Mal J Nutr 21(3): 285 - 297, 2015

Determinants of Body Weight Status of University Students: Exploratory Evidence from Universiti Sains Malaysia

Low HJ,[1] Tan AKG,[2*] & Kassim S[1]

[1] *School of Mathematical Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia*
[2] *School of Social Sciences, Universiti Sains Malaysia, 11800 Penang, Malaysia*

ABSTRACT

Introduction: Overweight and obesity are major health concerns among young adults in Malaysia. This study investigates the association between socio-demographic and health-lifestyle factors and body weight status among university students. **Methods:** Data were obtained from random questionnaire-based face-to-face interviews of 414 full-time students from Universiti Sains Malaysia (USM). Ordered probit analysis was conducted and marginal effects of socio-demographic and health-lifestyle variables on body-mass-index (BMI) calculated. **Results:** Among socio-demographic variables, ethnicity (Chinese), gender (male), monthly household income bracket, and family history of obesity were significant factors in determining body weight status. As a health-lifestyle factor, self-reported main meal portion size was significantly associated with BMI. **Conclusion:** It is concluded that health policy makers in institutions of higher learning should take appropriate intervention measures by focusing on socio-demographic and health-lifestyle related factors in addressing issues of overweight and obesity among university students. Policy recommendations include implementing specific nutrition awareness programmes among male students and promoting health education that elevated body weight issues could be associated with familial traits. Efforts to ensure affordable and accessible nutrient-rich foods in campus cafeterias may also be beneficial to the nutritional health of university students.

Keywords: Body weight, obesity, ordered probability model, overweight, university students

INTRODUCTION

Overweight and obesity are major health concerns in Malaysia. Statistics from the 2011 National Health and Morbidity Survey (NHMS) indicate that 29.4% and 15.1% of Malaysians aged 18 years and above are suffering from overweight and obesity, respectively (Institute of Public Health 2011). However, while studies in Malaysia have examined the issues of overweight and obesity among school-age children (Zainuddin *et al.*, 2014) and adults (Tan *et al.*, 2011), other specific age ranges, particularly between adolescence and young adulthood, are also relevant. Statistics from the NHMS show that even as overweight and obesity prevalence among Malaysian youths between ages 18–19 years are 14.1% and 9.9%, respectively, the corresponding rates rise to 18.1% and 10.8% among young adults between ages 20–24 years (Institute of Public Health, 2011).

* Correspondence: Andrew KG Tan; Email: *atan@usm.my*

Another reason to focus on this adolescence and young adulthood age group is because this is an important period when young persons are most vulnerable to life-changing decisions. These include susceptibility to unhealthy eating habits, substance abuse, interpersonal and psychological problems, physical inactivity, and other undesirable lifestyle elements (Nelson *et al.*, 2008; Gan *et al.*, 2011). The early promotion of healthy lifestyle interventions among those in this crucial stage in life may therefore diminish the hazards of lifestyle-related illnesses throughout later years.

University students represent a unique segment of this young adult population. These individuals are experiencing a new phase in their lives, whereby most are transitioning from the confines of their own homes during high school into an independent university surrounding. Once in the university, students are often faced with greater freedom and self-responsibility in making decisions on various issues, such as food choices and habits, physical activity participation, leisure/sleeping hours, budgetary constraints, ability to cope with stress, and so forth. All these issues affect the individual health conditions of the student, including their body weight status. In fact, studies have associated female university students with a desire for thinness or those with body image dissatisfaction to eating disorders (Mase *et al.*, 2013). Unhealthy food choices and physical inactivity may also lead to overweight or obese conditions among university students (Al-Isa, 1999), while stress and sleep loss are often associated with greater risk of weight gain in students in institutions of higher learning (Serlachius, Hamer, & Wardle, 2007).

It is noteworthy that education levels are inversely associated with weight categories within the general population as studies often suggest that better educated individuals possess lower likelihoods of being overweight or obese than lesser educated persons (Aekplakorn *et al.*, 2007). Two possible reasons are posited for this outcome. First, better educated persons may be more cognizant of their health, possess greater access to health information, and be exposed to a wider array of diet and exercise choices than less educated individuals (Tan, Yen, & Feisul, 2012). Second, differences in time preference point to variations in individual health-related behaviours (Robb, Huston, & Finke, 2008). As individuals with lower time preferences may seek greater prominence of their future well-being than current welfare, they may abstain from smoking and drinking, and indulge in healthy diets and physical activity instead. In the same vein, it is hypothesised that learned university students are among those who display lower time preferences in relation to individual health-related behaviours, while looking out for their future interests compared to their present wellbeing.

Salient contributions of this study are four-fold. First, while there exists numerous studies on factors relating to BMI risks in Malaysia (e.g., Tan *et al.*, 2011; 2012), there remains scant detailed investigations on the determinants of body weight status within the younger generation, particularly among students in institutions of higher learning. In this study, we conducted an exploratory analysis to examine the determinants of body weight status among university students based on primary data collected from a pool of respondents from Universiti Sains Malaysia (USM). Second, this study draws on the World Health Organization's (WHO) recommended BMI cut-off criteria for Asian adults (WHO, 2000). This is important given the relevance of using ethnic-specific cut-off ranges for ascertaining body fat differences instead of relying on those recommended for standard usage and centred on either European or Caucasian populations as reference (Misra, 2003). Third, although previous researchers (Tan *et al.*, 2011) have utilised the more conventional binary probit or logit model to examine the health risks of overweight/obesity, we extend the analysis by using an ordered probability model to examine body mass irregularities of underweight, at-risk weight, overweight and obese weight, as well as identification of the likelihoods of normal or healthy weight categories. Fourth, Berg *et al.* (2009) suggest that meal portion size is associated with body weight status. A two-dimensional photograph of meal portions of various sizes was therefore used in the current study as visual support for respondents to self-report their portions of main meals in a more accurate fashion.

METHODS

Data

Data for the study were obtained by questionnaire-based face-to-face interviews among full-time USM students. Based on convenience sampling, a total of 10 respondents from the School of Social Sciences and School of Mathematics were initially selected in a pilot study to pre-test and detect any potential problems. From the outcomes of the pilot study, several parts of the questionnaire were revised for clarity. For example, while the initial survey lasted about 8–10 minutes, several respondents showed survey fatigue or confusion in completing the survey. The questionnaires were then streamlined by eliminating questions that were irrelevant or ambiguous and the actual time required was reduced to about 6 minutes only. This included a modification of the figures of portion size in Berg *et al.* (2009) as respondents were confused by the array of choices provided.

Actual interviews were conducted from November 2013 till December 2013, whereby respondents were randomly approached at various on-campus locations. Based on the current student population of USM of approximately 20,000 undergraduates, an attempt was made to stratify the respondents according to the various disciplines of study, consisting of 56.8% science (e.g. those majoring in Pharmacy, Biology, Mathematical Sciences, Physics etc.), 26.0% hybrid (e.g. Management, Housing, Building & Planning, Distance Education etc.), and 17.2% arts (e.g. Arts, Social Sciences, Humanities, Language and Literature etc.) majors. The student enrollment at USM consists of 40.4% first-, 23.0% second-, and 36.6% third/fourth/final-year students, while the gender ratio is approximately 33:67 male-female (Unit Kemasukan USM, 2013) (Table 1). It is relevant to note that although information on the exact ethnic breakdown of USM students is unattainable due to the sensitive nature of the information, the proportions of respondents in the current study were based on the ethnic population in Malaysia: Malay/Bumiputera (68.1%), Chinese (23.8%), Indian (7.1%), and Others (1.0%) (Department of Statistics Malaysia, 2014). Due to the exploratory nature of the study, as well as time, economic, and resource constraints, no other formal sampling methods were employed during the data collection process. As the respondents were selected by chance and independently of one another, a certain level of randomness was anticipated.

The questionnaire was divided into two parts. In part one, information on the student's socio-demographic background (e.g. ethnicity, gender, year and discipline of study, location of residence, monthly household income bracket, family history of obesity) were elicited. The student's self-reported height (in meter, m) and weight (in kilogram, kg) were also canvassed. In the second part, information on health-lifestyle related factors (e.g. smoking status, eating habits, and main meal portion size) were obtained.

After removing questionnaires with missing or incomplete information, 414 observations were retained for the final analysis. While the total number

Table 1. Definitions and summary statistics of explanatory variables

Variable	*Definition*	*Under-*	*Normal weight*	*At-risk weight*	*Over-*	*Obese sample*	*Total population*[†]	*USM*
Binary explanatory variables (1 = Yes; 0 = No)								
Malay	Ethnicity is Malay	47.13	52.31	76.36	70.91	77.27	58.21	68.10‡
Chinese	Ethnicity is Chinese	45.98	42.05	16.36	25.45	13.64	35.75	23.80
Indian/Others*	Ethnicity is Indian or others	6.90	5.64	7.27	3.64	9.09	6.04	8.10
Male	Gender is male	31.03	39.49	47.27	56.36	50.00	41.55	33.00
Science	Science majors (e.g. majoring in Pharmacy, Biology, Mathematical Sciences, Physics etc).	54.02	60.51	47.27	50.91	31.82	54.59	56.80
Arts*	Arts majors (e.g. majoring in Arts, Social Science, Humanities, Language & Literature etc.)	19.54	18.46	34.55	30.91	36.36	23.43	17.20
Hybrid	Hybrid majors (e.g. majoring in Management, Housing, Building & Planning, Distance Education etc)	26.44	21.03	18.18	18.18	31.82	21.98	26.00
Year 1	First year of study	45.98	29.23	38.18	25.45	22.73	33.09	40.40
Year 2*	Second year of study	24.14	22.56	21.82	23.64	22.73	22.95	23.00
Year 3 or 4	Third or fourth (final) year of study	29.89	48.21	40.00	50.91	54.55	43.96	36.60
Urban	Hometown is urban (more than 10,000 residents)	62.07	63.59	56.36	45.45	59.09	59.66	–
Low-income	Monthly household income is RM0–2999	52.87	59.49	69.09	63.64	50.00	59.42	–
Middle-income	Monthly household income is RM3000–6999	36.78	35.90	27.27	32.73	45.45	35.02	–
High-income*	Monthly household income is ≥ RM7000	9.20	3.08	1.82	3.64	4.54	4.35	–
Smoke	Currently smoking cigarettes	1.15	3.59	7.27	7.27	9.09	4.35	–
Family history	Family history of obesity	16.09	17.44	20.00	32.73	63.64	21.98	–
Night meals	Eat meals past midnight	59.77	59.49	70.91	69.09	59.09	62.32	–
Small portion	Small portion eaten during each main meal	14.94	10.77	5.45	5.45	0.00	9.66	–
Moderate portion*	Moderate portion eaten during each main meal	72.41	72.31	80.00	70.91	54.55	72.22	–
Large portion	Large portion eaten during each main meal	12.64	16.92	14.55	23.64	45.45	18.12	–
Sample size		87	195	55	55	22	414	–
(%)		(21.0)	(47.1)	(13.3)	(13.3)	(5.3)	(100.0)	–

* denotes reference category. [†] *Source:* Unit Kemasukan USM (2013). [‡] *Source*: Department of Statistics Malaysia (2014).
As of 29 November 2013, exchange rate was approximately US$1.00 = RM3.17 or RM1.00 = US$0.31. The five income categories correspond to poverty (USD 0–314), low (USD 315–945), lower-middle (USD 946–1576), upper-middle (USD 1577–2207) and high (≥ USD 2208). Values are in percentages.

of respondents was not large, it was considered adequate given a ±5 percentage points margin of error, 95% confidence level, and a population size of about 20,000 students in USM (Creative Research Systems, 2014).

Variables definition

Self-reported height (in meter, m) and weight (in kilogram, kg) measurements were used to calculate BMI (kg/m^2), which was classified by weight categories — underweight (BMI ≤ 18.4), normal weight (18.5 ≤ BMI ≤ 22.9), overweight at-risk (23.0 ≤ BMI ≤ 24.9) (henceforth referred to as at-risk), overweight obese I (25.0 ≤ BMI ≤ 29.9) (overweight), and overweight obese II (BMI ≥ 30.0) (obese) — according to adult Asian criteria (WHO, 2000). The dependent variables in the current study, such as body-weight categories, corresponded to low, average, increased, moderate, and severe risk of co-morbidities, respectively.

Socio-demographic and health-lifestyle explanatory variables hypothesised to affect BMI relied on insights from previous studies (Berg *et al.*, 2009; Tan *et al.*, 2012; among others): (1) ethnicity; (2) gender; (3) field of study; (4) urbanicity of hometown; (5) year of study; (6) monthly household income group; (7) smoking status; (8) family history of obesity; (9) night time eating habits; and (10) self-reported main meal portion size (Table 1).

Specifically, ethnicity of respondents was classified according to the three main ethnic groups in Malaysia (Malay, Chinese, Indian).[1] Additional characteristics include gender (Male) and location of residence/hometown (Urban). Household income was categorised according to high (monthly household income ≥ RM7000), middle (RM3000–6999), and low (RM0–2999) income groups. Academic factors involving field of study were coded into the three categories of Science, Arts, Hybrid majors. Year of study in the university was classified under first-, second-, and third/fourth/final-year. For health-lifestyle factors, dummy variables denoting current smoking status (Smoke) and presence of a history of family illness (Family history) were used. Nutritional status was represented by night time eating patterns (Night meals) and meal portion size (Small, Moderate, Large). Based on previous studies (Berg *et al.*, 2009), respondents were also shown a two-dimensional pictorial as visual support of what their plate looked like when eating their main meal; they then self-reported the meal size normally consumed (Figure 1). It was hypothesised that this visual support would enable respondents to better gauge their meal size in terms of ease and consistency.

Statistical analysis

The dependent variable, body weight category, was categorical and ordered. There was a clear ordering of the variable, although the size of the difference (i.e., in body weight) between weight categories need not be consistent. One statistical model suitable for explaining variations on such ordinal outcomes is the ordered probit model (McKelvy & Zavoina, 1975) characterised as

$$\text{Weight status} = \begin{cases} \text{Under if } -\infty < x\beta + u \leq 0 \\ \text{Normal if } 0 < x\beta + u \leq \mu 1 \\ \text{At-risk if } \mu 1 < x\beta + u \leq \mu 2 \\ \text{Over if } \mu 2 < x\beta + u \leq \mu 3 \\ \text{Obese if } \mu 3 < x\beta + u \leq \infty, \end{cases} \quad (1)$$

where x is the vector of explanatory variables, β is a vector of parameters, u is a random error term, and the μ's are threshold parameters delineating the weight categories (Tan *et al.*, 2012). The probability of each category can be derived from (1). For example, the probability of being over-weight is

[1] Respondents of "Other" ethnic descent were grouped under Indians to form the "Indian/others" category due to the small sample size of both of these groups (less than 10% for both).

Figure 1. Figures of main meal portion size
Source: Modified from Berg *et al.* (2009)

$$\Pr(\text{over-weight}) = F(\mu 3 - x\beta) - F(\mu 2 - x\beta), \quad (2)$$

where $F(\bullet)$ is the cumulative distribution function (cdf). The model was estimated by the method of maximum-likelihood (ML) (Maddala, 1983: 46–49). Using the ML estimates, the effects of explanatory variables were derived by differentiating (or differencing, in the case of a discrete varriable) the category probabilities in (2) (Tan *et al.*, 2012).

To check for multicollinearity among exposure variables, we calculated the variance inflation factor (VIF) for each variable. While VIF values over 20 are illustrative of multicollinearity problems (Belsley, Kuh & Welsch, 2004), the VIFs for all variables in the present study were less than 5 for all samples considered, with the highest values being for Chinese (4.94) and Malays (4.73). Thus, there was no evidence of multicollinearity among the exposure variables.

RESULTS

Characteristics of respondents

Descriptive statistics of all explanatory variables and BMI by weight categories are presented in Table 1 and classified according to the adult Asian criteria by the WHO (2000). With a total of 414 respondents in the study, the sample consisted of 87 (21.0%) underweight, 195 (47.1%) normal, 55 (13.3%) at-risk, 55 (13.3%) overweight, and 22 (5.3%) obese individuals.

The total sample was made up of 58.2% Malays, 35.8% Chinese and 6.0% "Indians and others" (combined as Indians/others given the minority status of both ethnic groups). About 41.6% of the total sample were males. Overall, Science majors (54.6%) formed the majority of the sample, followed by arts majors (23.4%), and hybrid majors (22.0%). Third/fourth/final-year students made up the largest constituent in the samples (44.0%), followed by first (33.1%) and second (23.0%) year students. It is noteworthy that although an initial attempt was made to stratify the sample based on ethnicity, gender, discipline of study, and year of study, the ethnic breakdown of the total sample slightly understates (overstates) the percentage of Malay (Chinese) ethnic population in Malaysia, while the proportion for Indians or others are comparable. Further, it is acknowledged that the actual sample overstates (understates) the male (female), Arts (Hybrid) major, and Year 3 or 4 (Year 1) population of USM to some extent (Table 1).

Approximately 59.7% of the students sampled resided in urban areas in their respective hometowns. The majority of the students hailed from low-income families (59.4%), with 35.0% classified as middle-income, and only 4.4% in the high-income category. Approximately 4.4% of the students were current smokers, while 22.0% came from families with a history of obesity. Most of the students (62.3%) indulged in eating meals past midnight, although 72.2% indicated that they normally consume moderate portions during each main meal.

Marginal effects of explanatory variables

Marginal effects quantify the association between socio-demographic and health-lifestyle exposure variables and the probabilities of BMI (Table 2).[2] Ethnic Chinese students were 2.26% more likely to be in the normal BMI category than their Indian/other ethnic counterparts. Gender was significantly associated with body weight status among university students as males faced significantly higher at-risk weight (3.02%), overweight (5.02%), or obese weight (2.31%) likelihoods, while encountering lower likelihoods of underweight (7.62%) or normal weight (2.73%) relative to females.

Monthly household income levels were negatively associated with the probabilities of BMI categories. Students from low-income households were more likely to be in the at-risk weight (5.01%), overweight (7.72%) or obese weight (3.33%) ranges compared to their peers from high-income households. Those hailing from middle-income households were 11.63% less likely to be underweight, while displaying higher propensities to be at-risk weight (4.59%) or overweight (8.14%) than their high-income cohorts.

Family history of obesity was significantly associated with body weight status among university students. Individuals with a family medical history of obesity were more likely to be at-risk weight (5.18%), overweight (10.54%) or obese weight (5.97%) but less likely to be underweight (13.29%) or normal weight (8.41%) than those without any history of obesity in the family. This suggests that genetics may be an important determinant of elevated body weight risk development among university students.

Main meal portion size was significantly associated with the probabilities of BMI categories. Students who consumed small meal portions faced lower propensities to be at-risk weight (4.84%), overweight (6.46%), or obese weight (2.38%) but were 13.35% more likely to be underweight compared to those who consumed moderate portions during their meals. In contrast, those who consumed large meal portions exhibited increased likelihoods of being at-risk weight (3.65%), overweight (6.95%), or obese weight (3.65%), while being 9.16% and 5.09% less likely to be underweight and normal weight, respectively, than moderate portion eaters.

DISCUSSION AND CONCLUDING REMARKS

Results of this study suggest that there exists significant differences in the effects of socio-demographic and health-lifestyle variables on BMI category probabilities among university students. In particular, compared to their female cohorts, male students are more likely to be at-risk weight, overweight or obese. Income level

[2] Due to the numerous socio-demographic and health-lifestyle exposure variables hypothesised to affect BMI, an initial attempt was made to examine possible interaction effects between variables (e.g. gender vs ethnicity, gender vs income group, smoking status vs ethnicity, course of study vs ethnicity, urbanicity vs ethnicity, urbanicity vs income group, gender vs portion of meal size). However, all interaction terms were not statistically significant (results available upon request) and a decision was made to retain the current parsimonious model.

Table 2. Marginal effects of explanatory variables on BMI category probabilities

Variable	*Under-weight*	*Normal-weight*	*At-risk-weight*	*Over-weight*	*Obese*
Malay	–5.14	–1.46	2.02	3.19	1.39
	(6.42)	(1.70)	(2.52)	(3.89)	(1.70)
Chinese	10.45	2.26*	–4.02	–6.11	–2.58
	(7.22)	(1.27)	(2.71)	(3.92)	(1.66)
Male	–7.62**	–2.73*	3.02**	5.02**	2.31**
	(3.35)	(1.50)	(1.38)	(2.31)	(1.17)
Science	5.84	1.94	–2.31	–3.77	–1.69
	(3.97)	(1.49)	(1.60)	(2.63)	(1.23)
Hybrid	4.27	1.01	–1.67	–2.55	–1.07
	(4.68)	(0.85)	(1.80)	(2.61)	(1.06)
Urban	2.17	0.71	–0.86	–1.40	–0.62
	(2.92)	(1.02)	(1.17)	(1.91)	(0.86)
Year 1	5.88	1.46	–2.29	–3.54	–1.50
	(4.47)	(0.98)	(1.74)	(2.57)	(1.08)
Year 3 or 4	–2.38	–0.77	0.94	1.53	0.68
	(3.76)	(1.27)	(1.50)	(2.44)	(1.10)
Low-income	–13.07*	–3.00**	5.01*	7.72**	3.33*
	(7.12)	(1.53)	(2.67)	(3.94)	(1.81)
Middle-income	–11.63*	–5.13	4.59*	8.14*	4.03
	(5.95)	(3.55)	(2.35)	(4.58)	(2.64)
Smoke	–5.36	–2.75	2.16	3.96	1.99
	(5.92)	(4.46)	(2.41)	(5.08)	(2.91)
Family history	–13.29***	–8.41***	5.18***	10.54***	5.97***
	(2.60)	(2.88)	(1.20)	(2.72)	(1.94)
Night meals	4.99	1.78	–1.98	–3.29	–1.50
	(3.08)	(1.32)	(1.25)	(2.13)	(1.02)
Small portion	13.35**	0.33	–4.84**	–6.46***	–2.38***
	(6.64)	(1.69)	(2.24)	(2.52)	(0.89)
Large portion	–9.16***	–5.09*	3.65***	6.95**	3.65**
	(3.12)	(2.76)	(1.31)	(2.90)	(1.81)

Values are in percentages. Standard errors in parenthesis. Asterisks indicate levels of statistical significance: ***p < 0.01, **p < 0.05, *p < 0.10. Reference categories are Arts majors for type of major, Indian/others for ethnicity, Year 2 for year of study, High-income for monthly household income, and Moderate for portion eaten each meal.

is a significant determinant of BMI status as students from low and middle-income households are more likely to experience elevated body weight ranges compared to their high-income counterparts. Family history of obesity is a strong predictor of elevated BMI as students with obese family members exhibit higher likelihoods of being at-risk weight, overweight or obese than those without such conditions. Meal size is associated with BMI categories as students who consume small (large) portions during their main meals are less (more) likely to be at-risk weight, overweight, or obese, while being more (less) likely to be underweight than those who consume moderate meal portions. Based on these results, further discussions are provided vis-à-vis the socio-demographic and health-lifestyle related determinants of BMI among university students in Malaysia.

First, results herewith corroborate the findings of studies in other countries that male university students are more likely to fall in the unhealthy BMI ranges than females (Al-Isa, 1999). This outcome contradicts those of Tan *et al.* (2012) who found no statistical difference between gender and BMI categories based on national data in Malaysia. This implies that while gender differences may not distinguish between BMI categories within the general Malaysian population, it may be a significant factor among university students. As suggested by Wardle *et al.* (2004), this outcome can be attributed to the greater weight control involvement or stronger beliefs in healthier eating habits by female university students. Hence, while university policy makers should consider implementing specific nutrition awareness programmes to combat overweight and obesity among its students, particular attention should be focused on the male student population as they are about 7.3% more likely to be overweight or obese than their female peers.

Second, current results validate findings from Lazarevich *et al.* (2013) that obesity prevalence among university students is influenced by both genetic and environmental factors. Such findings also support those of Tan *et al.* (2011; 2012) based on data from the general population of Malaysia that family history of obesity is a significant determinant of unhealthy BMI ranges. It would therefore be worthy for university policy makers to enlighten students that the causes of overweight and obesity may include an individual's genetic makeup, with occurrences being more prevalent in some families than others (Paradis *et al.*, 2009). This includes disseminating cautionary information that those with a family history of obesity are cumulatively 16.5% more likely to be diagnosed as overweight or obese than others.

Third, the present results conform to existing studies (Crawford *et al.*, 2004; Wan, Kandiah, & Taib, 2004; Drewnowski and Darmon, 2005) on an inverse relationship between household income levels and body weight ranges. As suggested by Drewnowski and Darmon (2005), the higher rates of overweight and obesity among the lower income groups may be attributed to nutritional factors, such as dietary energy density and energy cost. Individuals facing budgetary constraints may favour lower-cost energy-dense diets which are nutrient poor (e.g. starchy rice, inexpensive grains, added sugars, and added fats) instead of healthy diets with higher costs (e.g. lean meat, fruits and vegetables, whole grains, low-fat milk products, fish, poultry). Crawford *et al.* (2004) note that reliance on high-fat and high-sugar foods as the cheapest source of calories among low-income individuals may result in excessive weight gain. In this case, university students may be opting for such unhealthy diets given their lower-income status. It may therefore be prudent for university officials to raise health awareness within its student population, particularly among those with lower socio-economic status, on the choice of nutrient-rich (energy-dense) foods to consume (avoid) in order to ensure optimal body weight ranges.

Fourth, our findings show the significance of main meal portion size in determining body weight status of university students. This confirms the results of Young and Nestle (2002) and Berg *et al.* (2009) on the importance of proper eating habits, such as correct portion-sizing meals, in order to achieve or maintain a normal BMI status. It is also worthy to reiterate the previous close relationship between gender and body weight status as cross-tabulation results (available upon request) show that female students, who were previously found to exhibit greater propensities to be underweight or normal weight, are more likely to choose moderate (76.4%) or small (14.9%) meal portion sizes compared to male scholars (66.3%, 2.3%). Similarly, males (31.4%) are more likely to choose large meal portion sizes than females (8.7%). Since proper meal portion-sizing may be effective in achieving proper body weight outcomes, it may therefore be practical for the Malaysian health authorities to educate the public, especially male university students, on the importance of choosing reasonable food portions for better health (Ledikwe, Ello-Martin, & Rolls, 2005). As shown in the present analysis, failure to abide by the appropriate meal size portion may result in body weight categories that are associated with moderate to severe risks of co-morbidities.

Last, explanatory variables that did not appear statistically significant merit some discussion. First, while consuming meals past midnight may facilitate higher BMI weight conditions due to excess calories consumed at night (Gallant, Lundgren, & Drapeau, 2012), this is not upheld by the current results. One rationalisation is that although studies have shown that night-eating may lead to a general increase in body weight, total caloric intake may be the key to changes in body mass instead of the time of day food is consumed (Wilborn & Kerksick, 2012). This result may be indicative of the elevated awareness levels among young and educated university students with respect to proper caloric intake even though meals are consumed during late night hours. Second, while studies among the general population in Malaysia have often found smokers to be less likely to experience higher weight conditions compared to non-smokers (Tan *et al.*, 2011), the present results indicate no significant differences in body weight categories among smoking and non-smoking university students. This outcome could possibly be due to the low reported smoking rates (4.4%) among students in the present study compared to the national prevalence of 19.3% (Institute of Public Health, 2011).

While this study serves as a catalyst to further investigations on the role of socio-demographic and health-lifestyle factors in affecting BMI categories among university students, four important caveats are relevant. First, measurements of height and weight were self-reported. It is recognised that formal measurement of the height and weight components to calculate BMI is important and may enhance the statistical findings. Hence, future studies could replicate our analysis based on specific clinical measurements (e.g. measuring height sans footwear or headwear using a stadiometer or weight using a balance beam or SECA beam scale with light clothing). Second, additional information (e.g. course workload, student grades, participation in physical activity) or longitudinal panel data may provide useful perspectives to evaluate the robustness of our results. Third, while a larger data set encompassing other institutions of higher learning may provide a more comprehensive understanding of the determinants of body weight status of university students in Malaysia, this is relegated as a suggestion for future research given existing time, economic and resource constraints. Fourth, among the exposure variables, we found interdependence between male and ethnic groups, which suggests males are more/less likely to be of one ethnic group. Such interdependence is worthy of further investigation but is beyond the scope of the current inquiry. We interfaced male with these ethnic groups but found the interaction terms jointly insignificant. Removal of male from the regression also did not produce discernible differences in the marginal effects. The issue of interdependence among exposure variables deserves further analysis in future studies. Further studies might also consider a probability-based sample design, and development of a weighting factor (variable) to accommodate unequal probability of the sampling units.

REFERENCES

Aekplakorn W, Hogan MC, Chongsuvivatwong V, Tatsanavivat P, Chariyalertsak S, Boonthum A, Tiptaradol, S & Lim SS (2007). Trends in obesity and associations with education and urban or rural residence in Thailand. *Obesity* 15(12): 3113–3121.

Al-Isa AN (1999). Obesity among Kuwait university students: An explorative study. *Perspect Public Health* 119(4): 223–237.

Belsley DA, Kuh E & Welsch RE (2004). Regression Diagnostics: Identifying Influential Data and Sources of Collinearity. Wiley, New York.

Berg C, Lappas G, Wolk A, Strandhagen E, Toren K, Rosengren A, Thelle D & Lissner L (2009). Eating patterns and portion size associated with obesity in a Swedish population. *Appetite* 52(1): 21–22.

Crawford PB, Townsend MS, Metz DL, Smith D, Espinosa-Hall G, Donohue SS, Diocson C & Kaiser LL (2004). How can Californians be overweight and hungry? *California Agr* 58(1): 12–17.

Creative Research Systems (2014). *Sample size calculator*. From *http://www.surveysystem.com/sscalc.htm* [Retrieved July 16 2015].

Department of Statistics Malaysia (2014). Social Statistics Bulletin Malaysia 2014. Putrajaya, Malaysia. From *https://www.statistics.gov.my/* [Retrieved September 15 2015].

Drewnowski A & Darmon N. (2005). The economics of obesity: Dietary energy density and energy cost. *Am J Clin Nutr* 82(suppl): 265S–273S.

Gan WY, Mohd Nasir MT, Zalilah MS & Hazizi AS (2011). Differences in eating behaviours, dietary intake and body weight status between male and female Malaysian university students. *Mal J Nutr* 17(2): 213–228.

Gallant AR, Lundgren J & Drapeau V (2012). The night-eating syndrome and obesity. *Obesity Rev* 13(6): 528–536.

Institute of Public Health (2011). National Health and Morbidity Survey 2011: Non-Communicable Diseases. Vol. II: Non-communicable Diseases. Putrajaya, Malaysia: Ministry of Health Malaysia.

Lazarevich I, Irigoyen-Camacho ME & Velazquez-Alva MDC (2013). Obesity, eating behaviour and mental health among university students in Mexico city. *Nutr Hosp* 28(6): 1892–1899.

Ledikwe JH, Ello-Martin JA & Rolls BJ (2005). Portion sizes and the obesity epidemic. *J Nutr* 135(4): 905–909.

Maddala, GS (1983). Limited-Dependent and Qualitative Variables in Econometrics. Cambridge University Press, Cambridge.

Mase T, Miyawaki C, Kouda K, Fujita Y, Ohara K & Nakamura H (2013). Relationship of a desire of thinness and eating behavior among Japanese underweight female students. *Eat Weight Disord* 18(2): 125–132.

McKelvey RD & Zavoina W (1975). Statistical model for the analysis of ordinal level dependent variables. *J Math Sociol* 4(1): 103–120.

Misra A (2003). Revisions of cutoffs of body mass index to define overweight and obesity are needed for the Asian-ethnic groups. *Int J Obesity* 27: 1294–1296.

Nelson MC, Story M, Larson NI, Neumark-Sztainer D & Lytle LA (2008). Emerging adulthood and college-aged youth: An overlooked age for weight-related behavior change. *Obesity* 16(10): 2205–2211.

Paradis AM, Godin G, Lemieux S, Perusse L & Vohl MC (2009). Eating behaviours of non-obese individuals with and without familial history of obesity. *Br J Nutr* 101: 1103–1109.

Robb CA, Huston SJ & Finke MS (2008). The mitigating influence of time preference on the relation between smoking and BMI scores. *Int J Obesity* 32(11): 1670–1677.

Serlachius A, Hamer M & Wardle J (2007). Stress and weight change in university students in the United Kingdom. *Physiology Behav* 92(4): 548–553.

Tan AKG, Dunn RA, Samad MIA & Feisul MI (2011). Sociodemographic and health-lifestyle determinants of obesity risks in Malaysia. *Asia Pac J Public Health* 23(2): 192–202.

Tan AKG, Yen ST & Feisul MI (2012). Determinants of body weight status in Malaysia: An ethnic comparison. *Int J Public Health* 57(2): 279–288.

Unit Kemasukan USM (Admissions Office USM) (2013). Statistics of students in Universiti Sains Malaysia. Penang, Malaysia: Universiti Sains Malaysia.

Wan PL, Kandiah M & Taib MNM (2004). Body image perception, dietary practices, and physical activity of overweight and normal weight Malaysian female adolescents. *Mal J Nutr* 10(2): 131–147.

Wardle J, Haase AM, Steptoe A, Nillapun M, Jonwutiwes K & Bellisle F (2004). Gender differences in food choice: the contribution of health beliefs and dieting. *Ann Behav Med* 27(2): 107–116.

WHO (World Health Organization) (2000). The Asia-Pacific Perspective: Redefining Obesity and its Treatment. World Health Organization, Western Pacific Region.

Wilborn C & Kerksick CM. (2011). The impact of nutrient timing considerations on weight loss and body composition. In: *Nutrient Timing: Metabolic Optimization for Health, Performance, and Recovery*. CM Kerksick (Ed.) (pp. 286–287). CRC Press,Boca Raton, FL.

Young LR & Nestle M (2002). The contribution of expanding portion sizes to the U.S. obesity epidemic. *Am J Public Health* 92(2): 246–249.

Zainuddin AA, Manickam MA, Baharudin A, Omar A, Cheong SM, Ambak R, Ahmad MH & Ghaffar SA (2014). Self-perception of body weight status and weight control practices among adolescents in Malaysia. *Asia Pac J Public Health* 26(5): 18S–26S.

Appendix

Table A1. Maximum-likelihood ordered probit regression estimates with interaction terms

Variable	*Parameter Estimates*	*Standard Errors*
Malay	–0.061	0.463
Chinese	–0.427	0.488
Male	0.493	0.884
Science	–0.700	0.871
Hybrid	–0.605	0.871
Urban	0.095	0.756
Year 1	–1.640**	0.812
Year 3 or 4	–0.581	0.606
Low-income	0.401	0.713
Middle-income	0.064	0.725
Smoke	1.168	0.803
Family history	0.608***	0.135
Night meals	–0.229*	0.126
Small portion	–0.453**	0.214
Large portion	0.455*	0.256
Male_Malay	0.843	0.570
Male_Chinese	0.422	0.574
Male_Low-income	–0.863	0.695
Male_Middle-income	–0.698	0.708
Male_Small portion	–0.231	0.601
Male_Large portion	–0.070	0.321
Arts_Malay	0.112	0.594
Arts_Chinese	0.482	0.630
Arts_Low-income	–0.676	0.663
Arts_Middle-income	–0.700	0.682
Urban_Malay	0.027	0.506
Urban_Chinese	–0.213	0.523
Urban_Low-income	–0.265	0.584
Urban_Middle-income	0.192	0.602
Smoker_Malay	–1.245	0.865
Smoker_Chinese	0.245	1.330
Year 1_Low-income	1.460*	0.832
Year 1_Middle-income	1.303	0.846
Year 3 or 4_Low-income	0.626	0.635
Year 3 or 4_Middle-income	0.679	0.649

Asterisks indicate levels of statistical significance: ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.