

**CHRONONUTRITION BEHAVIOURS AND
PHYSICAL ACTIVITY OF UNIVERSITY
STUDENTS AND ITS ASSOCIATION WITH
ABDOMINAL OBESITY**

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ABDOMINAL OBESITY**

by

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
CP-Q	Chrononutrition Profile Questionnaire (Malay CP-Q)
CVI	Content Validity Index
IPAQ	International Physical Activity Questionnaire
IPAQ-SF	International Physical Activity Questionnaire – Short Form
IDF	International Diabetes Federation
IQR	Interquartile Range
JEPeM	Jawatankuasa Etika Penyelidikan Manusia (USM Human Ethics Committee)
MET	Metabolic Equivalent of Task
NHMS	National Health and Morbidity Survey
PPSG	Pusat Pengajian Sains Pergigian (USM School of Dental Sciences)
PPSK	Pusat Pengajian Sains Kesihatan (USM School of Health Sciences)
PPSP	Pusat Pengajian Sains Perubatan (USM School of Medical Sciences)
REDISCOVER	Responding to Increasing Cardiovascular Disease Prevalence (study)
SPSS	Statistical Package for the Social Sciences
USM	Universiti Sains Malaysia
WC	Waist Circumference
WHO	World Health Organization

TINGKAH LAKU KRONONUTRISI DAN AKTIVITI FIZIKAL DALAM KALANGAN PELAJAR UNIVERSITI SERTA HUBUNGANNYA DENGAN OBESITI ABDOMEN

ABSTRAK

Obesiti abdomen merupakan salah satu faktor risiko penting bagi masalah kesihatan metabolik, manakala tingkah laku krononutrisi dan tahap aktiviti fizikal merupakan faktor gaya hidup yang berpotensi mempengaruhi kesihatan metabolik dalam kalangan pelajar universiti. Kajian keratan rentas ini bertujuan untuk mengkaji tingkah laku krononutrisi dan tahap aktiviti fizikal dalam kalangan 130 pelajar di Kampus Kesihatan Universiti Sains Malaysia (USM), serta hubungannya dengan obesiti abdomen. Tingkah laku krononutrisi diukur menggunakan Soal Selidik Profil Krononutrisi (Bahasa Melayu), aktiviti fizikal diukur menggunakan IPAQ-SF (Bahasa Melayu), dan lilitan pinggang diukur untuk menentukan status obesiti abdomen.

Hasil kajian menunjukkan beberapa corak pemakanan tidak sihat iaitu 56.7% pelajar melaporkan kerap melangkau sarapan (≥ 4 hari/minggu), 30.7% pelajar mempunyai tabiat makan lewat malam (≥ 4 malam/minggu), dan 75.8% pelajar menyatakan makan tengah hari sebagai hidangan utama. Sebaliknya, 80.0% pelajar mengekalkan tempoh waktu makan harian ≤ 12 jam. Bagi aktiviti fizikal, 72.3% pelajar mencapai tahap aktiviti sekurang-kurangnya sederhana (≥ 600 MET-min/minggu). Prevalens obesiti abdomen adalah 16.2%.

Ujian chi-kuasa dua mendapati tiada hubungan signifikan antara tingkah laku krononutrisi dan obesiti abdomen ($p > 0.05$), begitu juga antara tahap aktiviti fizikal dan obesiti abdomen ($p = 0.237$). Kesimpulannya, walaupun ramai pelajar mengamalkan tabiat pemakanan yang tidak teratur, tabiat waktu makan dan tahap aktiviti tidak

menunjukkan kaitan signifikan dengan obesiti abdomen dalam kalangan peserta. Penemuan ini memberikan data asas mengenai tabiat waktu makan dan aktiviti fizikal dalam kalangan dewasa muda Malaysia. Pendidikan kesihatan berterusan mengenai pola pemakanan teratur dan gaya hidup aktif adalah dicadangkan, manakala kajian lanjut dengan sampel lebih besar diperlukan untuk mengesahkan dapatan kajian ini.

CHRONONUTRITION BEHAVIOURS AND PHYSICAL ACTIVITY OF UNIVERSITY STUDENTS AND ITS ASSOCIATION WITH ABDOMINAL OBESITY

ABSTRACT

Abdominal obesity is an important risk factor for metabolic health problems, while chrononutrition behaviours and physical activity levels are lifestyle factors that may influence metabolic health among university students. This cross-sectional study aimed to investigate chrononutrition behaviours and physical activity levels among 130 students at Universiti Sains Malaysia (USM) Health Campus, and their association with abdominal obesity. Chrononutrition behaviours were assessed using the Malay Chrononutrition Profile Questionnaire, physical activity was measured with the Malay IPAQ-SF, and waist circumference was measured to classify abdominal obesity.

The results indicated several unfavourable eating patterns: 56.7% of students reported frequent breakfast skipping (≥ 4 days/week), 30.7% engaged in late-night eating (≥ 4 nights/week), and 75.8% identified lunch as their largest meal. Conversely, 80.0% maintained an eating window of ≤ 12 hours. Regarding physical activity, 72.3% of students achieved at least a moderate level of activity (≥ 600 MET-min/week). The prevalence of abdominal obesity was 16.2%.

Chi-square tests found no significant associations between chrononutrition behaviours and abdominal obesity ($p > 0.05$), nor between physical activity level and abdominal obesity ($p = 0.237$). In conclusion, although irregular eating habits were common, neither meal timing behaviours nor activity level were significantly related to abdominal obesity in this sample. The findings provide baseline data on meal timing and physical activity among young Malaysian adults. Continued health education on regular

meal patterns and active lifestyles is recommended, and further research with larger samples is needed to confirm these findings..

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Chrononutrition refers to the interaction between meal timing and the body's internal biological clock or circadian rhythm (Veronda *et al.*, 2020; Hairudin *et al.*, 2023). The circadian rhythm regulates key metabolic processes such as glucose utilization, fat oxidation, and hormone secretion. Eating patterns that conflict with the natural rhythm, such as skipping breakfast or eating late at night, can disrupt metabolic regulation and increase the risk of weight gain and metabolic disorders (Bernardes da Cunha *et al.*, 2023; Say *et al.*, 2025). University students commonly experience irregular daily routines due to academic demands, late-night studying, social activities, and inconsistent sleep schedules. These factors make them particularly vulnerable to poor chrononutrition behaviours.

Physical activity is one of the factors that supports metabolic health and prevents central fat accumulation. Previous study demonstrated that being physically active can increase energy expenditure and reduce visceral fat stored around internal organs (Armstrong *et al.*, 2022). Sedentary behaviours such as prolonged screen time, studying, and sitting for academic tasks are particularly common among undergraduate students, contributing to lower overall physical activity levels (Ramli & Appukutty, 2018). Physical activity may also interact with chrononutrition by improving glucose control, enhancing insulin sensitivity, and helping maintain circadian alignment, which may reduce the adverse metabolic effects of irregular meal timing (Wong *et al.* 2020).

Abdominal obesity is a major metabolic risk factor characterized by the accumulation of excess adipose tissue in the abdominal region and is associated with increased cardiometabolic risk. Waist circumference (WC) is a practical anthropometric measure of central adiposity and provides information on body fat distribution beyond body mass index (BMI). The Malaysian Clinical Practice Guidelines for the Management of Obesity recommend the assessment of WC as part of obesity evaluation and note that WC is particularly useful for assessing cardiometabolic risk, especially among individuals with normal or overweight BMI categories (Ministry of Health Malaysia, 2023). Increased abdominal adiposity is associated with metabolic abnormalities, including insulin resistance, dyslipidaemia, hypertension, type 2 diabetes, and cardiovascular disease. Therefore, WC was used in the present study to identify abdominal obesity because it provides a practical measure of central adiposity relevant to cardiometabolic risk (Ministry of Health Malaysia, 2023).

In Malaysia, increasing rates of overweight and obesity among university students have become a public health concern, as national data indicate rising central adiposity among young adults. According to the National Health and Morbidity Survey (NHMS) 2023, 37% of adults aged 18 to 29 years have abdominal obesity (Institute of Public Health, 2024), reflecting an early metabolic risk among this age group. Radzi *et al.* (2019) similarly reported that 31% of Malaysian university students were overweight or obese, demonstrating that a considerable proportion of young adults already exhibit excess body weight. University life often promotes irregular meal schedules, frequent late-night studying, and reduced physical activity which can disrupt circadian rhythm and contribute to abdominal fat accumulation (Juliana *et al.*, 2023; Ramli & Appukutty, 2018). However, most local studies have focused on BMI rather than waist circumference (WC), and few have examined how meal timing and physical activity interact to influence central

obesity. Understanding these factors among university students is therefore important for developing more effective lifestyle interventions within campus settings.

1.2 Statement of the problem

Abdominal obesity is increasingly prevalent among young adults in Malaysia and has become an important public health concern. As stated earlier, approximately 37% of Malaysian adults aged 18–29 years have abdominal obesity, indicating a rising trend of central adiposity among this age group (Institute for Public Health, 2024). This is particularly concerning because abdominal obesity is more strongly associated with metabolic complications such as insulin resistance, cardiovascular disease, and type 2 diabetes compared to general obesity measured using body mass index (BMI) (Anekwe, 2021; Ross *et al.*, 2020). The early development of abdominal obesity among young adults may therefore increase their long-term risk of chronic diseases.

In parallel with the increasing prevalence of abdominal obesity, physical inactivity remains highly prevalent among Malaysian university students (Zahari & Dahlan, 2023). Studies have shown that many undergraduates fail to achieve the recommended level of physical activity due to academic workload, prolonged sitting, screen-based learning, and limited engagement in structured exercise (Ramli & Appukutty, 2018). Low physical activity levels contribute significantly to the accumulation of visceral fat and are strongly associated with increased waist circumference. This sedentary lifestyle pattern among university students may therefore play a key role in the development of abdominal obesity.

In addition to physical inactivity, poor chrononutrition behaviours are commonly observed among university students. Local studies have reported frequent breakfast

skipping, irregular meal timing, late-night eating, and prolonged eating windows among Malaysian undergraduates (Juliana *et al.*, 2023; Hairudin *et al.*, 2023). These behaviours are often influenced by irregular class schedules, late-night studying, and disrupted sleep patterns (Juliana *et al.*, 2023). Such chrononutrition disturbances can interfere with circadian rhythm regulation, impair glucose metabolism, and promote fat storage, particularly in the abdominal region (Reytor-González *et al.*, 2025; Wong *et al.* 2020).

Although previous studies in Malaysia have examined obesity and lifestyle behaviours, most have focused primarily on BMI or total body weight (Ross *et al.*, 2020). Limited attention has been given to abdominal obesity as measured by waist circumference, despite its stronger association with metabolic risk. Furthermore, few local studies have investigated the combined influence of chrononutrition behaviours and physical activity on abdominal obesity among university students (Murakami *et al.*, 2025; Nurul-Fadhilah *et al.*, 2013). This gap limits the development of targeted lifestyle interventions aimed at reducing central obesity in this population.

Therefore, this study aims to examine the prevalence of abdominal obesity and to investigate the association between chrononutrition behaviours, physical activity levels, and abdominal obesity among undergraduate students at Universiti Sains Malaysia Health Campus. Understanding these relationships is essential for developing effective preventive strategies to reduce metabolic risk and promote healthier lifestyle practices among young adults.

1.3 Significance of the study

Abdominal obesity has become a growing health concern among young adults in Malaysia, particularly university students who often experience irregular schedules,

eating late at night, and declining physical activity. This issue is further reflected in national data, where the NHMS 2023 reported that 37% of adults aged 18–29 years have abdominal obesity (Institute of Public Health, 2024). These behaviours can disturb circadian rhythm and lead to abdominal fat accumulation, which is a major risk factor for metabolic diseases such as type 2 diabetes and cardiovascular disorders (Ross *et al.*, 2020).

In addition, this study provides a better understanding of how daily routines can influence abdominal obesity. The findings also can guide health educators and campus health units in designing more practical interventions that emphasize consistent meal timing, reduced late-night snacking, and increased physical activity.

The findings of this study also can add to the limited local evidence on chrononutrition behaviours among young adults and support the development of early prevention strategies to reduce long-term metabolic risk.

1.4 Research questions

1. What is the chrononutrition behaviours of undergraduate students at Universiti Sains Malaysia (USM) Health Campus?
2. What is the physical activity level of undergraduate students at Universiti Sains Malaysia (USM) Health Campus?
3. What is the prevalence of abdominal obesity among undergraduate students?
4. Is there any association between chrononutrition behaviours with abdominal obesity?
5. Is there any association between physical activity with abdominal obesity?

1.5 Research objectives

1.5.1 General objective

To examine the association between chrononutrition behaviours and physical activity levels, with abdominal obesity among undergraduate students at USM Health Campus.

1.5.2 Specific objectives

1. To assess the chrononutrition behaviours of undergraduate students.
2. To assess physical activity level of undergraduate students.
3. To determine the prevalence of abdominal obesity among undergraduate students.
4. To determine the association between chrononutrition behaviours with abdominal obesity.
5. To determine the association between physical activity levels with abdominal obesity.

1.6 Study hypotheses

Hypothesis 1

H₀: There is no significant association between chrononutrition behaviours and abdominal obesity among undergraduate students.

H_a: There is a significant association between chrononutrition behaviours and abdominal obesity among undergraduate students.

Hypothesis 2

H₀: There is no significant association between physical activity level and abdominal obesity among undergraduate students.

H_a: There is a significant association between physical activity level and abdominal obesity among undergraduate students.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This literature review synthesizes existing research on abdominal obesity, chrononutrition, chrononutrition among university students, and physical activity, and examines how each of these factors is associated with abdominal obesity. The review ultimately leads to the development of a conceptual framework and the identification of research gaps. It emphasizes recent studies published between 2020 and 2025 and incorporates both international and Malaysian literature where available.

The literature search was conducted using databases including PubMed, Scopus, and Google Scholar up to June 2026. Search terms included combinations of chrononutrition, meal timing, breakfast skipping, night eating, waist circumference, abdominal obesity, physical activity, and university students. Priority was given to English-language, peer-reviewed articles including randomized controlled trials, observational studies, systematic reviews, and authoritative reports published from 2010 onward, with greater emphasis on studies from the last five years. Studies were selected if they examined meal timing behaviours or physical activity in relation to obesity-related outcomes, particularly among young adults. National survey reports such as the National Health and Morbidity Survey and guidelines from the World Health Organization were also used to define key concepts and prevalence estimates. References from the original proposal were retained and supplemented with more recent evidence.

2.2 Abdominal Obesity

Abdominal obesity, also referred to as central obesity, is characterized by excessive accumulation of adipose tissue around the abdominal region and is commonly assessed using waist circumference (WC). Waist circumference is a practical measure of central adiposity and provides information on cardiometabolic risk beyond that obtained from body mass index alone. The Malaysian Clinical Practice Guidelines for the Management of Obesity recommend WC cut-off points of ≥ 90 cm for men and ≥ 80 cm for women to identify abdominal obesity and increased health risk among Asian populations. These lower cut-off values reflect the higher metabolic risk observed among Asian populations at relatively lower levels of adiposity. In addition to WC, waist-to-height ratio has also been proposed as a simple indicator of central adiposity and cardiometabolic risk, although WC remains a commonly used measure in clinical and population-based assessments.

Abdominal obesity reflects the accumulation of visceral fat, which is metabolically active and plays a significant role in metabolic dysfunction. Visceral fat secretes inflammatory cytokines such as interleukin-6 and tumor necrosis factor alpha, as well as free fatty acids that contribute to insulin resistance and systemic inflammation (Anekwe, 2021). In contrast, subcutaneous fat is comparatively less metabolically active and is considered less harmful (Anekwe, 2021). As a result, central fat accumulation is regarded as more strongly associated with adverse health outcomes. Higher waist circumference has been consistently linked to increased risk of type 2 diabetes and cardiovascular disease, independent of body mass index (Anekwe, 2021). For this reason, many clinical and epidemiological guidelines recommend routine measurement of waist

circumference or waist-to-hip ratio in addition to body mass index for more accurate risk assessment (Anekwe, 2021).

Globally, abdominal obesity is highly prevalent, although precise estimates vary depending on definitions and measurement methods (Ross et al. 2020). Existing studies suggest that approximately 20 to 40% of adults have central obesity, with higher prevalence observed among older individuals and females (Wong et al. 2020). Some global analyses have reported that around 41.5% of the population may be classified as having central obesity when varying cut-off points are applied (Wong et al. 2020). Overall trends indicate a steady increase in central obesity across many regions of the world.

In Malaysia, national health data similarly indicate a growing burden of obesity and central adiposity (Institute for Public Health Malaysia, 2024). Although waist circumference specific prevalence data are limited, findings from the National Health and Morbidity Survey suggest increasing rates of elevated waist circumference among adults. The National Health and Morbidity Survey 2015 reported that nearly half of adult women and more than one-third of men had waist circumference values above recommended thresholds (Institute for Public Health, 2015). More recent findings from the National Health and Morbidity Survey 2023 indicate that more than half of Malaysian adults are overweight or obese, which strongly implies a parallel increase in abdominal obesity, with a higher burden typically observed among women (Institute for Public Health Malaysia, 2024). Among younger populations, abdominal obesity is also becoming more common. For example, a Malaysian adolescent study reported that only about half of individuals aged 12 to 19 consumed breakfast daily, and those who frequently skipped breakfast had significantly higher body mass index and waist circumference values (Institute for Public Health Malaysia, 2024).

Excess abdominal fat is strongly associated with cardiometabolic diseases (Ross et al. 2020). Individuals with central obesity have higher risks of insulin resistance, dyslipidemia, hypertension, and chronic systemic inflammation. Waist circumference provides additional predictive value for type 2 diabetes and cardiovascular disease even after adjusting for overall body mass index. Central adiposity is therefore considered a core component of metabolic syndrome. Visceral fat has been identified as an independent risk factor for metabolic disorders, with individuals carrying higher levels of visceral fat showing significantly greater risk of metabolic syndrome and its complications compared to those with similar body mass index but lower abdominal fat distribution (Ross *et al.*, 2020). Consequently, reducing abdominal obesity through lifestyle interventions such as dietary modification and increased physical activity remains an important public health priority.

In research and clinical practice, waist circumference and waist-to-height ratio are commonly used anthropometric indicators of central adiposity. Waist circumference is measured in the horizontal plane at the midpoint between the lowest palpable rib and the iliac crest, following standardized measurement protocols (Ministry of Health Malaysia, 2023). Waist-to-height ratio is another useful indicator of central adiposity, with a ratio of 0.5 or above indicating increased health risk in adults ([NICE], 2026). Although imaging techniques such as magnetic resonance imaging and dual-energy X-ray absorptiometry can provide more detailed assessment of body fat distribution, they are less practical for routine clinical and population-based assessment because of their higher cost and limited accessibility (Ministry of Health Malaysia, 2023). For this study, waist circumference was selected as the primary indicator of abdominal obesity because it is a practical measure of central adiposity and is recommended in Malaysian guidelines, with

Asian-specific cut-off values of ≥ 90 cm for men and ≥ 80 cm for women (Ministry of Health Malaysia, 2023).

2.3 Chrononutrition

2.3.1 Concept and Circadian Biology

Chrononutrition examines the relationship between the timing of food intake and the body's circadian rhythms, and how this interaction may influence metabolic health (Alotaibi et al., 2026). Circadian rhythms are approximately 24-hour biological cycles that regulate physiological processes such as sleep–wake patterns, hormone secretion, glucose metabolism, and gastrointestinal function. These rhythms are coordinated by a central biological clock located in the suprachiasmatic nucleus of the hypothalamus, together with peripheral clocks located in tissues such as the liver, skeletal muscle, and adipose tissue.

Environmental and behavioural cues known as zeitgebers help synchronize circadian rhythms. Light and darkness are important signals for the central circadian clock, while the timing of food intake can act as an important cue for peripheral clocks involved in metabolic regulation. Under normal conditions, these circadian rhythms contribute to the temporal regulation of metabolic processes, including insulin sensitivity and glucose metabolism, which generally vary across the day (Alotaibi et al., 2026).

Chrononutrition encompasses several aspects of eating behaviour, including the timing of meals, frequency of eating occasions, duration of the daily eating window, and the regularity of food intake. These behaviours are considered in relation to the body's endogenous circadian system because the metabolic response to food may vary according to the time at which food is consumed (Alotaibi et al., 2026). In this context,

chrononutrition provides a framework for examining whether eating patterns are temporally aligned with physiological circadian rhythms.

Disruption or misalignment between eating patterns and circadian rhythms has been described as circadian disruption or chronodisruption and has been associated with adverse metabolic outcomes, including impaired glucose regulation and obesity (Alotaibi et al., 2026). Meal timing may be particularly relevant because insulin sensitivity and glucose tolerance vary according to the time of day. Eating later in the biological day, particularly close to bedtime, may therefore produce different metabolic responses compared with eating earlier in the day. Melatonin, a hormone involved in the regulation of sleep and circadian timing, also increases during the evening and has been associated with reduced insulin secretion and insulin sensitivity, providing a possible biological mechanism linking late eating with metabolic disturbances (Alotaibi et al., 2026).

Overall, chrononutrition emphasizes that metabolic health may be influenced not only by the amount and composition of food consumed but also by the timing and regularity of food intake in relation to the body's circadian system (Alotaibi et al., 2026).

2.3.2 Chrononutrition Key Behaviours

2.3.2(a) Eating Window

The eating window refers to the duration between the first and last caloric intake within a 24-hour period. It therefore represents the period during which an individual consumes food and beverages containing energy, while the remaining period represents the overnight fasting interval (Hairudin et al., 2023). The duration of the eating window is an important component of chrononutrition because prolonged food intake across the day may shorten the period of overnight fasting.

Time-restricted eating is an approach in which food intake is limited to a defined daily period, commonly involving an eating window of approximately 8 to 10 hours. Recent evidence suggests that time-restricted eating may produce modest improvements in body weight and selected metabolic outcomes in some populations, although the magnitude of benefit varies according to the population and intervention characteristics (Chen et al., 2025). In overweight women, time-restricted eating has also been associated with improvements in fasting insulin and insulin resistance measures without significant loss of lean body mass (Chen et al., 2025).

Conversely, prolonged food intake extending from early morning until late evening may result in a shorter overnight fasting period and has been associated with less favourable metabolic responses in some studies (Chen et al., 2025). However, evidence regarding the optimal duration of the eating window remains heterogeneous, and shorter eating windows should not be assumed to be universally superior. Therefore, the eating window is considered one component of the overall chrononutrition profile rather than an independent indicator of metabolic health..

2.3.2(b) Breakfast Skipping

Breakfast skipping refers to the omission or delay of the first meal of the day and is commonly observed among young adults. This behaviour extends the overnight fasting period and may be associated with differences in energy intake during subsequent meals. Epidemiological studies have reported associations between breakfast skipping and less favourable metabolic outcomes, including overweight, obesity, and abdominal obesity (Minari & Pisani, 2025; Zhang et al., 2020).

In Malaysia, a study by Nurul-Fadhilah *et al.* (2013) found that adolescents who consumed breakfast at least five days per week had significantly lower body mass index,

body fat percentage, and waist circumference compared to those who frequently skipped breakfast. Similarly, a randomized controlled trial in overweight adults demonstrated that consuming a high energy breakfast rather than a high energy dinner resulted in greater reductions in body weight and waist circumference.

The proposed mechanism underlying these findings is that morning food intake coincides with higher insulin sensitivity, which facilitates more efficient glucose metabolism. In contrast, skipping breakfast may lead to excessive caloric intake later in the day and metabolic responses that occur at less optimal circadian phases. Regular breakfast consumption is therefore considered a beneficial chrononutrition behaviour.

2.3.2(c) Late-night Eating

Late night eating refers to the consumption of food during the late evening or nighttime period, particularly after the biological evening phase when metabolic activity begins to decline. This behaviour may conflict with the natural circadian reduction in digestive and metabolic efficiency. Several studies have associated late night eating with increased body weight and impaired glycemic control.

A review by Bernardes da Cunha *et al.* (2023) and Armstrong *et al.* (2022) reported that higher energy intake during the evening and nighttime is associated with obesity and metabolic syndrome. In intervention studies, allocating a greater proportion of daily energy intake to earlier meals, particularly breakfast, compared to dinner has been shown to improve weight loss outcomes and reduce waist circumference.

Late-night eating may disrupt metabolic regulation by increasing nocturnal glucose levels and reducing insulin sensitivity. Experimental evidence has shown that late dinner can result in nocturnal glucose intolerance, while later eating timing has also been

associated with poorer insulin sensitivity and greater waist circumference (Popp et al., 2021; Vahlhaus et al., 2025). Therefore, habitual consumption of food during later evening hours may be associated with increased abdominal adiposity.

2.3.2(d) Evening Latency

Evening latency refers to the duration between the last eating event of the day and sleep onset (Veronda et al., 2020; Hairudin et al., 2023). A short evening latency, in which food is consumed shortly before sleep, may result in eating occurring during a period of reduced metabolic capacity and may be associated with less favourable metabolic responses (Popp et al., 2021). In the Malaysian validation study of the Malay-Chrononutrition Profile Questionnaire, poor evening latency (≤ 2 hours between the last eating event and sleep onset) was observed in 78.2% of participants during the test and 77.3% during the retest (Hairudin et al., 2023). The original CP-Q identifies evening latency as one of six chrononutrition behaviours relevant to health and defines it based on the interval between the last eating event and bedtime (Veronda et al., 2020). Therefore, evening latency is included in the present study as one component of chrononutrition behaviour.

2.3.2(e) Night Eating

Night eating refers to the consumption of food during nighttime hours and is one of the behavioural components assessed by the Chrononutrition Profile Questionnaire (Veronda et al., 2020). Night Eating Syndrome (NES), however, is a distinct clinical condition characterized by recurrent evening hyperphagia and/or nocturnal eating episodes, together with features such as morning anorexia and sleep disturbance. Therefore, general night eating should not be equated with a diagnosis of NES.

Regular night-time eating has been associated with less favourable metabolic outcomes in some studies, including alterations in insulin sensitivity and increased risk of metabolic abnormalities (Cheng and Yew, 2025). In the Malaysian validation of the Malay-CPQ, night eating was assessed according to the frequency of night-time eating episodes, with most participants reporting good scores (one day per week or less), while a smaller proportion reported frequent night eating (Hairudin et al., 2023). Therefore, night eating is included in the present study as a behavioural component of the chrononutrition profile rather than as a measure of Night Eating Syndrome.

2.3.2(f) Largest Meal Timing

Largest meal timing refers to the distribution of daily energy intake, specifically identifying whether the largest meal of the day occurs at breakfast, lunch, or dinner. Evidence suggests that the timing of the largest meal plays an important role in metabolic health.

A study by Ahluwalia (2022) found that overweight adults who consumed a high energy breakfast rather than a high energy dinner experienced greater reductions in body weight, waist circumference, and fasting insulin levels. In contrast, consuming the largest meal during the evening, which is a common pattern in many Western and some Asian populations, has been associated with increased fat storage and less favorable metabolic outcomes.

Overall, distributing energy intake such that a larger proportion is consumed earlier in the day, particularly at breakfast, and a lighter meal is consumed in the evening is considered a more favorable chrononutrition pattern for metabolic health.

2.3.3 Assessment of Chrononutrition

Several tools have been developed to quantify eating timing behaviours in research settings. The Chrononutrition Profile Questionnaire is a validated self-report instrument that assesses multiple dimensions of meal timing and eating patterns, including eating window, breakfast consumption, evening latency, and night eating behaviours. This instrument has been adapted for use in different languages and populations to improve its applicability across cultural contexts. For example, Hairudin et al. (2023) developed a Malay version of the Chrononutrition Profile Questionnaire and validated it among Malaysian young adults by comparing questionnaire responses with dietary diary data. The Malay-CPQ demonstrated acceptable content validity (CVI = 0.94) and internal consistency (Cronbach's $\alpha = 0.77$) (Hairudin et al., 2023).

In their study involving 110 participants, the findings indicated that university students generally demonstrated moderate scores for eating window and breakfast consumption, but exhibited particularly poor evening latency patterns, with many individuals consuming meals close to bedtime. Although dietary assessment methods such as food diaries and 24 hour dietary recalls can also be used to derive chrononutrition variables such as meal timing and frequency, these methods are often more time consuming and less practical for large scale studies. Questionnaires such as the Chrononutrition Profile Questionnaire therefore offer a more feasible alternative for population-based research.

In the present study, a validated questionnaire based on the Chrononutrition Profile Questionnaire will be used to assess chrononutrition behaviours among university students..

2.3.4 Chrononutrition Behaviours Among University Students

University students often experience significant lifestyle transitions that influence both meal timing and overall dietary patterns. This group typically faces irregular daily schedules, including late night studying or social activities, varying class timetables, and early morning commitments. In addition, easy access to energy dense snack foods and changing social environments further contribute to inconsistent eating behaviours. As a result, many students develop irregular and suboptimal eating patterns.

Globally, studies have consistently reported high prevalence of breakfast skipping and late eating behaviours among university populations. For example, Juliana *et al.* (2023) found that in a Malaysian college sample, only 33% of students consumed breakfast daily. The same study also reported an average eating window of approximately 12.5 hours, with a high frequency of late evening snacking. Similarly, research from other countries has shown that between 40 and 70% of college students regularly skip breakfast. In a study conducted in the United States, approximately 68% of students reported skipping breakfast at least two days per week. In a medical school setting in the Middle East, 42% of students were classified as breakfast skippers, while nearly half reported consuming their dinner within two hours before sleep. These findings reflect a broader tendency among young adults toward later chronotypes, which refers to a preference for later sleep and activity schedules.

In the Malaysian context, breakfast consumption patterns among young people are generally poor. Nurul-Fadhilah *et al.* (2013) reported that only about half of Malaysian adolescents consumed breakfast daily, and that infrequent breakfast consumption was associated with higher body mass index and greater waist circumference. Among female university students, Ramli and Appukutty (2018) found that more than 40% did not

consume breakfast, and breakfast skipping was associated with higher body mass index. A more recent study by Hairudin *et al.* (2023) using the Malay Chrononutrition Profile Questionnaire reported that young Malaysian adults tend to have delayed meal timing and frequent late night eating behaviours. Following the COVID 19 pandemic period, Juliana *et al.* (2023) also observed that students continued to exhibit irregular eating patterns, including frequent post dinner snacking and inconsistent meal timing even after restrictions were lifted. These behaviours are particularly concerning as they coincide with a life stage that is commonly associated with weight gain, often referred to as the freshman fifteen phenomenon.

Physical inactivity is also commonly reported among university students and may contribute to weight-related outcomes, as discussed in a later section. University students often experience lifestyle factors that may affect their eating behaviours, including academic demands, irregular schedules, late-night studying, and social activities. These factors may contribute to delayed meal timing and inconsistent eating patterns. Malaysian studies have also reported frequent late-night eating, post-dinner snacking, and irregular meal timing among young adults and university students (Hairudin *et al.*, 2023; Juliana *et al.*, 2023). Although much of the available evidence is cross-sectional, these findings suggest that university students may be a population vulnerable to unhealthy chrononutrition behaviours.

Importantly, these dietary patterns have been associated with poorer diet quality and increased adiposity. Individuals who frequently skip breakfast or consume food late at night tend to have lower overall nutrient intake quality and higher levels of body fat. It is therefore expected that Malaysian university students exhibit similar patterns, including a high prevalence of breakfast skipping, delayed meal timing, and shortened overnight

fasting periods. This study will quantify these behaviours using the Malay Chrononutrition Profile Questionnaire.

2.4 Physical Activity

Physical activity is a well-established determinant of overall body fat distribution and particularly abdominal adiposity. The World Health Organization recommends that adults engage in at least 150 minutes of moderate to vigorous physical activity per week to maintain general health and reduce the risk of non-communicable diseases. Regular physical activity increases energy expenditure and can help regulate body fat accumulation, while physical inactivity and sedentary behaviours are associated with poorer metabolic health outcomes. Evidence from a meta-analysis of randomised controlled trials also demonstrated that moderate-to-vigorous aerobic exercise and high-intensity interval training significantly reduced visceral adipose tissue (Chang et al., 2021).

At the global level, physical inactivity remains highly prevalent. Approximately 31% of adults and up to 80% of adolescents do not meet recommended physical activity guidelines, reflecting a widespread sedentary lifestyle that contributes to the increasing burden of obesity worldwide. In Malaysia, national health surveys similarly indicate that a large proportion of both adults and youth are insufficiently active, although detailed estimates for younger populations remain limited (Ministry of Health Malaysia, National Health and Morbidity Survey data).

Among university students, physical activity levels are often suboptimal due to academic demands, prolonged screen time, and irregular schedules. Many students may engage mainly in lower-intensity activities such as walking, while lack of time can act as

an important barrier to exercise participation. A Malaysian study among undergraduate students at Universiti Sultan Zainal Abidin found that 66.4% of participants were classified as sedentary based on pedometer measurements, with only 5.2% classified as somewhat active or highly active (Yusoff et al., 2018). Insufficient physical activity and sedentary behaviour may contribute to adverse weight-related and metabolic outcomes among university students.

Importantly, exercise has been shown to have a specific effect on reducing visceral fat. A meta analysis of randomized controlled trials by Chang *et al.* (2021) demonstrated that both moderate to vigorous aerobic exercise and high intensity interval training significantly reduced visceral adipose tissue, with standardized mean differences of -0.29 and - 0.38 respectively. Resistance training alone showed comparatively smaller effects on visceral fat reduction. The analysis further suggested that engaging in approximately three exercise sessions per week, each lasting 30 to 60 minutes over a period of 12 to 16 weeks, is effective in reducing visceral fat. These findings indicate that regular aerobic exercise can reduce abdominal fat even in the absence of significant overall weight loss.

Conversely, physical inactivity can rapidly increase visceral fat accumulation. Evidence from controlled trials has shown that overweight individuals who remain sedentary may experience greater increases in visceral fat compared to those who maintain regular physical activity over time. This highlights physical activity as a key modifiable factor in the prevention of abdominal obesity.

Given its importance, physical activity is commonly controlled for in studies examining the relationship between dietary behaviours and adiposity. In the present

Given its importance, physical activity is commonly controlled for in studies examining the relationship between dietary behaviours and adiposity. In the present study, physical activity will be assessed using the short form International Physical Activity Questionnaire (IPAQ-SF) in order to account for its potential confounding effects. The IPAQ-SF assesses walking, moderate-intensity and vigorous-intensity physical activities performed during the previous seven days, and physical activity levels can be classified as low, moderate, or high according to the standard IPAQ scoring protocol (IPAQ Research Committee, 2005). Students will also be classified according to whether they meet or do not meet the recommended physical activity guidelines based on the World Health Organization recommendations (World Health Organization, 2020).

It is also important to acknowledge that the relationship between physical activity and chrononutrition behaviours is complex. Some emerging evidence suggests that the timing of exercise, such as morning versus evening activity, may influence metabolic outcomes and fat oxidation, although findings in this area remain inconclusive. Overall, physically active individuals are generally less likely to accumulate abdominal fat, and physical activity level should be considered alongside chrononutrition behaviours when examining determinants of central obesity.

2.5 Association Between Chrononutrition Behaviours and Abdominal Obesity

A central question in chrononutrition research is whether specific eating timing behaviours are associated with abdominal obesity. Epidemiological evidence on this relationship has been mixed, although many studies have reported associations between unhealthy chrononutrition patterns and greater adiposity. One of the most frequently

studied behaviours is breakfast skipping, which has often been linked to increased waist circumference and higher body fat levels. In Malaysia, Nurul-Fadhilah *et al.* (2013) found that adolescents who frequently skipped breakfast had significantly higher waist circumference and body fat percentage compared to those who consumed breakfast regularly. Similarly, evidence from Western populations has shown that irregular breakfast consumption is associated with a higher prevalence of obesity and metabolic syndrome (St-Onge *et al.*, 2017). One proposed explanation is that skipping breakfast may contribute to excessive energy intake later in the day and impaired glycemic regulation, which may promote central fat accumulation over time.

The duration of the daily eating window has also been examined in relation to abdominal obesity. Evidence suggests that restricting the eating window may have beneficial effects on body weight and metabolic health. Studies on time restricted eating, where food intake is limited to less than approximately 10 hours per day, have demonstrated reductions in body weight and waist circumference. A meta analysis by Chen *et al.* (2025) reported that overweight women following time restricted eating interventions experienced significant reductions in fasting insulin and modest reductions in visceral fat compared to control groups. A systematic review and meta-analysis of randomized controlled trials found that 8-hour time-restricted eating reduced body weight, fat mass, and waist circumference in adults with overweight or obesity, although evidence for reductions in visceral fat was not significant (Huang *et al.*, 2023). In contrast, observational research has shown that prolonged eating windows exceeding 14 hours per day are common among adults with overweight or obesity (Popp *et al.*, 2021). Overall, shorter eating windows accompanied by longer overnight fasting periods appear to be protective against abdominal fat accumulation.