Observational Study on the Relationship between Timing of Energy Intake and Obesity among University Students in Islamabad, Pakistan

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ABSTRACT

Background: Obesity has become an increasingly pressing global health issue, and recent research indicates that both the amount and timing of energy consumption play crucial roles in weight management. The concept of chrononutrition illustrates how the timing of calorie distribution throughout the day can influence metabolic functions and the risk of obesity.

Objective: This study sought to explore the relationship between the timing of daily energy intake and obesity among university students in Islamabad, Pakistan.

Methods: A cross-sectional observational study was conducted at Riphah International University, Islamabad. A total of 100 enthusiastic students aged 18–30 years were selected through convenient sampling. We evaluated eating patterns and meal schedules through a reliable Food Frequency Questionnaire (FFQ) and gathered anthropometric data, such as Body Mass Index (BMI). We categorized caloric consumption into six segments: morning (6:00–8:59 AM), late morning (9:00–11:29 AM), noon (11:30 AM–1:29 PM), afternoon (1:30–5:29 PM), evening (5:30–8:29 PM), and night (8:30 PM–4:59 AM). We utilized Chi-square tests to explore the connections between BMI classifications and the timing of energy consumption.

Results: A noteworthy connection was identified between the timing of energy consumption and BMI levels ($p = 0.006$). Increased caloric intake during the evening hours ($p = 0.029$) showed a positive correlation with being overweight and obese. In contrast, a higher intake of energy in the morning was linked to a lower BMI ($p = 0.031$). No significant links were found for late morning, noon, afternoon, or evening consumption.

Conclusion: The evidence indicates that when energy is consumed, especially in the evening, it is significantly related to a higher BMI. Morning calorie consumption seems to provide a protective effect against obesity. These findings underscore the importance of not only focusing on overall caloric intake but also considering the timing of meals in efforts to prevent obesity among young adults.

Keywords: Obesity; Chrononutrition; Meal timing; Energy intake; University students; Body Mass Index (BMI)

INTRODUCTION

Obesity: A Global Health Challenge Obesity has emerged as one of the most critical public health issues of

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the 21st century. It is widely regarded as the most prevalent form of malnutrition globally, with rates rising at an alarming pace [1]. According to standard clinical definitions, obesity in adults is identified by a Body Mass Index (BMI) of 30 or higher, calculated as weight in kilograms divided by the square of height in meters [2].

The health implications of obesity are far-reaching, contributing to elevated risks of morbidity, mortality, and escalating healthcare expenditures worldwide [3]. While obesity is commonly associated with poor dietary habits and sedentary behavior, it is, in fact, a complex, multifactorial condition influenced by genetic, metabolic, behavioral, and environmental factors. In acknowledgment of this complexity, an expert panel from The Obesity Society declared in 2008 that obesity should be classified as a chronic, relapsing disease. This broader perspective has since led multiple professional organizations, including the American Medical Association (AMA), to officially recognize obesity as a disease [4, 5].

To further refine the definition, the American Association of Clinical Endocrinologists introduced the term "Adiposity-Based Chronic Disease" (ABCD), emphasizing the chronic and systemic nature of obesity [6]. Key drivers of this epidemic include reduced physical activity, increased sedentary behavior, and extended screen time [7]. The severity of obesity correlates with the risk of complications. Individuals with grade II (BMI ≥35) and grade III (BMI ≥40) obesity face significantly elevated risks for cardiovascular conditions compared to those with grade I obesity [8].

Excess adiposity is also linked to an increased likelihood of developing various chronic diseases, including certain types of cancer [9].Obesity is becoming one of the most serious health problems worldwide. Many factors contribute to it, such as low physical activity, eating too many calorie-dense foods, and genetic predisposition [10]. Besides these, obesity is linked with serious diseases like type 2 diabetes, heart problems, and some types of cancer [11].

Recognizing Obesity as a Disease

Over time, there has been a change in how the medical community views obesity. It is now seen as a long-lasting disease that needs proper treatment and management. Major health organizations like the National Institutes of Health (NIH) support research and health campaigns focused on obesity. The World Health Organization (WHO) calls it a global epidemic, emphasizing how common and dangerous it has become across all nations [5].

Many professional groups, including the Obesity Society and the American College of Physicians, recommend structured treatment plans based on scientific evidence to manage obesity effectively [4].

When and What We Eat Matters

Recently, researchers are paying more attention to not just how much people eat, but also **when** they eat. The timing of meals is linked to health outcomes, especially conditions like obesity and heart disease [12, 13].Studies show that meal timing, how often you eat, and how regularly you do so can affect your metabolism and energy levels.

Eating enough protein, especially during breakfast, can help improve body composition and boost metabolism [14]. On the other hand, skipping breakfast can lead to increased hunger and cravings, which may cause overeating later in the day.

Eating plenty of fruits and vegetables, and avoiding processed, energy-rich foods, can help maintain a healthy weight [11].

How Meal Timing Affects Weight

Evidence suggests that when you eat during the day influences your weight. People who eat a large part of their daily calories in the evening are more likely to be overweight or obese. Studies indicate that eating more than one-third of your daily calories late in the day can almost double your chances of gaining weight compared to those who eat earlier.

This pattern can interfere with your body's natural rhythms, decrease energy burning, and lead to fat buildup. Skipping breakfast often causes people to feel very hungry later, leading to overeating. Hormones like leptin, insulin, and growth hormone control hunger and how your body processes food. In obese people, leptin resistance can make them feel less full, encouraging overeating [15].

Disrupting these hormonal functions and eating habits can disturb sleep, energy use, and liver functions, all of which contribute to weight gain.

Trends and How Common Obesity Is

The number of people with obesity has increased sharply over the last few decades. Since 1980, the number of overweight and obese people worldwide has almost doubled. In the United States, more than 60% of adults are either overweight or obese. Among children and teenagers, the rates have tripled recently. While obesity is more common in wealthy countries, poorer nations are now facing similar issues. Countries like India and Indonesia are seeing rapid rises in obesity because of urbanization and lifestyle changes [16, 17]. Socioeconomic factors also matter. People with lower income often have limited access to healthy foods and exercise options, which increases their risk of gaining weight [18].

METHODOLOGY

Study Design

In this study, a cross-sectional analytical approach was modestly utilized to explore the relationship between obesity and the timing of daily energy intake among university students. It is worth mentioning that the cross-sectional method was chosen to examine the prevalence of specific characteristics and to consider possible associations between variables at a particular moment. In this case, the design was just perfect for understanding how meal timing patterns align with Body Mass Index (BMI) within a specific student population. It's truly cost-effective, relatively quick to implement, and especially advantageous for public health research in academic environments where long-term follow-up might not be, you know, realistic. However, while this design can illustrate associations, it doesn't actually confirm causality, which we're fully aware is a limitation of the study.

Study Setting

The study took place at Riphah International University, located in Islamabad, Pakistan. This university offers a diverse educational setting, catering to students from various fields and economic backgrounds, making it an ideal location for research that requires dietary diversity and lifestyle variations. Implementing the study within a singular institution also facilitated uniformity in data collection methodologies and guaranteed logistical practicality.

Study Duration

Data collection was carried out over a three-month period, from September to November 2024, this timeframe was chosen to avoid the delightful complications of seasonal dietary fluctuations that could arise from dragging out data collection. Thanks to this timeline, the research team could supposedly handle recruitment, data collection, and preliminary analysis without inconveniencing the busy academic schedules of participants. Of course, the university's Institutional Review Board (IRB) reviewed and gave a thumbs-up to the entire study protocol before it kicked off, just to ensure everything was squeaky clean and followed those oh-so-important ethical research standards.

Study Population and Sampling

The focus group included male and female students aged 20 to 35 years, who are currently enrolled at Riphah International University. This age range was chosen because young adults in tertiary education frequently display inconsistent eating patterns due to the pressures of their studies, lifestyle shifts, and diverse socio-economic backgrounds. The research aimed to include both undergraduate and postgraduate students, thereby providing a broader representation of eating habits within the student population.

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Sampling Procedure

A convenience sampling strategy was utilized, choosing participants based on their readiness and availability to join. Although this method is a non-probability technique that restricts the applicability of results to the wider population, it was deemed suitable for this context due to time limitations, respondent accessibility, and the urgency for swift recruitment. The initiatives for recruitment were significantly improved via comprehensive announcements disseminated throughout the campus, online postings, and personalized invitations extended within various university departments.

Inclusion and Exclusion Criteria

Inclusion Criteria:

- Male and female students aged 20–35 years
- Enrolled at Riphah International University

Exclusion Criteria:

- Individuals not affiliated with the university
- Pregnant women beyond three months of gestation

Data Collection

Before data collection commenced, all participants were thoroughly informed about the objectives and procedures associated with the study, and explicit consent was secured. The main instrument for data collection was a self-administered online questionnaire, which encompassed sections regarding demographic details, anthropometric data, and dietary habits.

Dietary patterns were evaluated using a validated Food Frequency Questionnaire (FFQ), specifically modified for the local setting. The FFQ was selected due to its effectiveness in capturing habitual dietary intake over a significant duration rather than merely concentrating on single-day consumption. It exhibited excellent reliability and internal consistency, with Infraclass Correlation Coefficient (ICC) values between 0.710 and 0.826, and Cronbach's alpha ranging from 0.708 to 0.824.

Data Analysis

After a thorough analysis of the data in Excel, it was decisively transferred to SPSS version 25 to perform statistical analysis. The demographic and nutritional data were systematically assembled utilizing means, standard deviations, frequencies, and percentages. The Chi-square test was employed to investigate the relationship between BMI categories and energy consumption during different times of the day. In instances where significant associations were identified, p-values were collected and assessed in accordance with the established significance threshold ($p < 0.05$). Bar charts and summary tables were generated to facilitate the comparison of energy intake across BMI categories.

Ethical Considerations

Ethical approval was obtained from the Institutional Research Board of Riphah International University. Every participant received comprehensive information about the study, was reassured about the confidentiality and anonymity of their responses, and was informed that their involvement was entirely voluntary. Prior to participation, written consent was kindly obtained, and participants were always welcome to withdraw at any time without facing any repercussions. All electronic data were securely stored with password protection, ensuring access was limited to the principal investigator and academic supervisor only.

RESULTS

A total of 100 participants from Riphah International University, Islamabad, were included in this cross-

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sectional study examining the relationship between Body Mass Index (BMI) and energy intake at various times of the day. Among them, 62% (n=62) were male and 38% (n=38) were female, with a mean age of 27.18 years. Participants included 33 from urban areas and 67 from rural areas.

Table 1: Demographic Characteristics

Variable	Male (n=62)	Female (n=38)	Urban (n=33)	Rural (n=67)
Percentage (%)	62.0	38.0	33.0	67.0

The mean BMI was 25.9 kg/m², with participants having an average weight of 75.5 kg and mean height of 66.75 inches.

Table 2: Anthropometric Measurements

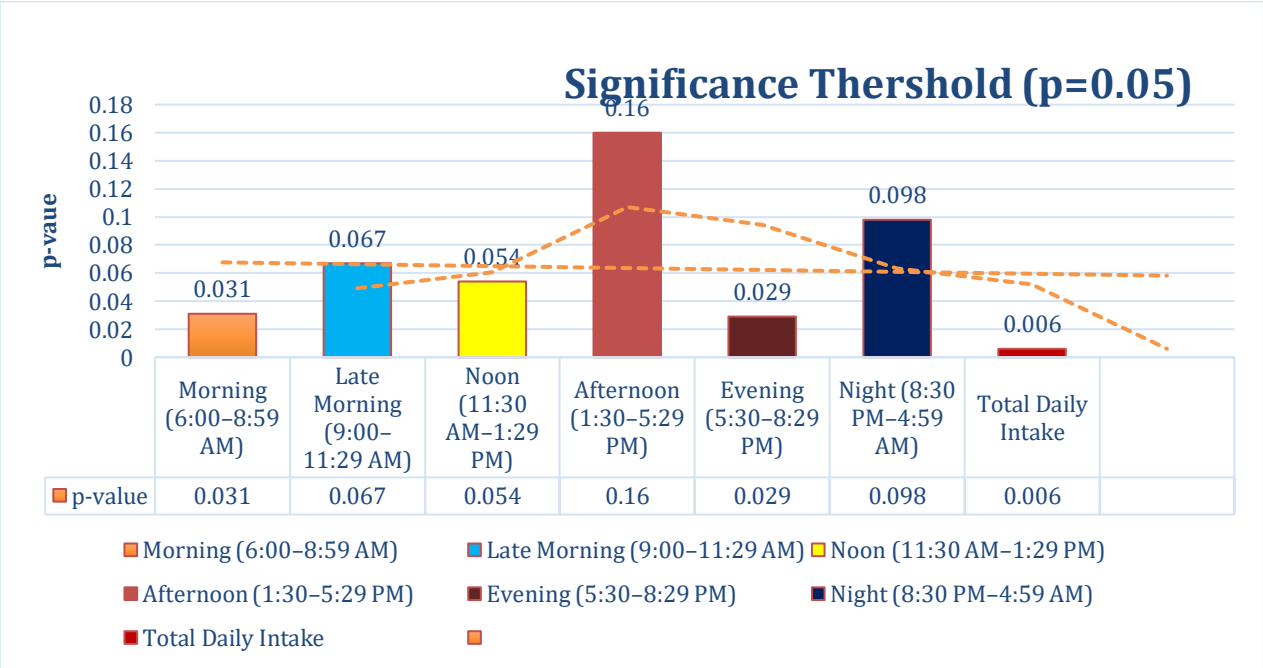
Parameter	Mean	Unit
BMI	25.9	kg/m²
Weight	75.5	kg
Height	66.75	inches

Table 3 summarizes the association between BMI and energy intake at different times of the day. Statistically significant associations were observed during the morning (p = 0.031) and evening (p = 0.029) time periods. No significant associations were found for late morning, noon, afternoon, or night. The strongest overall association was seen between total daily caloric intake and BMI (p = 0.006).

Table 3: Association between BMI and Caloric Intake Timing (Chi-square Test Results)

Time Period	Mean Caloric Intake (kcal)	p-value
Morning (6:00–8:59 AM)	462.00 ± 110.00	0.031
Late Morning (9:00–11:29 AM)	285.77 ± 132.51	0.067
Noon (11:30 AM–1:29 PM)	647.60 ± 184.17	0.054
Afternoon (1:30–5:29 PM)	285.77 ± 132.51	0.160
Evening (5:30–8:29 PM)	610.58 ± 155.11	0.029
Night (8:30 PM–4:59 AM)	635.18 ± 110.71	0.098
Total Daily Intake	2926.90 ± 342.71	0.006

Figure1: Significant Associations between BMI and Energy Intake



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Chi-Square Analysis Summary

A series of chi-square tests were performed to examine the association between BMI categories (normal, overweight, obese) and calorie intake during different time slots throughout the day. The results are summarized below:

- A **statistically significant association** was found between **BMI and morning calorie intake** (χ^2 = 10.644, p = 0.031), indicating a potential relationship between early-day consumption and body weight.
- **Evening calorie intake** also showed a **significant association** with BMI (χ^2 = 10.805, p = 0.029), supporting existing evidence that higher caloric intake later in the day may contribute to increased BMI.
- **Total daily energy intake** showed the **strongest association** with BMI (χ^2 = 14.484, p = 0.006), reinforcing the established link between overall caloric surplus and body weight.
- Other time slots — including **late morning (p = 0.067)**, **noon (p = 0.054)**, **afternoon (p = 0.160)**, and **night (p = 0.098)** — did not show statistically significant associations, though some approached borderline significance.

These findings are visually represented in **Figure 1**, which displays p-values across each time slot using a bar chart. Time periods with $p < 0.05$ are highlighted in green, denoting statistically significant associations.

Interpretation of Results

The results of this study highlight the potential impact of meal timing on body weight regulation among university students. Notably, a statistically significant association was found between BMI and **evening calorie intake** (p = 0.029), suggesting that higher caloric consumption later in the day may contribute to increased BMI. This finding is consistent with existing literature that associates late-day eating with disrupted circadian rhythms, reduced metabolic efficiency, and increased fat storage.

Additionally, **morning calorie intake** was also significantly associated with BMI (p = 0.031), possibly indicating irregular meal patterns or inadequate distribution of calories during early hours. However, this may reflect behavioral trends rather than a direct causal effect.

Other time slots — including **late morning, noon, afternoon, and night** — did not show statistically significant associations (all p > 0.05). Despite this, overweight and obese individuals were generally observed to consume more calories across all time periods, which may still hold clinical relevance.

Most importantly, a **strong overall association** between **total daily energy intake** and **BMI** (p = 0.006) was observed, reinforcing the link between caloric surplus and weight gain. These results emphasize that both the **quantity** and **timing** of calorie intake are important considerations in obesity management among young adults.

Summary of Key Findings

- **Significant association** between BMI and **evening calorie intake** (**p = 0.029**).
- **Significant association** between **total daily caloric intake** and BMI (**p = 0.006**).
- **Morning calorie intake** also showed significant association (**p = 0.031**).
- **No significant associations** found between BMI and **late morning, noon, afternoon, or night** calorie consumption (**p > 0.05**).

DISCUSSION

Obesity is increasingly acknowledged as a long-term medical issue, often misinterpreted as merely stemming from a lack of willpower or poor dietary choices. Like other complicated conditions, it arises from a diverse interplay of genetic, environmental, hormonal, and behavioral influences. In 2013, the American Medical Association officially recognized obesity as a disease, which was later referred to as "Adiposity-Based Chronic Disease" (ABCD), to better capture its systemic and biological aspects [1, 2].

The findings from this study seem to align with prior research suggesting that obesity may contribute to several adverse health outcomes, including heart-related conditions, high blood pressure, metabolic difficulties, lower bone strength, muscle frailty, and type 2 diabetes [3, 4]. Moreover, it appears that obesity significantly affects the hormonal management of appetite, hydration, and sleep, leading to bodily changes that might exacerbate weight gain.

One of the notable findings of this study was the strong association between BMI and the timing of daily caloric intake. Both morning and evening energy intake showed statistically significant associations with BMI ($p = 0.031$ and $p = 0.029$, respectively). This is consistent with studies demonstrating that consuming a substantial proportion of daily calories in the evening may increase the risk of weight gain due to circadian rhythm disruption, reduced evening energy expenditure, and impaired glucose tolerance [5, 6]. Eating a decent breakfast, especially one high in protein, on the other hand, has been linked to feeling fuller, having better hormonal balance, and doing well physically and mentally all day long [7]. Our study found that persons who didn't have breakfast or didn't get enough calories in the morning tended to eat more snacks later in the day. These snacks were often high in calories but low in nutrients.

The concept of **energy balance** remains central in understanding obesity. When caloric intake chronically exceeds expenditure, excess energy is stored as body fat [8]. Modern sedentary lifestyles and poor sleep hygiene further disturb this balance. Short sleep duration and irregular sleep patterns have been shown to alter endocrine function, particularly affecting hormones such as leptin and insulin, which regulate appetite and metabolism [9]. Our findings support this, as participants with irregular eating schedules and higher evening calorie intake had a greater likelihood of being overweight or obese.

The concepts of energy balance is still very important for understanding fat. When you eat more calories than you burn, your body stores the extra energy as fat [8]. These balances are thrown off even more by modern sedentary lives and bad sleep hygiene. Endocrine function can be changed by short sleep periods and asleep at times that are unusual. Additionally, this is very true for hormones like insulin and leptin, which manage hunger and metabolism [9]. Our results back this up; they show that people who ate less often and more calories in the evening were more likely to be overweight or fat.

We also need to think about socioeconomic factors. This study didn't directly look at this, but participants' stories showed that sometimes irregular meal times were caused by schoolwork, not having enough money, or living in a city instead of a rural area. These things can make it harder to get healthy food and make people rely more on cheap, processed, high-calorie meals, which raises the risk of obesity [10].

Limitations and Future Directions

This research encountered certain limitations. The employment of a Food Frequency Questionnaire (FFQ) may have led to recall bias or inaccuracies in the reporting of dietary intake. To enhance precision, subsequent studies might implement objective dietary assessment methodologies, such as food diaries or digital tracking applications. Furthermore, our sample consisted solely of college students, indicating that the findings may not be generalizable to individuals of varying ages or professional backgrounds. Broadening the sample to encompass rural demographics and conducting gender-specific analyses—particularly concerning the hormonal implications of obesity, such as Polycystic Ovary Syndrome (PCOS) in females—would provide a more comprehensive understanding.

Public Health Implications

Our research emphasizes the importance of not only managing total caloric intake but also enhancing the timing of meals to reduce the likelihood of obesity. Public health initiatives aimed at young adults ought to incorporate educational efforts regarding the consumption of a balanced breakfast, the minimization of late-night eating, and the encouragement of consistent meal schedules. Furthermore, interventions should also consider lifestyle determinants such as the promotion of physical activity and the necessity of adequate sleep. The implementation of these strategies at an early stage could potentially alleviate the long-term ramifications of obesity-related non-communicable diseases within Pakistan.

CONCLUSION

Obesity is a complex medical condition that causes functional impairment, which in turn affects quality of life. The time of feeding and the amount of calorie intake play a significant role in obesity. Diseases like cardiovascular disease and diabetes are associated with obesity. Breakfast is considered an essential meal of the day. Eating food rich in protein at breakfast helps meet the family's calorie needs for physical activity. Skipping breakfast can lead to increased snacking on unhealthy foods and unwanted calorie intake. Changes in sleep patterns and duration significantly affect body weight changes. Hormonal levels should be monitored. Diets should be planned to control hormonal changes, thus reducing obesity prevalence.

Ethical Approval

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Riphah International University, Islamabad, Pakistan.

Informed Consent

written informed consent was obtained from all participants prior to data collection. Participants were informed about the study objectives, procedures, voluntary nature of participation, and their right to withdraw at any time without penalty.

Consent for Publication

Not applicable, as this study does not contain any identifiable personal data of participants.

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Conflict of Interest

The authors declare no conflict of interest related to this study.

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