

**ASSOCIATION OF CARIOGENIC FOOD
FREQUENCY INTAKE, PHYSICAL ACTIVITY LEVEL
WITH BODY MASS INDEX AMONG
UNDERGRADUATE STUDENTS IN USMKK**

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LIST OF ABBREVIATIONS

AOR	Adjusted Odds Ratio
BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
CFF	Cariogenic Food Frequency
CFFQ	Cariogenic Food Frequency Questionnaire
CI	Confidence Interval
GPAQ	Global Physical Activity Questionnaire
GPAQ-M	Malay Version of the Global Physical Activity Questionnaire
IQR	Interquartile Range
M-CFFQ	Malay Cariogenic Food Frequency Questionnaire
MET	Metabolic Equivalent of Task
NHMS	National Health and Morbidity Survey
OR	Odds Ratio
PPSG	School of Dental Sciences
PPSK	School of Health Sciences
PPSP	School of Medical Sciences
SD	Standard Deviation
SES	Socioeconomic Status
SPSS	Statistical Package for the Social Sciences
SSB	Sugar-Sweetened Beverage
UHT	Ultra-High Temperature
USMKK	Universiti Sains Malaysia Health Campus, Kubang Kerian
WHO	World Health Organization

**HUBUNGAN ANTARA KEKERAPAN PENGAMBILAN MAKANAN KARIOGENIK,
TAHAP AKTIVITI FIZIKAL DENGAN INDEKS JISIM BADAN DALAM
KALANGAN PELAJAR PRASISWAZAH DI USMKG.**

ABSTRAK

Pengambilan makanan kariogenik yang kerap dan tahap aktiviti fizikal yang rendah berpotensi mempengaruhi keseimbangan tenaga serta status berat badan dalam kalangan pelajar universiti. Kajian ini bertujuan untuk menentukan kekerapan pengambilan makanan kariogenik, tahap aktiviti fizikal dan status Indeks Jisim Badan serta menilai hubungan antara pemboleh ubah tersebut dalam kalangan pelajar prasiswazah di Kampus Kesihatan Universiti Sains Malaysia. Kajian keratan rentas ini melibatkan 209 orang pelajar prasiswazah daripada Pusat Pengajian Sains Perubatan, Pusat Pengajian Sains Pergigian dan Pusat Pengajian Sains Kesihatan. Pengambilan makanan kariogenik dinilai menggunakan Malay Cariogenic Food Frequency Questionnaire, manakala tahap aktiviti fizikal dinilai menggunakan Malay Version of the Global Physical Activity Questionnaire. Berat badan dan ketinggian responden diukur bagi menentukan Indeks Jisim Badan. Data dianalisis menggunakan IBM SPSS Statistics versi 27. Statistik deskriptif digunakan untuk menghuraikan pemboleh ubah kajian, manakala ujian Khi Kuasa Dua digunakan untuk menentukan hubungan antara pemboleh ubah pada aras signifikan $p < 0.05$. Hasil kajian menunjukkan bahawa 72.2% responden mempunyai tahap pengambilan makanan kariogenik sederhana dan 27.8% mempunyai tahap pengambilan rendah. Sebanyak 49.8% responden mempunyai tahap aktiviti fizikal tinggi, 38.8% sederhana dan 11.5% rendah. Bagi status Indeks Jisim Badan, 45.5% responden mempunyai berat badan normal, 23.4% obes, 18.2% kurang berat badan dan 12.9% berlebihan berat badan. Tiada hubungan yang signifikan antara pengambilan makanan kariogenik dengan status Indeks Jisim Badan, $\chi^2(3) = 1.640$, $p = 0.650$, serta antara tahap aktiviti fizikal dengan status Indeks Jisim

Badan, $\chi^2(6) = 1.526$, $p = 0.958$. Kesimpulannya, walaupun tiada hubungan yang signifikan ditemui, lebih daripada satu pertiga responden berada dalam kategori berlebihan berat badan atau obes. Program pemakanan sihat, pengurangan pengambilan makanan bergula, aktiviti fizikal dan pengurusan berat badan perlu diperkukuh dalam kalangan pelajar universiti.

**ASSOCIATION OF CARIOGENIC FOOD FREQUENCY INTAKE, PHYSICAL
ACTIVITY LEVEL WITH BODY MASS INDEX AMONG UNDERGRADUATE
STUDENTS IN USMKK.**

ABSTRACT

Frequent consumption of cariogenic foods and low levels of physical activity are associated with energy imbalance and unhealthy weight status among university students. However, evidence regarding the relationships between cariogenic food consumption, physical activity level and Body Mass Index among undergraduate students at Universiti Sains Malaysia Health Campus remains limited. This study aimed to determine cariogenic food consumption, physical activity level and Body Mass Index status, and to examine the associations between these variables. A cross-sectional study was conducted among 209 undergraduate students from the School of Medical Sciences, School of Dental Sciences and School of Health Sciences. Cariogenic food consumption was assessed using the Malay Cariogenic Food Frequency Questionnaire, while physical activity level was measured using the Malay Version of the Global Physical Activity Questionnaire. Body weight and height were measured to determine Body Mass Index. Data were analysed using IBM SPSS Statistics version 27. Descriptive statistics were used to summarise the study variables, while Chi-square tests were used to examine associations at a significance level of $p < 0.05$. The findings showed that 72.2% of respondents had moderate cariogenic food consumption and 27.8% had low consumption, with no respondents classified in the high-consumption category. Regarding physical activity, 49.8% had a high level, 38.8% had a moderate level and 11.5% had a low level. For Body Mass Index status, 45.5% had normal weight, 23.4% were obese, 18.2% were underweight and 12.9% were overweight. Overall, 36.3% were overweight or obese. No significant association was found between cariogenic food consumption and Body Mass Index status, $\chi^2(3) = 1.640$, $p = 0.650$,

or between physical activity level and Body Mass Index status, $\chi^2(6) = 1.526$, $p = 0.958$. Although no significant associations were identified, the high proportion of overweight and obesity indicates the need to strengthen healthy eating, physical activity and weight-management programmes among university students.

Chapter 1

INTRODUCTION

1.1 Background of the Study

Overweight and obesity were recognised as major global health concerns, and their prevalence had increased significantly over recent decades. According to the World Obesity Federation (2024), global obesity rates had nearly tripled since 1975. Obesity was associated with serious health risks, including type 2 diabetes, hypertension, cardiovascular disease, and certain cancers. In Malaysia, the situation was similarly concerning. The National Health and Morbidity Survey (NHMS) 2023 reported that 30.5% of Malaysian adults were overweight and 23.1% were obese (Ministry of Health Malaysia, Institute for Public Health, 2024). Young adults, including university students, represented an important group affected by this trend as they transitioned into independent living and began making their own dietary choices.

One factor that contributed to weight gain among young adults was the frequent consumption of cariogenic foods. Cariogenic foods are foods and beverages that contribute to tooth decay by supplying fermentable carbohydrates that oral bacteria convert into acids, leading to enamel demineralisation. Examples include sugar-sweetened beverages (SSBs), chocolates, pastries, biscuits, sweetened milk drinks, and other confectionery products (Canadian Sugar Institute, n.d.). These foods were generally energy-dense and low in nutritional value. Because sugary beverages and snacks provided calories without promoting satiety, individuals often consumed them frequently without fully recognising their contribution to total daily energy intake (Biltoft-Jensen et al., 2022).

In Malaysia, the consumption of cariogenic foods was common among young adults. Among university students, Zuki et al. (2019) found that 89.3% consumed at least one sugary drink daily, with many consuming them several times per day. This level of intake exceeded the World Health Organization (WHO) recommendation that free sugar intake should be limited to less than 10% of total daily energy intake, with an ideal target of less than 5% to reduce the risk of chronic diseases (WHO, 2015).

High consumption of sugary foods and beverages was consistently associated with increased Body Mass Index (BMI). Several systematic reviews and meta-analyses reported positive associations between sugar-sweetened beverage intake and weight gain among adolescents and adults (Malik et al., 2013; Nguyen et al., 2023). Excessive sugar intake could result in a positive energy balance, leading to increased fat storage and eventual weight gain.

Apart from dietary intake, physical activity played an important role in regulating energy balance and maintaining a healthy BMI. The WHO Guidelines on Physical Activity (2023) recommended that adults aged 18 to 64 years engage in at least 150 to 300 minutes of moderate-intensity physical activity or 75 to 150 minutes of vigorous-intensity physical activity per week. However, many university students did not meet these recommendations due to academic commitments, sedentary study habits, and lifestyle factors (World Health Organization, 2024).

Previous studies showed that higher physical activity levels were associated with lower body fat and better body composition among young adults (Aleksandra Jaremków et al., 2023). A Malaysian study involving pre-university students reported a weak but negative correlation between physical activity and both BMI and fat mass, indicating that more active students generally had lower adiposity levels (Huay Woon et al., 2020). Similarly, Hao et al. (2023) found that insufficient physical activity significantly predicted higher BMI among university

students in China, while physical activity score was identified as a negative predictor of obesity ($\beta = -0.04$, $p < 0.05$).

Conversely, sedentary behaviour was associated with poorer weight outcomes among university students. Several studies reported a positive relationship between prolonged sitting time and increased BMI. Carpenter et al. (2021) found that undergraduate students in the United States spent more than 12 hours per day engaging in sedentary activities, with recreational screen time contributing the largest proportion. Both total sedentary time and screen-based activities were positively correlated with BMI, suggesting that students with higher sedentary exposure were more likely to have higher body weight.

Similar findings were reported in other populations. Jufiya et al. (2025) found a significant association between sedentary lifestyle level and BMI among nursing students in Indonesia ($p = 0.037$), with the prevalence of overweight increasing from 11.6% in the low sedentary group to 25.2% in the high sedentary group. Likewise, Joshi et al. (2023) reported that more than 93% of medical students and young faculty members engaged in sedentary behaviour for over six hours per day, and longer sedentary duration was significantly associated with a greater likelihood of being overweight ($p = 0.028$). These findings suggested that prolonged sitting, particularly during academic and screen-based activities, contributed to adverse body composition and acted as an independent risk factor for elevated BMI among young adults.

Among university students, barriers such as limited time, heavy academic workload, and lack of motivation often reduced participation in regular physical activity. A systematic review involving more than 37,000 students identified lack of time, lack of motivation, and limited access to facilities as the most common barriers to physical activity participation (Ferreira Silva et al., 2021). These barriers were particularly relevant in health-campus

environments such as USMKK, where long academic hours and clinical commitments could limit opportunities for exercise.

University students were considered a population at increased risk of overweight and obesity due to the combined effects of frequent cariogenic food consumption, sedentary lifestyles, and inadequate physical activity. As lifestyle habits developed during university years often continued into adulthood, understanding these behaviours was important for early prevention efforts. Therefore, examining the association between cariogenic food frequency intake, physical activity, and BMI among undergraduate students at USMKK was necessary to identify modifiable factors that contributed to excess weight. The findings of this study were expected to provide useful information for developing evidence-based interventions, including nutrition education programmes, healthier food choices on campus, and initiatives that encourage physical activity. These strategies could support students in adopting healthier lifestyles and help reduce the long-term risk of obesity within the university community.

1.2 Problem Statement

Overweight and obesity were recognised as growing public health concerns in Malaysia, particularly among young adults. The National Health and Morbidity Survey (NHMS) 2023 reported that 30.5% of Malaysian adults were overweight and 23.1% were obese (Ministry of Health Malaysia, Institute for Public Health, 2024). University students were considered a vulnerable group because they were transitioning towards a more independent lifestyle. During this period, many experienced changes in dietary habits, irregular meal patterns, academic-related stress, and an increased reliance on convenience foods.

One factor that contributed to weight gain among young adults was the frequent consumption of cariogenic foods, particularly sugar-sweetened beverages, confectioneries, pastries, and refined snacks. These foods were typically high in free sugars and energy but low in nutritional value. A study among Malaysian university students found that 89.3% consumed at least one sugar-sweetened beverage daily, while many also consumed sugary foods several times per day (Zuki et al., 2019). This level of consumption exceeded the World Health Organization (WHO) recommendation that free sugar intake should be limited to less than 10% of total daily energy intake (WHO, 2015). Excessive consumption of sugary foods contributed to a positive energy balance, which could lead to an increase in Body Mass Index (BMI) and a higher risk of overweight and obesity. Previous systematic reviews consistently reported a positive association between sugar intake and higher BMI among adolescents and young adults (Malik et al., 2013; Nguyen et al., 2023).

Besides dietary behaviours, physical activity played an important role in maintaining a healthy body weight. The WHO Guidelines on Physical Activity recommended that adults engage in at least 150 to 300 minutes of moderate-intensity physical activity or 75 to 150 minutes of vigorous-intensity physical activity per week. However, many university students

did not meet these recommendations due to academic workload, prolonged sitting, and sedentary study habits. Previous studies showed that higher physical activity levels were associated with lower BMI and body fat percentage among young adults. In contrast, insufficient physical activity and prolonged sedentary behaviour were linked to increased adiposity and poorer body composition (Huay Woon et al., 2020; Hao et al., 2023; Xue et al., 2016).

Although cariogenic food intake and physical activity were recognised as important factors influencing BMI, most previous studies examined these factors separately. There remained a limited understanding of how the combined effects of frequent cariogenic food consumption and physical activity levels influenced BMI, particularly among Malaysian university students. Furthermore, data specific to undergraduate students at Universiti Sains Malaysia Health Campus, Kubang Kerian (USMKK), were limited.

Therefore, this study aimed to address the existing gap in knowledge regarding the combined association between cariogenic food frequency intake, physical activity level, and BMI among undergraduate students at USMKK. The findings were expected to provide valuable information for the development of targeted, campus-based strategies to prevent overweight and obesity among university students.

1.3 Rationale of the Study

The increasing prevalence of overweight and obesity in Malaysia highlighted the need for early prevention strategies, particularly among young adults. University students were at an important stage of life where independent lifestyle habits, including dietary choices and physical activity behaviours, were developed. Frequent consumption of cariogenic foods, especially sugar-sweetened beverages and sweetened snacks, contributed to excess caloric intake and could lead to an increase in Body Mass Index (BMI). At the same time, many university students engaged in low levels of physical activity due to academic workload, prolonged sedentary study periods, and limited opportunities for exercise. Insufficient physical activity, together with high levels of sedentary behaviour, further increased the risk of weight gain and poor body composition.

As unhealthy dietary habits and inadequate physical activity often continued into adulthood, understanding their combined effects during the undergraduate years was important for long-term health promotion. By examining the association between cariogenic food frequency intake, physical activity level, and BMI among undergraduate students in USMKK, this study provided valuable insights into how lifestyle behaviours influenced weight status within this population.

The findings of this study could assist universities and health professionals in developing appropriate interventions to promote healthier lifestyles among students. These interventions might include nutrition education programmes, physical activity initiatives, health awareness campaigns, and strategies aimed at creating a healthier campus environment.

In addition, this study served as a useful reference for future research investigating dietary behaviours and physical activity patterns in relation to weight-related health outcomes

among Malaysian university students. Overall, the findings contributed to ongoing efforts to reduce excessive sugar consumption, encourage active lifestyles, and prevent obesity-related non-communicable diseases among young adults.

1.4 Conceptual Framework

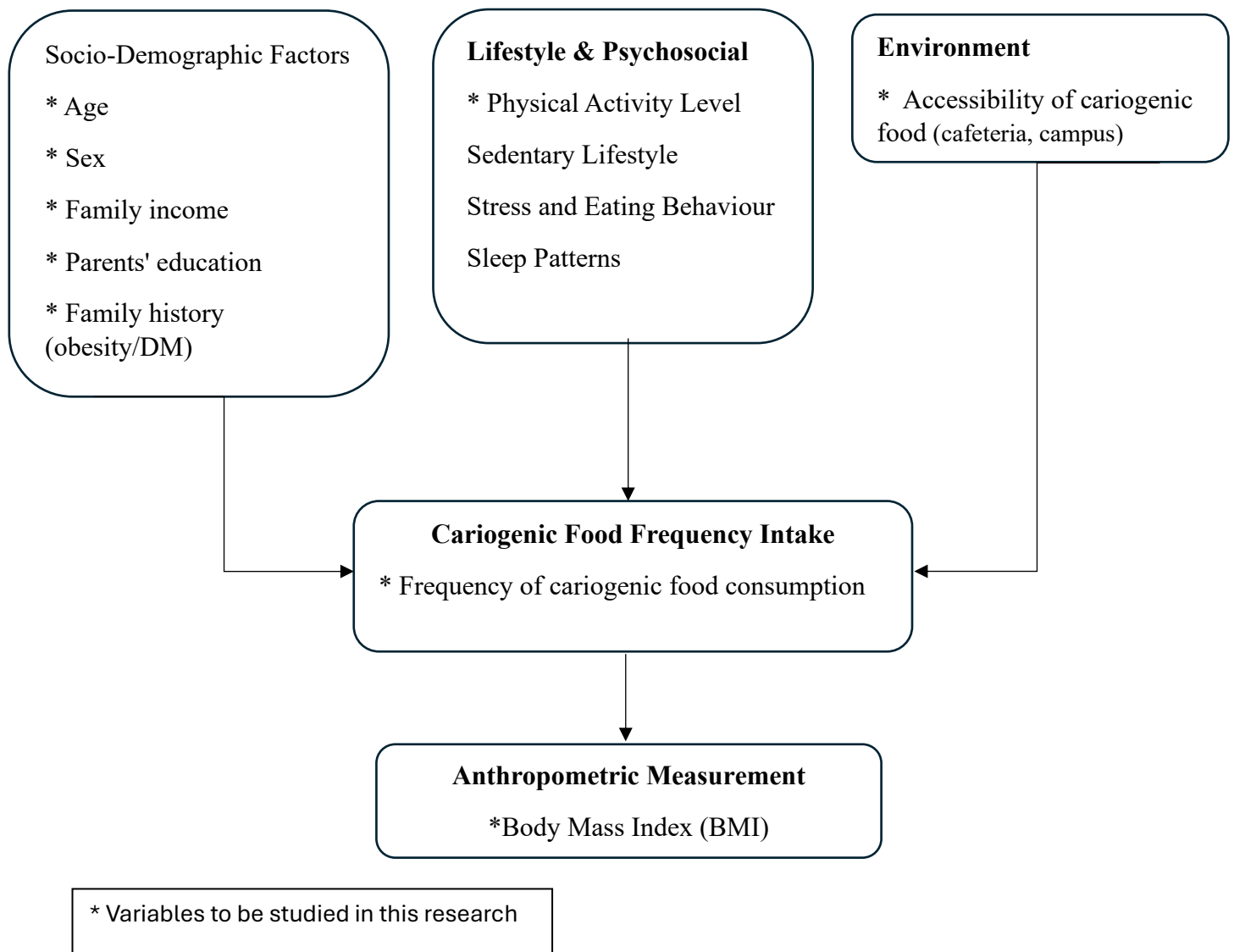


Figure 1 Conceptual Framework of Cariogenic Food Frequency Intake, Physical Activity Level with Body Mass Index Among Undergraduate Student In USMKK

The conceptual framework illustrated the hypothesised relationship between cariogenic food frequency intake and Body Mass Index (BMI) among undergraduate students at Universiti Sains Malaysia Health Campus, Kubang Kerian (USMKK). The framework also incorporated sociodemographic, lifestyle, and environmental factors that could influence students' dietary behaviours and health outcomes. This model provided a basis for examining how frequent consumption of cariogenic foods was associated with overweight and obesity while taking into account the surrounding factors that shaped eating habits.

Sociodemographic factors were recognised as important determinants of dietary choices and health outcomes. Age and sex were considered relevant factors because younger undergraduates tended to engage more frequently in snacking behaviours compared to older students, while male students generally consumed more sugar-sweetened beverages (SSBs) than female students (Salleh et al., 2021; Almoraie et al., 2024). These differences could influence overall sugar intake and subsequently affect BMI.

Family income also played an important role in food selection. Students from lower-income backgrounds often had limited access to healthier food options and were more likely to consume inexpensive, energy-dense foods such as sweetened beverages, fried snacks, and refined carbohydrate products (French et al., 2010; Ravikumar et al., 2022). On the other hand, students from higher-income households generally had better access to a variety of foods but might still consume high-sugar convenience foods due to busy academic schedules (Jurado-Gonzalez et al., 2025). In addition, parental education level influenced dietary knowledge and eating habits. Families with higher educational attainment were more likely to encourage balanced dietary practices, which could reduce the frequency of cariogenic food consumption among their children (Vallejos et al., 2025).

A family history of obesity or diabetes was another factor that could affect nutritional status. Students with a family history of these conditions were more likely to be vulnerable to weight gain and metabolic disorders due to both genetic influences and shared lifestyle practices within the household (Górczyńska-Kosiorz, Kosiorz, & Dzięgielewska-Gęsiak, 2024; van't Riet et al., 2010).

Lifestyle factors were equally important in understanding the relationship between cariogenic food intake and BMI. Physical activity influenced energy expenditure, and students who engaged in higher levels of physical activity might offset some of the effects of frequent cariogenic food consumption. In contrast, sedentary behaviours such as prolonged screen time and lack of regular exercise could increase the impact of excess caloric intake, leading to higher BMI values (Goyal & Rakhra, 2024; Daniel, John, & Can, 2025).

Stress also influenced students' eating behaviours. Academic demands, examinations, and social pressures often encouraged stress-related eating, where students tended to consume sugary foods and beverages for comfort (Choi, 2020). Sleep quality was another important factor. Poor or insufficient sleep had been associated with increased cravings for sugary foods and impaired appetite regulation, which could contribute to weight gain over time (Gomes et al., 2023). Together, these lifestyle factors demonstrated how student behaviours could either strengthen or reduce the relationship between cariogenic food intake and BMI.

The university environment also played a significant role in shaping food choices. Easy access to vending machines, convenience stores, and cafeterias that offered affordable sugary drinks and refined snacks made cariogenic foods readily available to students. Von Philipsborn et al. (2019) reported that environmental interventions, such as reducing the availability of sugar-sweetened beverages in public settings, were effective in lowering consumption and

reducing obesity risk. Without such measures, the campus environment could encourage frequent intake of cariogenic foods and increase overall energy consumption among students.

At the centre of the framework was cariogenic food frequency intake, which served as the independent variable. Frequent consumption of sugary foods and beverages contributed to a positive energy balance and could lead to increased BMI over time. Previous systematic reviews consistently reported that regular consumption of SSBs was associated with weight gain and obesity among both children and adults (Malik et al., 2013; Nguyen et al., 2023).

In this study, BMI served as the dependent variable and an indicator of nutritional status. By incorporating sociodemographic, lifestyle, and environmental factors, the framework acknowledged that eating behaviours were influenced by multiple interconnected factors. For example, a student from a lower-income family who experienced academic stress and had limited access to healthier food options might be more likely to consume cariogenic foods frequently and experience a higher BMI or obesity. In contrast, students who maintained regular physical activity, received family support, and possessed greater nutritional knowledge might demonstrate a weaker relationship between cariogenic food intake and BMI.

Overall, the conceptual framework highlighted the complex relationship between dietary behaviours and nutritional status. It supported the need for a comprehensive approach when examining overweight and obesity among university students. The framework also emphasised that reducing cariogenic food consumption required not only individual behavioural changes but also supportive environments and consideration of sociodemographic influences.

1.5 Objective

1.5.1 General Objective

To assess the association between cariogenic food frequency intake, physical activity level, and Body Mass Index (BMI) among undergraduate students in USMKK.

1.5.2 Specific Objectives

1. To assess the frequency of cariogenic food intake among undergraduate students in USMKK.
2. To assess the physical activity levels among undergraduate students in USMKK.
3. To assess the Body Mass Index (BMI) status of undergraduate students in USMKK.
4. To assess the association between cariogenic food frequency intake, physical activity level and Body Mass Index (BMI) among undergraduate students in USMKK.

1.6 Research Questions

1. What is the frequency of cariogenic food intake among undergraduate students in USMKK?
2. What are the physical activity levels of undergraduate students in USMKK?
3. What is the Body Mass Index (BMI) status of undergraduate students in USMKK?
4. Is there an association between cariogenic food frequency intake, physical activity level and Body Mass Index (BMI) among undergraduate students in USMKK?

1.7 Hypothesis

- **H₀ (Null Hypothesis):**
 - a) There is no significant association between cariogenic food frequency intake and Body Mass Index (BMI) among undergraduate students in USMKK.
 - b) There is no significant association between physical activity level and Body Mass Index (BMI) among undergraduate students in USMKK.
- **H₁ (Alternative Hypothesis):**
 - a) There is a significant association between cariogenic food frequency intake and Body Mass Index (BMI) among undergraduate students in USMKK.
 - b) There is a significant association between physical activity level and Body Mass Index (BMI) among undergraduate students in USMKK.

Chapter 2

LITERATURE REVIEW

2.1 Pattern of Cariogenic Food Intake

Previous studies reported that Malaysian adolescents and young adults consumed cariogenic foods and beverages at relatively high levels. The National Health and Morbidity Survey (NHMS) Adolescent Nutrition Survey found that 98.2% of adolescents aged 10 to 17 years had consumed sugar-sweetened beverages during the month preceding the survey, with an average intake of 1.4 cups per day (Salleh et al., 2021). Similarly, the NHMS 2022 reported that 32.4% of Malaysian adolescents consumed carbonated soft drinks daily, while the prevalence in Penang was 21.5% (Zaki et al., 2025).

Among university students, high consumption of sugary foods and beverages was also reported. Zuki et al. (2019) found that approximately 89.3% of undergraduates consumed at least one sugary drink every day. This finding suggested that dietary habits developed during adolescence often continued into early adulthood. Such consumption levels were concerning because they exceeded the World Health Organization (WHO) recommendation that free sugar intake should contribute less than 10% of total daily energy intake, with less than 5% considered the ideal target (Yan et al., 2022). Furthermore, Amarra, Khor, and Chan (2016) reported that sugar contributed up to 28% of daily energy intake among Malaysian children and adolescents, which was almost three times higher than the recommended limit. These findings highlighted the need to address excessive sugar consumption among university students, as this stage of life was often associated with greater independence in food choices and the establishment of long-term eating habits.

Similar patterns were observed internationally. Studies conducted in developing countries reported that between 40% and 69% of university students consumed sugar-sweetened beverages daily (Zuki et al., 2019). In some populations, the prevalence was even higher, ranging from 54% to 89%, which was comparable to rates reported in high-income countries such as the United States, where between 59% and 68% of adolescents consumed sugary drinks every day (Cheah et al., 2023). In addition, a recent meta-analysis found that approximately 40% of adolescents worldwide consumed carbonated soft drinks at least once daily (Zaki et al., 2025).

Besides sugary beverages, the frequent consumption of sweets and refined carbohydrate snacks was also common among young people. Lisetyaningrum et al. (2021) reported that snacking behaviour among children and adolescents in the United States increased substantially, from 74% in 1977-1978 to 98% in 2003-2006. These findings suggested that many young individuals consistently exceeded recommended sugar intake levels, increasing their risk of oral health problems, overweight, obesity, and other chronic health conditions.

2.2 Impact of Cariogenic Foods on Health

2.2.1 Impact of Cariogenic Foods on Oral Health

Cariogenic foods are foods and beverages that contain fermentable carbohydrates, particularly free sugars, which contribute to the development of dental caries. Frequent consumption of these foods provided a continuous source of substrate for oral bacteria such as *Streptococcus mutans* and *Lactobacillus* species (Tungare & Paranjpe, 2023). These bacteria metabolised sugars and produced acids that lowered the pH of the oral environment. When the pH dropped below the critical level,

demineralisation of the tooth enamel occurred, which increased the risk of dental caries (Tungare & Paranjpe, 2023).

Dental caries was one of the most common oral diseases worldwide and remained a major public health concern (Wang et al., 2025). The World Health Organization (2025) reported that untreated dental caries in permanent teeth affected approximately 3.7 billion people globally. Numerous studies consistently demonstrated a positive association between frequent sugar consumption and the prevalence of dental caries among children, adolescents, and adults. Individuals who consumed sugary foods and beverages more frequently were found to have a greater risk of developing tooth decay compared to those with lower sugar intake (Touger-Decker & van Loveren, 2003; Journal of Datta Meghe Institute of Medical Sciences University, 2025; Pombo-Lopes et al., 2026).

In addition to the amount of sugar consumed, the frequency of consumption was an important factor influencing oral health (Pombo-Lopes et al., 2026). Repeated exposure to sugary foods throughout the day prolonged acid attacks on the tooth surface and reduced the opportunity for remineralisation to occur (Alosaimi & Bernabé, 2022). Sugar-sweetened beverages, candies, chocolates, biscuits, pastries, and other sweet snacks were considered highly cariogenic because they were often consumed between meals and remained in contact with the teeth for longer periods (Oral Health Foundation, 2025).

Poor oral health resulting from excessive cariogenic food consumption could lead to several adverse consequences, including tooth pain, tooth loss, difficulty chewing, reduced quality of life, and increased healthcare costs (World Health Organization, 2025). Among university students, dental problems could also affect

academic performance and daily activities due to discomfort and reduced concentration. Therefore, limiting the intake of cariogenic foods and beverages was important for maintaining oral health and preventing dental caries. Public health strategies aimed at reducing sugar consumption were reported to contribute significantly to improved oral health outcomes among young adults (Moynihan & Kelly, 2013; Seirawan et al., 2012; Peltzer & Pengpid, 2017).

2.2.2 Impact of Cariogenic Foods on General Health

Previous studies reported that the effects of cariogenic food consumption extended beyond oral health problems. Diets that were high in sugar and refined carbohydrates contributed to excessive energy intake while providing limited nutritional value (NHS, 2023). Sugar-sweetened beverages such as carbonated drinks, sweetened tea, and sweetened coffee were particularly concerning because they provided large amounts of calories without creating a feeling of fullness (*Sugary Drinks*, 2013). As a result, individuals could consume excess energy without reducing their intake of other foods (von Philipsborn et al., 2019). This imbalance often contributed to weight gain and obesity. Numerous studies, including systematic reviews and meta-analyses, reported a strong association between sugar-sweetened beverage consumption and increased body weight among both children and adults (Malik et al., 2013; Nguyen et al., 2023). In addition, the World Health Organization (2014) reported that higher consumption of sugary beverages was associated with weight gain, while reducing intake could lower the risk of overweight and obesity. These findings suggested that cariogenic dietary patterns played an important role in the increasing prevalence of obesity worldwide.

Apart from influencing overall body weight, excessive sugar consumption was also associated with changes in body fat distribution (Della Corte et al., 2023). High intake of free sugars, particularly from foods with a high glycaemic index such as white bread and refined starches, was linked to increased accumulation of visceral fat (Brand-Miller et al., 2002). This was reflected through higher waist circumference measurements and increased body fat percentage, both of which were recognised as important indicators of cardiometabolic risk (Nuñez-Leyva et al., 2022). Della Corte et al. (2023) reported that higher added sugar intake was positively associated with increased BMI and body fat percentage. The study also found that diets with higher glycaemic index values were associated with larger waist circumferences.

The accumulation of excess abdominal fat, commonly referred to as central obesity, was particularly concerning because it was associated with a greater risk of developing chronic diseases such as type 2 diabetes, hypertension, and cardiovascular disease (Marttila et al., 2024; Ren et al., 2023). Therefore, dietary patterns characterised by frequent consumption of cariogenic foods not only increased the risk of dental caries but also contributed to overweight, obesity, and other non-communicable diseases (Sarmadi et al., 2025; Pia et al., 2017). These findings highlighted the importance of reducing excessive sugar intake as part of strategies aimed at improving overall health and preventing chronic diseases among young adults.

2.3 Prevalence of Obesity among University Students

Obesity had become a major public health concern worldwide, including among young adults studying at universities. According to the World Health Organization, 43% of adults aged 18 years and above were overweight in 2022, while about 16% were obese. The global prevalence of obesity among adults had increased from 7% in 1990 to 16% in 2022. This

showed that the prevalence of obesity had more than doubled within three decades (World Health Organization, 2024, 2025).

University students were at risk of gaining weight because entering university often changed their daily routines. Many students experienced changes in their eating habits, physical activity, sleeping patterns, stress levels, and living arrangements. Previous studies found that the prevalence of overweight and obesity among university students worldwide generally ranged from 20% to 40%. However, the prevalence differed between countries and universities due to differences in lifestyle, socioeconomic background, study population, and BMI classification methods (Ilić et al., 2024).

A study involving university students from 22 low-, middle-, and high-income countries found that 22% of the students were overweight or obese. The prevalence was higher among male students, at 24.7%, compared with 19.3% among female students. Among male students, 18.9% were overweight and 5.8% were obese. Among female students, 14.1% were overweight and 5.2% were obese. These findings showed that overweight and obesity were common among university students from different parts of the world (Peltzer et al., 2014).

Other studies also reported different prevalence rates among university students. In Bangladesh, 38.2% of university students were overweight or obese, and the prevalence was higher among male students than female students (Emon et al., 2024). In Syria, Alolabi et al. (2022) found that 21.4% of university students were overweight and 6.8% were obese. This gave a combined prevalence of 28.2%. In comparison, a study involving medical students from five Western Balkan countries found that 12.0% were overweight and 2.3% were obese (Ilić et al., 2024). These differences might have been influenced by cultural practices, food choices, physical activity, living environment, and socioeconomic conditions in each country.

In Malaysia, the prevalence of overweight and obesity among adults had also increased over the years. The National Health and Morbidity Survey 2023 reported that 54.4% of Malaysian adults were overweight or obese. This was higher than the prevalence reported in 2011, 2015, and 2019, which was 44.5%, 47.7%, and 50.1%, respectively (Institute for Public Health, 2023). The prevalence had increased by almost ten percentage points between 2011 and 2023. Although these findings represented Malaysian adults in general, they showed that excess body weight had become a growing health concern in Malaysia.

Studies among Malaysian university students also reported high levels of overweight and obesity. Akhtari-Zavare et al. (2025) found that 17.5% of university students were overweight and 7.9% were obese. The combined prevalence was 25.4%. The study also found that male students were more likely to be overweight or obese than female students. Similarly, Wafdi et al. (2024) reported that 25.4% of 351 undergraduate students at Universiti Kuala Lumpur Royal College of Medicine were overweight or obese.

Higher prevalence rates were reported in other Malaysian universities. A study involving students from two public universities in Sarawak found that 22.19% were overweight and 16.88% were obese. The combined prevalence was about 39.1% (Pitil & Ghazali, 2022). Ali and Jaafar (2020) reported an even higher prevalence, where 42.5% of university students in Kuantan were overweight or obese. The differences between these studies might have been caused by differences in study location, sample size, student background, BMI classification, and methods used to measure body weight and height.

Overall, the findings showed that overweight and obesity were common among university students worldwide and in Malaysia. In several Malaysian studies, at least one-quarter of the students were overweight or obese, while some studies reported prevalence rates of almost 40% or more. This was concerning because excess weight gained during early

adulthood might continue into later life and increase the risk of non-communicable diseases. Therefore, studying the prevalence of obesity among university students was important for planning suitable nutrition education, physical activity programmes, and health promotion activities at universities.

2.4 Anthropometric Indicators

Body Mass Index (BMI)

Body Mass Index (BMI) was one of the most commonly used indicators for assessing general adiposity. It was calculated by dividing an individual's body weight in kilograms by the square of their height in metres (kg/m^2). According to the World Health Organisation (WHO), BMI was classified into four main categories: underweight ($<18.5 \text{ kg/m}^2$), normal weight ($18.5\text{-}24.9 \text{ kg/m}^2$), overweight ($25.0\text{-}29.9 \text{ kg/m}^2$), and obesity ($\geq 30.0 \text{ kg/m}^2$) (WHO, 2020). However, previous research reported that Asian populations tended to have a higher percentage of body fat at lower BMI values compared to Western populations. Therefore, lower BMI cut-off points were recommended for Asian populations, namely underweight ($<18.5 \text{ kg/m}^2$), normal weight ($18.5\text{-}22.9 \text{ kg/m}^2$), overweight ($23.0\text{-}24.9 \text{ kg/m}^2$), and obesity ($\geq 25.0 \text{ kg/m}^2$). These modified classifications provided a more accurate representation of health risks among Asians, as metabolic disorders such as diabetes and cardiovascular disease often occurred at lower BMI levels (Lim et al., 2017).

BMI was widely used as a population-level screening tool because it was simple, inexpensive, and easy to apply in large-scale studies (Wu et al., 2024). Previous studies consistently reported an association between high sugar intake and increased BMI. Malik et al. (2013) found that consumption of sugar-sweetened beverages (SSBs)

was positively associated with BMI increases among both children and adults. Similarly, Nguyen et al. (2023) conducted a systematic review involving 91,713 children and 448,661 adults and reported that each additional daily serving of SSBs was associated with a 0.07 kg/m² increase in BMI among children and a 0.42 kg increase in body weight among adults. The study also demonstrated a dose-response relationship, whereby higher levels of SSB consumption were associated with greater increases in BMI over time.

Supporting these findings, Luger et al. (2017) reviewed studies published between 2013 and 2015 and reported that 96% of the 26 prospective cohort studies included in the review (n = 242,352) found a positive association between SSB intake and higher BMI. Only one study reported no significant relationship. Based on these findings, the authors concluded that SSB consumption was a reliable predictor of weight gain among both adults and children.

More recent studies among adolescents also reported similar findings. El Ouardi et al. (2025) conducted a cross-sectional study among adolescents aged 11 to 16 years in Erbil, Iraq, and found that the average SSB intake was 686.7 ± 197.5 mL per day, with male participants consuming significantly more than females. The study further reported that each additional millilitre of SSB consumed was associated with a 0.002-unit increase in BMI ($p < 0.001$). In addition, 41.7% of the adolescents were classified as overweight or obese, suggesting that frequent SSB consumption contributed substantially to increased BMI in this population.

Similar results were reported by Yu et al. (2023) in a large surveillance study involving 119,467 students aged 8 to 17 years in Jiangsu Province, China. The study found that students who frequently consumed SSBs had significantly higher odds of