide informed consent were also excluded. These criteria were intended to reduce potential confounding of metabolic indicators by known endocrine conditions and physiological states.

The final sample of 430 participants was considered adequate for the planned descriptive and association analyses.

7.5 Demographic Characteristics of Participants

A total of **430 participants** were included in the final illustrative analysis. The participants had a mean age of **28.7 ± 5.9 years**, with ages ranging from 18 to 40 years.

Table 1. Demographic Characteristics of Participants (N = 430)

Characteristic	Category	n	%
Age group	18–24 years	112	26.0
	25–30 years	143	33.3
	31–35 years	101	23.5
	36–40 years	74	17.2
Sex	Female	228	53.0
	Male	202	47.0
Occupation	Student	184	42.8
	Employed	198	46.0
	Self-employed	28	6.5
	Other	20	4.7
Living arrangement	With family	267	62.1
	With roommates	96	22.3
	Alone	67	15.6
Work/study schedule	Fixed daytime	318	74.0
	Rotating schedule	72	16.7
	Night/late schedule	40	9.3

The demographic distribution indicated representation from different age groups and occupational categories. Approximately three-fourths of participants reported a fixed daytime schedule, while the remainder reported rotating or predominantly late/night schedules.

7.6 Late-Night Eating Distribution

Late-night eating was operationally defined as regular consumption of food or caloric beverages after **10:00 PM**, or within two hours of habitual bedtime, occurring at least three times per week for the frequent category. The questionnaire also permitted participants to be classified into four frequency groups: never/rarely, occasional, frequent, and habitual. This operational definition follows the framework established in the study protocol.

Table 2. Frequency of Late-Night Eating Among Participants (N = 430)

Late-night eating category	Frequency definition	n	%
Never/rarely	<1 time/week	98	22.8
Occasional	1–2 times/week	110	25.6
Frequent	3–5 times/week	147	34.2
Habitual	≥6 times/week	75	17.4
Total		**430**	**100.0**

Overall, **222 participants (51.6%)** reported consuming food or caloric beverages late at night three or more times per week and were therefore classified as frequent or habitual late-night eaters.

The most commonly reported late-night food categories were snacks, fried foods, packaged foods, sweets, and sugar-sweetened beverages. Participants who reported frequent or habitual late-night eating also tended to report shorter sleep duration and greater recreational screen exposure than participants in the never/rarely category.

7.7 BMI and Waist-Circumference Findings

BMI was calculated from reported height and weight and classified using the Asian BMI classification framework specified in the study protocol. Waist circumference was recorded in centimetres using the measurement instructions provided to participants.

Table 3. BMI and Waist Circumference According to Late-Night Eating Frequency

Late-night eating category	n	Mean BMI (kg/m²)	SD	Mean waist circumference (cm)	SD
Never/rarely	98	21.6	2.8	72.7	7.1
Occasional	110	22.6	3.1	75.9	7.6
Frequent	147	23.9	3.4	81.2	8.3

Late-night eating category	n	Mean BMI (kg/m²)	SD	Mean waist circumference (cm)	SD
Habitual	75	25.1	3.7	84.2	8.9

A progressive increase in both BMI and waist circumference was observed across increasing categories of late-night eating. Participants in the habitual late-night eating group had the highest mean BMI and waist circumference, whereas participants who rarely consumed food late at night had the lowest mean values.

The difference in mean BMI across the four late-night eating groups was statistically significant in the illustrative analysis (**one-way ANOVA, $p < 0.001$**). A statistically significant difference was also observed for waist circumference (**$p < 0.001$**).

The pattern suggests a graded association between the frequency of late-night eating and anthropometric indicators. However, because the data were collected cross-sectionally, the direction of the relationship cannot be established.

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8. Practical Implications

The findings of the illustrative analysis have several potential practical implications for nutrition education and health promotion among young adults.

First, late-night eating may represent a **modifiable lifestyle behaviour** that can be addressed through nutrition and health education programmes. Rather than focusing exclusively on total food intake, health-promotion interventions may also consider the timing of meals and snacks.

Second, educational institutions and workplaces may benefit from incorporating information regarding regular meal timing, adequate sleep, healthier evening food choices, and the relationship between nighttime eating and lifestyle behaviours.

Third, the observed association between frequent late-night eating and less favourable anthropometric indicators suggests that individuals with frequent nighttime eating habits may benefit from broader lifestyle counselling that considers **meal timing, sleep, physical activity, screen exposure, and dietary quality together**, rather than treating late-night eating as an isolated behaviour.

Finally, the findings may provide a basis for future longitudinal and intervention-based studies. The present cross-sectional analysis can identify patterns of association, but controlled or prospective studies would be required to determine whether changing late-night eating behaviour produces measurable improvements in metabolic health.

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9. Limitations

Several limitations should be considered when interpreting the findings.

First, the **cross-sectional design** does not permit causal inference. Although an association between late-night eating and metabolic indicators was observed, it cannot be determined whether frequent late-night eating contributed to poorer metabolic indicators or whether individuals with existing metabolic or lifestyle concerns were more likely to eat late at night.

Second, several variables were based on **self-reported information**, including dietary behaviour, sleep duration, physical activity, anthropometric measurements, and metabolic health concerns. Self-reporting may introduce recall bias, reporting error, or social desirability bias.

Third, the study used **convenience/purposive sampling**, which may limit the generalisability of the findings to the broader young-adult population. Certain occupational, socioeconomic, or lifestyle groups may have been over- or under-represented.

Fourth, although we considered important potential confounders such as age, sex, physical activity, dietary pattern, sleep duration, and screen time, we cannot completely exclude residual confounding from factors such as family history, detailed socioeconomic status, medication use, and genetic predisposition.

Finally, late-night eating was assessed over a relatively limited period and therefore may not fully represent long-term or seasonal changes in eating behaviour.

10. Conclusion

The illustrative findings indicate a statistically significant association between the frequency of late-night eating and selected indicators of metabolic health among young adults aged 18–40 years. Participants who reported more frequent late-night eating demonstrated progressively higher mean BMI and waist circumference, with the highest values observed among habitual late-night eaters.

The analysis also suggested a greater occurrence of reported metabolic health concerns among participants with frequent or habitual late-night eating patterns. The observed association remained statistically significant after adjustment for selected lifestyle and demographic factors in the illustrative multivariable analysis.

Nevertheless, these findings should be interpreted as **associations rather than evidence of causation**, because the study employed a cross-sectional design. Late-night eating may interact with other behaviours, including sleep duration, dietary quality, physical activity, and screen exposure, and these factors may collectively influence metabolic health.

The study therefore supports the need for further longitudinal and intervention-based research to determine whether modification of late-night eating patterns can contribute to improvements in

metabolic health among young adults. The present findings provide a basis for considering meal timing as one component of broader lifestyle and nutrition education programmes.

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