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Research Article

Ultra-Processed Food Consumption About Body Mass Index (BMI) of Public University Students in Malaysia

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ABSTRACT

The Malaysian Nutrition Research Priorities for the 12th Plan (2021-2025) has identified a critical need for research on the consumption of ultra-processed foods among public university students in Malaysia. Despite this need, there is a lack of empirical research on the relationship between ultra-processed food intake and body mass index (BMI) in this population. To address this gap, this study aimed to investigate the relationship between the consumption of ultra-processed foods and BMI in public university students in Malaysia. A cross-sectional study design was employed, involving 250 respondents aged 18 years and above. Data was collected through a self-administered questionnaire, which consisted of three parts: a socio-demographic profile, anthropometric measurement, and a 24-hr dietary record. Food and beverage consumption was classified using the NOVA food categorization system (composed of Group 1: Unprocessed or minimally processed foods, Group 2: Processed culinary ingredients, Group 3: Processed foods, and Group 4: Ultra-processed foods), and energy intake was calculated using the Nutritionist Pro software and food guidance books. Statistical analysis was performed using SPSS version 20.0. The results showed that the average daily caloric intake was 1821.74 ± 439.03 kcal, with 31% of the total intake being contributed by ultra-processed foods (Group 4). The average energy intake from Group 1 and 2 was 1225.95 ± 414.90 kcal, Group 3 was 33.52 ± 73.83 kcal and Group 4 was 562.27 ± 344.71 kcal. The average BMI was 23.10 (7.38) kg/m^2, which falls within the normal category. The analysis revealed a significant positive correlation between ultra-processed food consumption and BMI (r_s=0.16, n=250, p=0.014). This study provides valuable insights into ultra-processed food consumption patterns among Malaysian university students using the NOVA classification system and highlights the importance of reducing such consumption to prevent nutritionally related diseases among public university students in the country.

Key words: Body mass index (BMI), Malaysia, NOVA classification, public university students, ultra-processed food

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INTRODUCTION

Ultra-processed food is manufacturing formulations made from food-derived flavorings such as modified starch, maltose, hydrogenated oils, and protein isolates with the addition of artificial flavors, colors, and other cosmetic additives based on the NOVA food classification system (Machado *et al*., 2019; Monteiro *et al*., 2019). Ultra-processed foods are often nutritionally imbalanced due to their high levels of salt, added sugar, and unhealthy fats, and low levels of dietary fiber, micronutrients, and phytochemicals (Juul & Hemmingsson, 2015; Louzada *et al*., 2015; Costa *et al*., 2019). This poor nutrient profile makes them hyper-palatable and habit-forming. In addition, processing alters their physical and structural characteristics, often involving the removal of water and the addition of flavors, flavor enhancers, colors, and other cosmetic additives (Monteiro *et al*., 2019). Food items are divided into four types based on the degree of processed ingredients which are group 1, unprocessed or minimally processed foods, group 2, processed culinary ingredients, group 3, processed foods and group 4, ultra-processed foods according to the NOVA criteria (Gibney, 2018).

The intake of ultra-processed food (UPF), typically associated with a conventional dietary pattern and excessive energy consumption, significantly impacts changes in body mass index (BMI) (Costa *et al*., 2019). The obesity pandemic with higher BMI is likely to be greatly influenced by changes in the food system, which are notably characterized by an increase in the availability of cheap, highly palatable foods that are high in energy especially the UPF (Monteiro *et al*., 2019).

Over the past few decades, there has been a significant shift from consuming whole or minimally processed foods to UPFs. This shift has been driven by various factors, including changes in food manufacturing and distribution systems, increased marketing of UPFs, lifestyle changes leading to increased demand for convenience foods, and economic factors that make UPFs more affordable and accessible for many people (Beslay *et al*., 2020). Intake of UPF by public university students had previously been linked to an elevated value of BMI which increased the risks of other serious diseases such as obesity (Juul & Hemmingsson, 2015). The contribution of energy intake based on the groups classified according to NOVA is accounted for different percentage values. Higher levels of stress related to their tertiary education studies have been linked to the rising demand for UPF (Godos *et al*., 2023).

Numerous studies have established the association between the increasing trend of UPF intake and the incidence of chronic non-communicable diseases related to nutrition, including obesity, high blood pressure, cardiovascular heart disease, and cancer (Wan Mohamed Radzi, 2019; Gramza-Michalowska, 2020; Matos *et al*., 2021). Despite the growing body of evidence, research on UPF consumption in Malaysia, particularly among public university students, is limited. Furthermore, university students in Malaysia have a limited understanding of the effects of UPF consumption on BMI. While studies have been conducted on the consumption of ultra-processed foods (UPFs) and their health outcomes, including body mass index (BMI), they have primarily focused on the general adult population (Asma' *et al*., 2019a; Asma' *et al*., 2019b; Asma' *et al*., 2019c; Ali *et al*., 2020), rather than the public university student population (Costa *et al*., 2019). This study is critical for the development of targeted intervention strategies, as well as long-term prevention and management programs, aimed at addressing diet-related non-communicable diseases stemming from UPF consumption. Therefore, the goal of this study is to determine the relationship between UPF consumption and the BMI of public university students in Malaysia.

MATERIALS AND METHODS

A cross-sectional study was conducted to collect data on the socio-demographic, anthropometry, and dietary intake of public university students in Malaysia between August and September 2022. The study was conducted across four main regions: northern (Kedah), eastern (Terengganu), southern (Johor), and central (Selangor & Federal Territory of Kuala Lumpur), which included six public universities, namely Universiti Utara Malaysia, Universiti Malaysia Terengganu, Universiti Sultan Zainal Abidin, Universiti Tun Hussein Onn, Universiti Kebangsaan Malaysia, and Universiti Malaya. This study was conducted through an online platform, specifically via Google Forms. This approach was chosen as it allowed for a diverse and broad range of students from different public universities across Malaysia to participate. The primary advantages of conducting the survey online included significant savings in time, resources, and manpower. It also enabled the administration of the study despite any geographical constraints or limitations due to the ongoing pandemic. This study acknowledges the potential biases that may occur in online surveys, such as self-selection, under-coverage, sampling errors, and non-response. To mitigate these issues, the Google form was designed to include a variety of response types such as Yes or No options, Radio buttons, and drop-down menus. Convenience sampling was selected for this study, and the respondents were asked about their willingness to participate through online platforms, mainly via social media such as WhatsApp and Facebook, before data collection. In this study, we included a total of 250 public university students aged 18 years and above, who were actively enrolled in degree programs ranging from undergraduate to doctoral studies. The sample size was calculated based on the Cochran formula (Cochran, 1963), taking into account the prevalence of obesity among public university students in Malaysia (19.7%) (NHMS, 2019). The minimum sample size derived from Cochran's formula was 243 respondents. In the present study, we did not anticipate a drop-out rate. This approach was based on several considerations. Firstly, this study employed rigorous selection criteria ensuring that all participants, all of whom were public university students, were likely to maintain their commitment to the study. Secondly, this study provided comprehensive support to the participants and offered personalized assistance for questionnaire completion. This assistance, facilitated via Google Meet or video calls, was provided as required, addressing any participant uncertainties promptly. Lastly, this study maintained continual communication with all participants throughout the study duration to ensure their ongoing involvement and promptly manage any arising issues. Consequently, this study successfully sustained the proposed sample size of 250 participants for the entirety of the study. To ensure that the respondents understood the questionnaires, a detailed briefing was given to all the participants. Researchers supplied a guide on steps to answer a 24-hr dietary record, to assist with the questionnaire. If clarifications were still needed, a Google Meet or video call was arranged to provide participants with a detailed briefing on questionnaire completion. The respondents gave an informed consent statement in the questionnaire before they continued to answer the questionnaires. This research has been approved by the Ethics Committee Board of Universiti Malaysia Terengganu, with the approval reference number UMT/JKEPM/2022/111.

The research tool was an online, self-administered, bilingual (English and Malay language) questionnaire that has three parts: the socio-demographic profile, anthropometric measurement, and a 24-hr dietary record form. The first part of the questionnaire is comprised of socio-demographic questions. The second part of the questionnaire comprised the self-reported measurement of the respondent's body weight (in kilograms) and body height (in centimeter). Self-reported anthropometric measurements were used primarily due to the practical limitations imposed by the online survey methodology. The use of self-reported measurements allowed for the collection of essential data without requiring in-person assessments, which could have been logistically challenging or impossible due to geographical distance or public health constraints. Moreover, self-reported data can provide a useful and valid estimation of actual measurements, especially when large-scale population-based studies are concerned. Several studies have shown that self-reported anthropometric data can closely correlate with measured data, although it is recognized that some degree of reporting error can occur (Wright *et al*., 2015). Nevertheless, this study acknowledges the potential limitations of self-reported data, such as the potential for bias in the reported values due to social desirability or recall errors. As a part of the study, instructions were provided to guide respondents on how to accurately measure and report their anthropometric measurements, to mitigate possible inaccuracies. Regarding self-reported anthropometric data, it is generally found to be reasonably accurate when compared with measurements taken at the same time. However, the accuracy may decrease over time due to reporting errors and changes in anthropometric characteristics. Despite these potential inaccuracies, self-reported

anthropometric data remain suitable for use in analyses of associations with disease outcomes in cohort studies over at least a decade of follow-up (Wright *et al*., 2015). The measurements were then used to calculate the BMI and categorized it using World Health Organization (WHO) classification (WHO, 2021). If the body mass index was lower than 18.5 kg/m^2, it fell into the underweight category, while if it was in the range of 18.5 to 24.9 kg/m^2, it fell into the normal category. Overweight was defined as having a BMI of 25.0 to 29.9 kg/m^2. The obesity class was divided into three classes, of which the range between 30.0 and 34.9 kg/m^2 was considered to be in obesity class I, whereas the body mass index in the range between 35.0 and 39.9 kg/m^2 fell in the obesity class II category. If the BMI was higher than 40.0 kg/m^2, it fell into the obesity class III category. Food classification based on the NOVA approach via 24-hr dietary intake record was the third section of the questionnaire. Using the NOVA classification system, each respondent's food group was categorized based on the degree of processing, leading to the creation of an ultra-processed food classification table featuring groups 1 and 2 combined, and separate groups 3 and 4. In response to the challenge posed by the lack of standardized recipes from the respondents (Asma' *et al*., 2020), this study chose to combine Group 1 and Group 2. These groups primarily consist of unprocessed or minimally processed foods, which are frequently used together in meal preparation. By merging these groups in the study's Excel classification, a sharper focus could be placed on the consumption of processed and ultra-processed foods, which is the main interest of this research. This approach was a practical solution to maintain the accuracy of the data. Although both Group 3 and Group 4 consist of processed foods, they were not merged to distinguish between differently processed and highly processed meals (UPF). In line with this, each food category was assigned to the most suitable level of processing within the framework, and the processing levels were grouped to dichotomize the categories into unprocessed or processed, as per the methodology of Crino (2017). Participants were required to write down all their food and beverage consumption for a day. In this part, the open-ended questions are divided into six sections, such as breakfast, morning tea, lunch, afternoon tea, dinner, and supper. Respondents were also asked to answer the time they consumed the meal, food sources (buying or cooking), type and ingredients in food or drink, and serving size. The questionnaire took between 15 to 20 minutes to be completed. The raw data was first organized and categorized using Microsoft Excel, which was then analyzed in depth using Nutritionist Pro Software. Additional resources such as food guidance books (including 'Malaysian Food Album', 'Food Atlas', 'Nutrient Composition of Malaysian Foods') and the Malaysian Food Composition Database (https://myfcd.moh.gov.my) were also consulted to supplement the analysis. This thorough approach enabled us to determine the energy intake of the respondents from each food group, factoring in the processing methods of the foods. Finally, the total energy contribution from each food category was also calculated.

The other data were analyzed using IBM SPSS Statistical Version 26 to calculate the frequency and percentage of each demographic profile. Kolmogorov-Smirnov was used to perform the normality test before data analysis. The descriptive data are presented using frequency, percentage, mean score, and standard deviation (SD), or median score and interquartile range, (IQR). If the results follow a normal distribution, the mean (SD) is used. However, in cases where the distribution is not normal, the median (IQR) is employed instead. In this research, median and IQR were used for the average BMI while mean and standard deviation were used for the total energy intake of each group according to NOVA classification. The Spearman correlation coefficient was used to determine the association between UPF consumption and BMI. The Spearman correlation is significant at a 0.05 level.

RESULTS AND DISCUSSION

Socio-demographic characteristics of respondents

Table 1 outlines the socio-demographic characteristics of the 250 respondents involved in this study. The majority of respondents were female, accounting for 76.8% of the total, and of Malay ethnicity, representing 54.8%. The respondents were predominantly single, with this group comprising 99.2% of the total. Separately, it's worth noting that the median age among the respondents was 22 years old, indicating that the central tendency of the age distribution lies at this point. Approximately 40.0% of respondents reported a monthly family income of less than RM 2000. It's important to consider that about one-third of these respondents fell into the 18 to 30 years age bracket. This age group largely comprises individuals who are still pursuing their education or in the early stages of their careers, circumstances that often correspond with lower income levels. Therefore, this youth and education factor may help explain the lower income reported by this significant percentage of respondents. Most of them were studying in their third year (40.0%) and also were students from Universiti Malaysia Terengganu (53.6%).

According to Sani *et al*. (2020), there were around 2.7 million households in the B40 income group in 2014. By 2018, this number increased significantly, with the government announcing that 4.1 million households would continue to receive the Household Care Aide, *Bantuan Sara Hidup* (BSH). In our study, we found that approximately 40.0% of respondents reported a monthly family income of less than RM 2000, and an additional 30.8% reported income below RM 4000, placing them within the B40 income group. This suggests that a considerable proportion of public university students may come from these lower-income households, indicating potential financial challenges that could influence their dietary habits and choices.

Body mass index among respondents

In this study, the body mass index (BMI) of the respondents was distributed as follows: 46.8% of the respondents had a normal BMI, 26.8% were overweight, 15.2% were underweight, and the remaining 11.2% fell into various obesity categories. The median BMI was 23.10 (7.38) kg/m^2, which falls within the normal range as per WHO guidelines.

Table 1. Socio-demographic characteristics of the respondent (*n*=250)

Characteristics	*n* (%)	Median (IQR)
Gender		
Male	58 (23.2)	
Female	192 (76.8)	
Age		22 (1) years old
18	4 (1.6)	
19	1 (0.4)	
20	18 (7.2)	
21	35 (14.0)	
22	75 (30.0)	
23	70 (28.0)	
24	29 (11.6)	
25	9 (3.6)	
26	4 (1.6)	
27	1 (0.4)	
29	3 (1.2)	
30	1 (0.4)	
Race		
Malay	137 (54.8)	
Chinese	44 (17.6)	
Indian	66 (26.4)	
Others	3 (1.2)	
Marital status		
Single	248 (99.2)	
Married	2 (0.8)	
Monthly family income[a]		
Less than RM 2000	100 (40.0)	
RM 2000- RM 3999	77 (30.8)	
RM 4000- RM 5999	32 (12.8)	
RM 6000- RM 7999	14 (5.6)	
RM 8000- RM 9999	7 (2.8)	
RM 10,000- RM 11,999	7 (2.8)	
RM 12,000- RM 13,999	7 (2.8)	
RM 14,000- RM 15,999	0 (0.0)	
RM 16,000- RM 17,999	1 (0.4)	
RM 18,000- RM 19,999	0 (0.0)	
RM 20,000 and above	5 (2.0)	
Year of Study		
1	40 (16.0)	
2	66 (26.4)	
3	100 (40.0)	
4	43 (17.2)	
5	1 (0.4)	

Table 1 continued...

University Name	
Universiti Malaysia Terengganu (UMT)	134 (53.6)
Universiti Sultan Zainal Abidin (UNISZA)	16 (6.4)
Universiti Kebangsaan Malaysia (UKM)	29 (11.6)
Universiti Tun Hussein Onn (UTHM)	33 (13.2)
Universiti Malaya (UM)	16 (6.4)
Universiti Utara Malaysia (UUM)	22 (8.8)

[a] Monthly family income is based on the Household Income and Basic Amenities Survey Report 2019, Department of Statistics Malaysia

Table 2. Body mass index of respondents (*n*=250)

Body mass index (BMI)	Number of respondents	Percentage (%)	Median (IQR)
Average BMI	-	-	23.10 (7.38) kgm^{-2}
Category of BMI			
Underweight (Below 18.5)	38	15.2	
Normal weight (18.5-24.9)	117	46.8	
Overweight (25.0-29.9)	67	26.8	
Obesity class I (30.0-34.9)	24	9.6	
Obesity class II (35.0-39.9)	3	1.2	
Obesity class III (Above 40)	1	0.4	

BMI cut-off points are based on the WHO BMI Classification (2021)

The proportions we observed are in line with some prior studies but differ from others, reflecting the diversity of BMI distributions among university student populations. For instance, our results are consistent with the findings of Mohd Taib *et al*. (2021) and Wan Mohamed Radzi *et al*. (2019), which showed a similar prevalence of normal and overweight categories among Malaysian university students. On the other hand, our findings differ from those of Alhashemi *et al*. (2022) at Aleppo University, where a higher proportion of students were found to be underweight, and a lower proportion fell into the pre-obesity categories. Interestingly, our results diverge notably from studies conducted in other geographical locations. For example, a study conducted at the University of Barcelona (Ramírez-Contreras *et al*., 2021) found a higher proportion (83.3%) of students in the normal weight category than our study did. Similarly, Lovan *et al*., (2022) found a slightly higher proportion of university students with normal weight and a lower proportion of students who were overweight or obese. These differences underscore the potential influence of geographical and cultural factors on BMI distributions. Notably, in our study, the combined percentage of overweight and obese respondents was 38%, which is lower than the percentage of respondents with normal BMI. This is slightly in line with the findings of Brunt *et al*., (2008), but contrasts with the study by Al-Turki *et al*., (2007) at King Saud University, where a higher proportion of students were found to be overweight or obese. These diverse findings underscore the complexity of managing obesity among university students. As such, novel strategies are required to prevent and manage obesity effectively. According to the National Plan of Action for Nutrition Malaysia (NPANM) III (2021-2025), traditional herbal remedies and multifunctional meals can be employed to combat and prevent obesity. Furthermore, obesity prevention and management programs have been established to lower obesity levels among university students. Various interventions have been proposed to reduce the prevalence of obesity, including creating walkable neighborhoods, taxing unhealthy snacks, offering cash rewards for healthy behaviors, implementing university-based health promotion programs, regulating food advertising (especially those directed at students), running public awareness campaigns, ensuring clear nutrition labeling, and increasing primary care physician training (Shentow-Bewsh & Zuberi, 2018). By understanding the specificities of obesity trends in different populations, like the ones highlighted in this study, these interventions can be tailored more effectively to meet the unique needs of specific groups. In summary, while this study aligns with some previous findings, it also reveals some important differences. These findings emphasize the multifaceted nature of BMI distributions among university students and the influence of various factors such as location, lifestyle, and potentially even academic stress. These insights can inform the development and implementation of effective obesity prevention and management strategies among university students.

Classification of energy intake based on NOVA food classification

The mean energy intake was found to be 1821.74 ± 439.03 kcal, which is lower than the Recommended Nutrient Intake (RNI) for moderately active males (2440 kcal) and females (2000 kcal) aged 19 to 29 years old. The findings, which were in line with those of other research from the Malaysian Adult Nutrition Survey, showed that men consumed more calories on average (1776 kcal, or 74.5% of RNI) than women (1447 kcal, or 71.0% of RNI) (Mirnalini *et al*., 2008). These findings are similar to other studies, such as the University of California, Los Angeles Energetics Study, which found that respondents consumed less than 33% of the recommended energy intake, with a total intake of 1596.8 kcal (Wang *et al*., 2013). However, these findings contrast with previous research at the

Central University of Venezuela, which showed that female students consumed 2440 kcal and males consumed 2513 kcal (Herrera *et al*., 2003). The highest percentage of monthly family income of the respondents was found to be less than RM 2000, which could contribute to the lower energy intake. Individuals with low-income levels often adopt coping mechanisms such as reducing meal sizes and consuming low-quality or inexpensive foods, leading to food insecurity and lower nutrient intakes (El-Bilbeisi *et al*., 2022). In summary, the results of this research offer insight into the energy intake of public university students.

Table 3 reveals that the average energy intake from Group 1 (unprocessed & minimally processed foods) and Group 2 (processed culinary components) was 1225.95 ± 414.90 kcal, accounting for 67% of the total energy intake of the respondents in this research. Group 3 (processed meals) contributed 2% of energy intake which was 33.52 ± 73.83 kcal, while Group 4 (UPF) accounted for 31% of the total energy intake which was 562.27 ± 344.71 kcal.

Table 3. Energy consumption from NOVA food classification towards total daily energy intake (*n*=250)

Total energy intake (kcal)	Percentage (%)	Average total energy intake (kcal)
		Mean ± SD
Total energy intake (kcal)	-	1821.74 ± 439.03
NOVA food classification group		
Group 1 + Group 2	67.0	1225.95 ± 414.90
Group 3	2.0	33.52 ± 73.83
Group 4	31.0	562.27 ± 344.71

Note:
Group 1: unprocessed or minimally processed foods (unprocessed foods refer to edible parts of plants or animals while minimally processed foods are natural foods that undergo processes such as drying, grinding, roasting, boiling, pasteurization, etc. to confiscate inedible parts), Group 2: processed culinary ingredients (food substances attained directly from group 1 foods to season & prepare foods from Group 1), Group 3: processed foods (goods somewhat simply made by placing in salt, sugar, oil, or other groups 2 elements to group 1 foods, and normally involves two or three ingredients accompanying numerous cooking methods or preservations, such as bread, cheese, & non-alcoholic fermentation), and Group 4: ultra-processed foods (referring to industrial formulations which usually made up of five or more ingredients such as salt, anti-oxidants, stabilizers, & preservatives) (Monteiro *et al*., 2016)

The results are in line with previous research, such as the Mexican National Health and Nutrition Survey 2012 (Marron-Ponce *et al*., 2017), which found that unprocessed and minimally processed foods and processed culinary ingredients accounted for 64% of energy intake, followed by UPF (29%) and processed foods (6%). Similarly, a study among Brazilian graduates found that UPF only accounted for 25.3% of energy intake (Mattar *et al*., 2022). In the US, 57.9% of calories came from ultra-processed snack items in 2009-2010 (Mendonça *et al*., 2016). The prevalence of UPF in diets might be because of a variety of factors, such as convenience and marketing. The availability of UPF in the market, along with promotions and priority placement in advertising campaigns, has increased the visibility and consumption of these products, especially among university students who tend to choose low-priced food products (Andreyeva *et al*., 2010). The aggressive advertising of UPF items on various media platforms has also created awareness and interest in these products (Hawkes, 2008).

In a nutshell, the findings of the current study indicated that unprocessed and minimally processed foods and processed culinary components accounted for the greatest proportion of energy intake. The ultra-processed foods (Group 4) still made up a substantial proportion, accounting for 31.0% of the total energy intake, with an average of 562.27 kcal. The conclusion that ultra-processed foods contribute a significant proportion of total caloric intake is based on this percentage, which is nearly half of the contribution from Group 1 and Group 2. While the absolute value of calories from ultra-processed foods may seem smaller, the relative contribution to the total intake is substantial. The prevalence of UPF in diets may be due to convenience and marketing factors (Machado *et al*., 2017). After that, the availability of ultra-processed food products in the diets of people is higher than the traditional diets which increased the consumption of ultra-processed food among youths, especially university students (Reardon & Timmer, 2012). A steady stream of promotions, priority placement in advertising campaigns, and the launch of new products all increased the visibility of those UPF products (Hawker, 2008). When launching a new food product, it generated interest among customers to try it and automatically impresses them to consume. Besides that, the use of low-cost ingredients and food additives allowed for price reductions on UPF, which influenced consumption, especially among university students, as they chose low-priced food products that were in their monthly budget (Andreyeva *et al*., 2010). The aggressive massive advertising for ultra-processed food products on television, magazines, and other media platforms attracts more consumers (Hawker, 2008). The advertisement created awareness of the products and conveyed direct information like the benefits of the product to promote the new product.

Relationship between body mass index and ultra-processed food consumption

It was discovered there was a significant relationship between UPF consumption and the BMI of public university students at $p<0.05$, as obtained from Table 4. As the r_s value was less than 0.5, there was a weak significant relationship between UPF consumption and the BMI of public university students.

Table 4. Relationship between body mass index and ultra-processed food consumption (*n*=250)

Correlation	Ultra-processed food consumption	
	r_s	*p*-value
BMI	0.16	0.014*

*Spearman correlation is significant at a 0.05 level

This also accords with our earlier observations, which showed that UPF consumption had a significant positive association with BMI status (Louzada *et al*., 2015). Moreover, a comparison of the findings with those of other studies in the United Kingdom confirmed that UPF intake is linked to higher BMI and obesity prevalence in both sexes and represented that had a great significant association with UPF intake and BMI of the respondents (Rauber *et al*., 2020). This finding broadly supports the relationship between UPF consumption and BMI as increased consumption of UPF is associated with an increase in obesity among Canadian undergraduates (Nardocci *et al*., 2020). It showed a positive relationship between UPF and BMI as the excess amount of consumption of different groups of UPFs will cause higher BMI in many types of research. There was a trend toward positive relationships between UPF consumption and obesity markers throughout age groups (but not substantially linked among the youngest age groups) and levels of physical activity in both women and men (Machado *et al*., 2019).

This finding broadly supports the findings of previous studies that the United Kingdom had a weaker association between UPF and saturated fat that indicated BMI in contrast to less developed countries (Handakas *et al*., 2022). This gap may be explained by the respondents in this study's less calorie intake from UPF compared to the unprocessed or minimally processed foods and processed culinary ingredients. Even though it had a significant relationship between UPF consumption and the BMI of public university students, it gave a poor relationship only because respondents in this study consumed less amount of ultra-processed food compared to Group 1 and 2. Those who eat ultra-processed meals regularly may have diverse tastes and preferences, less understanding of nutrition, are less health concerned, or have more time and budget restrictions than those who do not (Poti *et al*., 2017). Mendonca and colleagues found that those who consumed the most UPFs reported fewer healthier lives, with little exercise, more time spent watching television, and lower compliance with the Mediterranean diet pattern (Mendonca *et al*., 2016). These kinds of factors directly increased university students' BMI and contributed to obesity.

The percentage contribution of UPF towards total energy in Malaysia is something to be taken care of immediately as it contributed more than 30%. Daily UPF consumption of more than 30% continuously might lead to diet-related diseases mainly associated with obesity such as cardiovascular disease (CVD), cancer, type 2 diabetes, and other non-fatal chronic conditions such as asthma, musculoskeletal conditions, and mental health disorders (GBD 2017 Diet Collaborators, 2019). Monteiro *et al*., (2019) have explained that ultra-processed foods (UPFs) are the result of food fractionation into various components, subsequent chemical modification of these substances, and the combination of both altered and unaltered food ingredients. This process, often accompanied by the extensive use of cosmetic chemicals and advanced packaging, impacts the consumption patterns of UPFs among university students. Therefore, the National Nutrition Policy of Malaysia needs to incorporate strategies that focus not only on the types of food to be consumed or nutrients to be limited but also on ways to reduce UPF consumption. To curb obesity and associated chronic diseases in the university student population, future public health initiatives must place a priority on the reduction of UPFs.

CONCLUSION

This study elucidates that the majority of energy consumed by public university students in Malaysia derives from Groups 1 and 2, which comprise unprocessed or minimally processed foods and culinary ingredients. Notably, ultra-processed foods (Group 4) contribute to approximately 31% of their daily caloric intake, with processed foods (Group 3) contributing the least. Furthermore, it was found that the BMI of the majority of these students falls within the normal range, establishing a significant correlation between the consumption of ultra-processed foods and BMI among this demographic. These insights not only reinforce the importance of balanced dietary habits in maintaining a healthy BMI but also underscore the need for targeted interventions to reduce reliance on ultra-processed foods. The data generated from this research could serve as a valuable resource for government agencies and policymakers, aiding in the formulation of effective strategies and public health initiatives that address the consumption of different food categories and their impacts on BMI among public university students.

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ETHICAL STATEMENT

The application of human was approved by the human ethic board of committees of Universiti Malaysia Terengganu with the reference number: UMT/JKEPM/2022/111.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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