ORIGINAL ARTICLE

Sociodemographic Factors Associated with Waist Circumference among Male and Female Adults: Findings of the Malaysian Adult Nutrition Survey 2014

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ABSTRACT

Introduction: This study examined how waist circumference (WC) varied across sociodemographic characteristics of Malaysian adults using a nationally representative data. **Methods:** Data from the Malaysian Adult Nutrition Survey 2014 (n = 2696) was used. In the sample, 46.55% were males and 53.45% were females. The outcome variable was WC. Waist circumference was categorised into four ordinal outcomes: very low, low, high and very high. The explanatory variables were age, monthly individual income, education, gender, marital status, ethnicity, employment status and household location. Ordered probit models were utilised. **Results:** The majority of males had a low WC (54.66%), and only a small proportion had a very high WC (0.96%). Similarly, a high proportion of females had a low WC (55.59%), and only 1.94% had a very high WC. Younger males were more likely to have a high WC than their older counterparts. Males who had monthly income of RM2000-2999 or RM3000-3999 were more likely to have a high WC compared with those who had monthly income of ≤RM999. Chinese and Indian males were more likely to have a high WC than Bumiputera males. For females, those who were married, widowed/divorced and Bumiputera were likely to have a high WC. **Conclusion:** WC was associated with various sociodemographic profiles of males and females. In particular, there were positive associations between the likelihoods of having a high WC and younger age group, higher income, Chinese, Indian, and being married. Our findings provided policy makers with better information on formulating intervention measures.

Keywords: Ethnicity, Gender, Income, Obesity, Waist circumference

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INTRODUCTION

Obesity has become a serious issue in developed and developing countries. There appears to be an increasing public health concern about the high prevalence of obesity. In Malaysia, approximately 27.8% of males and 33.6% of females were obese in 2015, which was higher than the figures reported in the National Health and Morbidity Survey (NHMS) 2011 (1, 2). In the NHMS 2011, only 25% of males and 29.6% of females were obese (2). These increasing trends of obesity are somewhat similar to the United States (US) and globally (3). Consequently, if rising prevalence of obesity is unresolved, it will have a negative impact on the economic and health profiles of a country. Annually in Malaysia, about 10-20% of national health expenditures are allocated for obesity related diseases (4). Compared to other developing countries in South-East Asia, such as Thailand, Vietnam and Philippines, Malaysia has the highest costs related to obesity (4).

With increasing prevalence of obesity, there are numerous studies that examine the associations between sociodemographic factors and the likelihood of being obese worldwide, especially in developing countries (5-

17). In Malaysia, studies by Mohd Zaki et al. (18) and Norafidah et al. (19) are among a few comprehensive studies that examined the relationships between sociodemographic profiles and waist circumference (WC). Although body mass index (BMI) has widely been used to measure obesity, WC remains a better predictor of obesity-related diseases, such as hypertension, hypercholesterolemia and metabolic syndrome (20, 21). This is mainly because BMI is unable to distinguish people who have high muscle mass and those with high body fat. Having a high WC appears to be more dangerous than having a high BMI. The main advantage of using WC is that it is a more accurate indicator of abdominal fat, that is, the main cause of cardiovascular disease, and mortality compared with BMI (20, 22).

However, previous studies do have some limitations (18, 19). Mohd Zaki et al.'s (18) study used data from the National Health and Morbidity Survey of Malaysia to investigate the trends of WC, which only estimated the mean and prevalence and did not examine the probability of having a high/low WC. On the other hand, Norafidah et al. (19) employed a logistic regression model to analyse the odds of having a high WC, but did not use a nationally representative data. Also, several important sociodemographic variables, such as income, education level and marital status were omitted.

In Southeast Asia, there are studies that investigate sociodemographic factors associated with obesity in Thailand, Indonesia and Singapore (23-25). In Thailand, the study only focused on prevalence and did not examine the likelihood of being overweight or obese (23). Besides, the study also did not obtain data on WC. The Indonesian study did not use a nationally representative data as it concentrated on the elderly in a district (24). Similarly, the findings evidenced in the study conducted in Singapore could not be generalized to the entire population because the study only focused on the elderly (25). Moreover, these three studies did not categorise WC into ordinal categories for a rigorous analysis.

The objective of the present study is to narrow these identified research gaps. In brief, the present study attempted to contribute to the existing literature in three ways. First, unlike other studies that categorised WC into two categories, i.e., low and high, the present study grouped WC into four ordinal categories, i.e., very low, low, high and very high. The purpose of dividing WC into four ordinal categories was that we wanted to make it to become similar to BMI, which consisted of four ordinal categories as well, i.e., underweight, normal weight, overweight and obesity (26). This categorisation may offer useful information for obesity risk evaluation, thus leading to a better policy formulation. Previous studies that divided WC into two categories were inadequate for risk evaluation (18, 19, 23-25). Likewise, continuous WC cannot provide important information as it is unable to determine which cohorts of people have a high, medium or low risk of obesity-related diseases.

Ordered probit models were utilised to examine sociodemographic factors associated with the probabilities of having each of these categories. Sociodemographic differences in WC must be well-identified, so that which population are at risk of obesity-related diseases can be known. Ordered probit is able to provide a deep understanding of which groups of population have a high, medium or low risk of suffering from obesity-related diseases. Specifically, using ordered probit, we are able to identify which individuals have a high likelihood of having a very low, low, high or very high WC. If the individuals have a high likelihood of having a very high WC, they are considered having a high risk of obesity-related diseases, whereas if the individuals have a high likelihood of having a very low WC, they are considered having a low risk of obesity-related diseases. Moreover, compared to a binary logistic regression, an ordered probit approach is more able to fully utilise the available information and prevent loss of details caused by reducing the categories of the responses (27).

Second, a nationally representative data with a large sample size (n = 2696) was used. This data has comprehensive information on individuals' sociodemographic profiles and WC. Hence, important findings could be generated. Third, the country of interest of the present study is Malaysia, where there is a lack of comprehensive studies related to sociodemographic factors associated with WC. Findings of the present study could then be compared with those in other developing countries, such as, Turkey, Iran, Sri Lanka, Ghana and Nepal.

The present study reaches a wider readership in two ways. First, results of the present study can be generalised to the entire population in Malaysia. A comparison between our findings and those evidenced in other countries can be drawn. Second, the present study offers a better knowledge of sociodemographic differences in the likelihood of having a very low, low, high and very high WC among adults. These findings can help to determine which individuals have high, medium or low risk of suffering from obesity-related diseases, which can serve as a useful guideline for policy development in Malaysia and other countries.

MATERIALS AND METHODS

Data

The present study used a cross-sectional analysis of the Malaysian Adult Nutrition Survey (MANS) 2014 (28). The Ministry of Health Malaysia conducted the first MANS in 2001. The MANS 2014 is the second survey, which is the latest survey available for secondary analysis. The MANS used a multi-stage random

sampling to collect a nationally representative sample of Malaysian adults. In the first stage, Malaysia as a whole was segmented into several enumeration blocks (EBs). In the second stage, living quarters (LQs) in each EB were randomly selected. In the third stage, individuals who resided in the selected LQs were randomly selected. The exclusion criterion was individuals who were institutionalised, pregnant, breastfeeding or followed specific diet because of illnesses. Details of individuals' sociodemographic profiles were obtained using face-to-face interviews. These profiles included age, income, education, gender, marital status, ethnicity, employment status and household location. While the targeted respondents were 4,000, only 3,574 respondents were actually interviewed. The MANS 2014 was approved by the Medical Research and Ethics Committee of Ministry of Health Malaysia (NMRR-12-815-13100). A consent form was given to each of the selected respondents before the interview. If the respondents were minor or disabled, consent was sought from their parents or guardians. In an effort to ensure that our findings are nationally representative and can be generalised to the entire population in Malaysia, the minors and the disabled were not excluded from our study.

Outcome variable

The outcome variable was WC. During the survey, tape SECA 201 (seca Deutschland, Hamburg, Germany) was used by interviewers to measure individuals' WC. Following the study by Bray (26), WC was formatted as a categorical variable with four ordinal outcomes: very low, low, high and very high. Because the WC guidelines are different in males and females, two separate variables for WC were created. For males, those who had <80 cm, 80-99 cm, 100-120 cm and >120 cm of WC were considered to have a very low, low, high and very high WC, respectively. For females, those who had <70 cm, 70-89 cm, 90-109 cm and >110 cm of WC were considered to have a very low, low, high and very high WC, respectively.

Explanatory variables

The explanatory variables were individuals' sociodemographic profiles, which comprised age (≤29 years, 30-39 years, 40-49 years or ≥50 years), monthly individual income [≤ Ringgit Malaysia (RM) 999, RM1000-1999, RM2000-2999, RM3000-3999 or ≥RM4000], education level (tertiary, secondary, primary or no-formal education), gender (male or female), marital status (married, single or widowed/divorced), ethnicity (Bumiputera, Chinese, Indian or others), employment status (employed or unemployed) and household location (urban or rural). The income categories were formed based on a nationwide study conducted by Cheah et al. (29). Because the data on household income was not available in the MANS 2014, we were unable to categorise the income according to B40, M40 and T20. The explanatory variables were selected based on the findings of previous studies (5-17).

However, health and behavioural profiles were not used as the explanatory variables because of possible endogeneity issue. We expected that there was a causal interrelationship, i.e., two-way causal relationship, between health and behavioural profiles, such as dietary behaviour and physical activity, and WC, which may result in endogeneity issue (caused by simultaneous bias) in the multiple regression. For instance, individuals who are physically inactive are likely to have a high WC, and individuals who have a high WC are probably physically inactive too since they may face difficulties participating in physical activity. This endogeneity issue may cause the estimates to become inaccurate and imprecise, leading to an inaccurate conclusion. In order to overcome this issue, an appropriate instrumental variable (IV) for dietary behaviour or physical activity must be used. However, due to data limitation, we were unable to identify an appropriate IV. Information about endogeneity has been described elsewhere (30).

Statistical analysis

In the MANS 2014, the response rate was 89.35%. A total of 1304 respondents were removed from the present study because of incomplete information on sociodemographic profiles and WC. Hence, the final sample used for analyses comprised 2,696 respondents (1,255 males and 1,441 females). All statistical analyses were stratified by gender. In order to assess the bivariate relationships between sociodemographic factors and WC, chi-squared (χ^2) tests were utilised.

In terms of multivariate analysis, ordered probit models were used. The purpose was to estimate the probability for sociodemographic variables associated with very low, low, high and very high WC. The ordered probit models were multiple regressions, meaning that all the explanatory variables included in the models were controlled for when we estimated each of the parameters. For instance, when we analysed the effect of age on WC, sociodemographic factors other than age were held constant. In other words, the marginal effects of explanatory variables were calculated using partial derivatives. The variables that were found to be significantly associated with WC in previous studies were selected as the explanatory variables in the present study (5-17). Standard error of each explanatory variable was calculated. $p<0.05$ was considered to be statistically significant in all the tests. Stata statistical software was used to perform all statistical analyses (31).

RESULTS

Of the total sample, 46.55% were males and 53.45% were females. This gender structure is quite similar to the gender distribution in the NHMS 2015 (45.12% males, 54.88% females), indicating that the sample is nationally representative (1). The majority of males had a low WC (54.66%), followed by those with a very low (33.07%), high (11.31%) and very high WC

(0.96%). Among females, 12.98%, 55.59%, 29.49% and 1.94% had a very low, low, high and very high WC, respectively. The majority of males and females were aged 30-39 years, and about 60-70% of males and females had secondary-level education. Approximately 37.93% of males had a monthly income of ≤RM999, while more than half of females had a monthly income of ≤RM999. A large proportion of males and females were married and Bumiputera. Among males, 90.28% were employed and 51.95% resided in urban areas. Of all the females, 60.37% and 53.30% were employed and urban dwellers, respectively (Table I).

Table I: Summary statistics of variables, by gender

Variables	Total (n = 2696)		Male (n = 1255)		Female (n = 1441)	
	Freq.	%	Freq.	%	Freq.	%
Waist circumference						
Very low	–	–	415	33.07	187	12.98
Low	–	–	685	54.66	801	55.59
High	–	–	142	11.31	425	29.49
Very high	–	–	12	0.96	28	1.94
Age						
29 years	705	26.15	352	28.05	353	24.50
30-39 years	737	27.34	340	27.09	397	27.55
40-49 years	700	25.96	322	25.66	378	26.23
50 years	554	20.55	241	19.20	313	21.72
Income						
RM999	1409	52.26	476	37.93	933	64.75
RM1000-1999	573	21.25	373	29.72	200	13.88
RM2000-2999	266	9.87	164	13.07	102	7.08
RM3000-3999	190	7.05	107	8.53	83	5.76
RM4000	258	9.57	135	10.76	123	8.54
Education						
Tertiary	272	10.09	113	9.00	159	11.03
Secondary	1734	64.32	854	68.05	880	61.07
Primary	560	20.77	255	20.32	305	21.17
No-formal	130	4.82	33	2.63	97	6.73
Gender						
Male	1255	46.55	–	–	–	–
Female	1441	53.45	–	–	–	–
Marital status						
Married	1855	68.81	802	63.90	1053	73.07
Single	665	24.67	410	32.67	255	17.70
Widow/divorce	176	6.53	43	3.43	133	9.23
Ethnicity						
Bumiputera	1953	72.44	891	71.00	1062	73.70
Chinese	460	17.06	223	17.77	237	16.45
Indian	120	4.45	60	4.78	60	4.16
Others	163	6.05	81	6.45	82	5.69
Employment						
Employed	2003	74.30	1133	90.28	870	60.37
Unemployed	693	25.70	122	9.72	571	39.63
Location						
Urban	1420	52.67	652	51.95	768	53.30
Rural	1276	47.33	603	48.05	673	46.70

Note: Freq. refers to frequency.
Source: MANS 2014.

According to χ^2 tests, age, income and ethnicity were significantly associated with males' WC. The proportions of having a high and very high WC were highest among individuals aged ≥50 years, whereas the proportions of having a very low and low WC were highest among those aged 40-49 years. In terms of ethnicity, the proportion of having a very low WC was highest among others, whereas the proportion of having a very high WC was highest among Indians (Table II).

Table II: Proportion of males in very low, low, high and very high WC (n = 1255)

Variables	Waist circumference			
	Very low	Low	High	Very high
Age				
29 years	123 (34.94)	183 (51.99)	46 (13.07)	0 (0.00)
30-39 years	112 (32.94)	187 (55.00)	37 (10.88)	4 (1.18)
40-49 years	113 (35.09)	181 (56.21)	26 (8.07)	2 (0.62)
50 years	67 (27.80)	135 (56.02)	33 (13.69)	6 (2.49)
		18.54*		
Income				
RM999	178 (37.39)	246 (51.68)	49 (10.29)	3 (0.63)
RM1000-1999	131 (35.12)	195 (52.28)	43 (11.53)	4 (1.07)
RM2000-2999	43 (26.22)	98 (59.76)	22 (13.41)	1 (0.61)
RM3000-3999	26 (24.30)	64 (59.81)	16 (14.95)	1 (0.93)
RM4000	37 (27.41)	83 (61.48)	12 (8.89)	3 (2.22)
		19.00*		
Education				
Tertiary	28 (24.78)	76 (67.26)	7 (6.19)	2 (1.77)
Secondary	289 (33.84)	452 (52.93)	105 (12.30)	8 (0.94)
Primary	83 (32.55)	141 (55.29)	29 (11.37)	2 (0.78)
No-formal	15 (45.45)	17 (51.52)	1 (3.03)	0 (0.00)
		14.41		
Marital status				
Married	257 (32.04)	446 (55.61)	88 (10.97)	11 (1.37)
Single	144 (35.12)	218 (53.17)	47 (11.46)	1 (0.24)
Widow/divorce	14 (32.56)	22 (51.16)	7 (16.28)	0 (0.00)
		6.24		
Ethnicity				
Bumiputera	314 (35.24)	474 (53.20)	93 (10.44)	10 (1.12)
Chinese	51 (22.87)	144 (64.57)	27 (12.11)	1 (0.45)
Indian	16 (26.67)	28 (46.67)	15 (25.00)	1 (1.67)
Others	34 (41.98)	40 (49.38)	7 (8.64)	0 (0.00)
		29.57*		
Employment				
Employed	376 (33.19)	621 (54.81)	124 (10.94)	12 (1.06)
Unemployed	39 (31.97)	65 (53.28)	18 (14.75)	0 (0.00)
		2.80		
Location				
Urban	210 (32.21)	351 (53.83)	84 (12.88)	7 (1.07)
Rural	205 (34.00)	335 (55.56)	58 (9.62)	5 (0.83)
		3.62		

Note: Percentages in parentheses. *p<0.05.
Source: MANS 2014.

In addition, results of χ^2 tests showed that age and education were significantly associated with females' WC. Age group of ≥50 years had the highest proportion of very high WC and the lowest proportion of very low WC. Tertiary education had the higest proportion of low WC, whereas secondary education had the highest proportion of very low WC. Primary and no-formal education had the highest proportion of high and very high WC, respectively (Table III).

Table III: Proportion of females in very low, low, high and very high WC (n = 1441)

Variables	Waist circumference			
	Very low	Low	High	Very high
Age				
29 years	9 (13.88)	200 (56.66)	100 (28.33)	4 (1.13)
30-39 years	48 (12.09)	222 (55.92)	115 (28.97)	12 (3.02)
40-49 years	53 (14.02)	202 (53.44)	122 (32.28)	1 (0.26)
50 years	37 (11.82)	177 (56.55)	88 (28.12)	11 (3.51)
		15.97*		
Income				
RM999	1118 (12.65)	515 (55.20)	280 (30.01)	20 (2.14)
RM1000-1999	29 (14.50)	102 (51.00)	66 (33.00)	3 (1.50)
RM2000-2999	16 (15.69)	60 (58.82)	24 (23.53)	2 (1.96)
RM3000-3999	12 (14.46)	43 (51.81)	28 (33.73)	0 (0.00)
RM4000	12 (9.76)	81 (65.85)	27 (21.95)	3 (2.44)
		12.85		
Education				
Tertiary	17 (10.69)	93 (58.49)	46 (28.93)	3 (1.89)
Secondary	128 (14.55)	483 (54.89)	257 (29.20)	12 (1.36)
Primary	31 (10.16)	173 (56.72)	94 (30.82)	7 (2.30)
No-formal	11 (11.34)	52 (53.61)	28 (28.87)	6 (6.19)
		15.77*		
Marital status				
Married	128 (12.16)	587 (55.75)	317 (30.10)	21 (1.99)
Single	41 (16.08)	145 (56.86)	67 (26.27)	2 (0.78)
Widow/divorce	18 (13.53)	69 (51.88)	41 (30.83)	5 (3.76)
		8.02		
Ethnicity				
Bumiputera	131 (12.34)	588 (55.37)	322 (30.32)	21 (1.98)
Chinese	34 (14.35)	135 (56.96)	64 (27.00)	4 (1.69)
Indian	9 (15.00)	31 (51.67)	18 (30.00)	2 (3.33)
Others	13 (15.85)	47 (57.32)	21 (25.61	1 (1.22)
		3.76		
Employment				
Employed	112 (12.87)	494 (56.78)	250 (28.74)	14 (1.61)
Unemployed	75 (13.13)	307 (53.77)	175 (30.65)	14 (2.45)
		2.27		
Location				
Urban	99 (12.89)	425 (55.34)	229 (29.82)	15 (1.95)
Rural	88 (13.08)	376 (55.87)	196 (29.12)	13 (1.93)
		0.09		

Note: Percentages in parentheses. *p<0.05.
Source: MANS 2014.

For males, those aged 40-49 years were 6.57% more likely to have a very low WC, but were 3.20%, 2.99% and 0.38% less likely to have a low, high and very high WC, respectively, than those aged ≤29 years. Compared to males with income of ≤RM999, males who had income of RM2000-2999 were 2.68% and 3.84% more likely to have a low and high WC, respectively, while males with income of RM3000-3999 were 3.12% and 5.24% more likely to have a low and high WC, respectively. The probability of having a very low WC was 7.10% and 9.18% lower among males with income of RM2000-2999 and RM3000-3999, respectively, than males with income of ≤RM999. In terms of ethnicity, Chinese males were 6.21% less likely to have a very low WC, but were 2.46% and 3.27% more likely to have a low and high WC, respectively, compared to Bumiputera males. Indian males had a 11.56% lower probability of having a very low WC, but had a 3.32% and 7.04% higher probability of having a low and high WC, respectively, than Bumiputera males (Table IV).

Table IV: Marginal effects of sociodemographic variables on waist circumference among males (n = 1255)

Variables	Waist circumference			
	Very low	Low	High	Very high
Age				
29 years	Ref.	Ref.	Ref.	Ref.
30-39 years	0.0230 (0.0365)	-0.0107 (0.0174)	-0.0109 (0.0169)	-0.0014 (0.0022)
40-49 years	0.0657* (0.0406)	-0.0320* (0.0213)	-0.0299* (0.0174)	-0.0038* (0.0023)
50 years	-0.0298 (0.0413)	0.0127 (0.0167)	0.0150 (0.0216)	0.0021 (0.0031)
Income				
RM999	Ref.	Ref.	Ref.	Ref.
RM1000-1999	-0.0237 (0.0306)	0.0104 (0.0131)	0.0117 (0.0155)	0.0016 (0.0022)
RM2000-2999	-0.0710* (0.0377)	0.0268* (0.0116)	0.0384* (0.0228)	0.0057 (0.0040)
RM3000-3999	-0.0918* (0.0419)	0.0312* (0.0096)	0.0524* (0.0281)	0.0083 (0.0055)
RM4000	-0.0559 (0.0462)	0.0219 (0.0153)	0.0297 (0.0269)	0.0043 (0.0044)
Education				
Tertiary	Ref.	Ref.	Ref.	Ref.
Secondary	0.0130 (0.0457)	-0.0058 (0.0201)	-0.0064 (0.0226)	-0.0009 (0.0031)
Primary	-0.0006 (0.0538)	0.0003 (0.0242)	0.0003 (0.0261)	0.0001 (0.0035)
No-formal	0.1157 (0.0962)	-0.0652 (0.0632)	-0.0455 (0.0304)	-0.0051 (0.0031)
Marital status				
Married	-0.0260 (0.0331)	0.0120 (0.0155)	0.0124 (0.0156)	0.0016 (0.0021)
Single	Ref.	Ref.	Ref.	Ref.
Widow/divorce	-0.0224 (0.0671)	0.0095 (0.0266)	0.0113 (0.0354)	0.0016 (0.0051)
Ethnicity				
Bumiputera	Ref.	Ref.	Ref.	Ref.
Chinese	-0.0621* (0.0317)	0.0246* (0.0110)	0.0327* (0.0182)	0.0048 (0.0031)
Indian	-0.1156* (0.0452)	0.0332* (0.0064)	0.0704* (0.0346)	0.0119 (0.0076)
Others	0.0533 (0.0520)	-0.0269 (0.0288)	-0.0236 (0.0210)	-0.0029 (0.0025)
Employment				
Employed	0.0287 (0.0414)	-0.0121 (0.0162)	-0.0146 (0.0221)	-0.0020 (0.0033)
Unemployed	Ref.	Ref.	Ref.	Ref.
Location				
Urban	0.0088 (0.0257)	-0.0040 (0.0116)	-0.0043 (0.0125)	-0.0006 (0.0017)
Rural	Ref.	Ref.	Ref.	Ref.

Note: Standard errors in parentheses. Ref. refers to reference group. *p<0.05.
Source: MANS 2014.

With respect to females, those who were married were 3.71% and 2.18% less likely to have a very low and low WC, respectively, but were 5.18% and 0.71% more likely to have a high and very high WC, respectively. Widowed or divorced females were 3.96% less likely to have a very low WC, but were 6.55% more likely to have a high WC compared to single females. Compared to Bumiputera females, the probabilities of having a very low (5.87%) and low WC (2.43%) were higher among females who were from other ethnic groups. However, females from other ethnic groups were 7.40% and 0.9% less likely to have a high and very high WC compared to their Bumiputera counterparts (Table V).

Table V: Marginal effects of sociodemographic variables on waist circumference among females (n = 1441)

Variables	Waist circumference			
	Very low	Low	High	Very high
Age				
29 years	Ref.	Ref.	Ref.	Ref.
30-39 years	-0.0084	-0.0060	0.0126	0.0019
	(0.0183)	(0.0136)	(0.0278)	(0.0042)
40-49 years	0.0079	0.0052	-0.0115	-0.0017
	(0.0200)	(0.053)	(0.0288)	(0.0041)
50 years	0.0019	0.0013	-0.0028	-0.0004
	(0.0214)	(0.0013)	(0.0313)	(0.0046)
Income				
RM999	Ref.	Ref.	Ref.	Ref.
RM1000-1999	-0.0073	-0.0053	0.0110	0.0017
	(0.0192)	(0.0147)	(0.0293)	(0.0045)
RM2000-2999	0.0344	0.0179	-0.0462	-0.0061
	(0.0307)	(0.0115)	(0.0376)	(0.0045)
RM3000-3999	0.0133	0.0082	-0.0189	-0.0026
	(0.0315)	(0.0173)	(0.0430)	(0.0057)
RM4000	0.0262	0.0147	-0.0361	-0.0049
	(0.0310)	(0.0138)	(0.0399)	(0.0050)
Education				
Tertiary	Ref.	Ref.	Ref.	Ref.
Secondary	0.0309	0.0228	-0.0466	-0.0071
	(0.0225)	(0.177)	(0.0346)	(0.0056)
Primary	0.0055	0.0037	-0.0080	-0.0012
	(0.0286)	(0.0187)	(0.0414)	(0.0059)
No-formal	-0.0095	-0.0071	0.0144	0.0022
	(0.0334)	(0.0270)	(0.0521)	(0.0083)
Marital status				
Married	-0.0371*	-0.0218*	0.0518*	0.0071*
	(0.0205)	(0.0103)	(0.0271)	(0.0037)
Single	Ref.	Ref.	Ref.	Ref.
Widow/divorce	-0.0396*	-0.0372	0.0655*	0.0114
	(0.0226)	(0.0278)	(0.0417)	(0.0086)
Ethnicity				
Bumiputera	Ref.	Ref.	Ref.	Ref.
Chinese	0.0212	0.0128	-0.0299	-0.0041
	(0.0193)	(0.0102)	(0.0260)	(0.0035)
Indian	0.0091	0.0059	-0.0131	-0.0019
	(0.0328)	(0.0193)	(0.0459)	(0.0063)
Others	0.0587*	0.0243*	-0.0740*	-0.0090*
	(0.0350)	(0.0073)	(0.0377)	(0.0040)
Employment				
Employed	0.0030	0.0021	-0.0045	-0.0007
	(0.0147)	(0.0103)	(0.0218)	(0.0032)
Unemployed	Ref.	Ref.	Ref.	Ref.
Location				
Urban	-0.0195	-0.0134	0.0287	0.0042
	(0.0139)	(0.0094)	(0.0202)	(0.0030)
Rural	Ref.	Ref.	Ref.	Ref.

Note: Standard errors in parentheses. Ref. refers to reference group. *p<0.05.
Source: MANS 2014.

DISCUSSION

The MANS 2014 provides us with valuable information for investigating sociodemographic factors associated with WC among adults. The relationships between sociodemographic factors and WC are of interest to policy makers. For instance, if the findings show that higher income and married individuals are more likely to have a high WC than their lower income and single counterparts, government can consider implementing a policy that focuses primarily on lowering WC among higher income and married individuals. The MANS 2014 is nationally representative and has a large sample size, which allows us to stratify our analyses by gender and able to take into account various sociodemographic factors. WC and BMI are highly correlated, which means that individuals who have a very high WC are usually obese, whilst individuals who have a very low WC are usually underweight (20). However, WC alone predicts obesity-related diseases and mortality better than BMI (20, 22). While the four ordinal categories of WC proposed by Bray (26) have not been tested in Malaysia, they have been supported and validated by a European study (22, 32). In Malaysia, the standard cut-offs for WC are 83-92 cm for men and 83-88 cm for women, and thereby, empirical studies have usually used two categories of WC only (33). In our analysis, 11.31% and 29.49% of males and females had a high WC, respectively. However, only a small number of males and females had a very high WC. Additionally, this study showed that WC was independently associated with age, income, ethnicity and marital status.

Results from this study indicated that the percentage of having a high and very high WC was higher among females than males. This is consistent with the findings evidenced by Zhang et al. (8), Katulanda et al. (10), Tan et al.(11) and Dalvand et al. (12), who found that women had a higher risk of developing obesity than men. This finding is expected as women tend to spend more time on low-intensity physical activity, such as doing household chores rather than moderate/vigorous physical activity (11, 34). Another contributing factor to this outcome is pregnancy. Women are likely to gain weight after pregnancy (35). Besides, hormone also plays a significant role in explaining gender differences in WC (36). Men have a higher level of testosterone than women thus they tend to have more lean mass. Furthermore, the estrogen level in women falls drastically after menopause, which results in increases in thier visceral adiposity.

An earlier study from Barbados reported a negative relationship between age and the likelihood of being obese (6). Mohd Sidik and Rampal (9), in examining factors influencing obesity among adults in Selangor (Malaysia), contended that the odds of being obese reduced with age. The present study discovered the similar link between age and WC. Although the proportion of having a high WC among males aged 40-49 years was slightly higher than those aged (≤29 years), older males (40-49 years) were less likely to have a high or very high WC compared to their younger counterparts (≤29 years) if sociodemographic factors other than age were controlled for. A plausible explanation for this

outcome is that older individuals are prone to various diseases, especially obesity-induced diseases and with this concern, they are likely to monitor their body fat (6). Regardless of other sociodemographic factors, males with monthly income of RM2000-2999 or RM3000-3999 were more likely to have a high WC and were less likely to have a very low WC compared to their counterparts with income of ≤RM999, indicating that middle-income group was more susceptible to obesity. Perhaps this is because middle-income individuals are less likely to participate in physical activity than low-income individuals (37). Our finding is consistent with previous studies conducted in other developing countries (Turkey, Sri Lanka, Ghana, Nepal) (5, 10, 15, 17). These studies consistently found that higher income people were more likely to be obese or overweight compared to their lower income counterparts. As explained by Al Kibria et al. (17), physically inactive lifestyle and consumption of high-calorie foods were closely linked to high body fat among higher income people. In addition, higher income individuals have a better financial capability than lower income individuals and are more inclined to consume more foods (5, 10). Because of data limitation, we were unable to identify the causal effects of dietary behaviour and physical activity on WC. Thereby, we could not make a very strong conclusion that being physically inactive and consuming high-calorie foods could definitely cause high income Malaysians to have a high WC. Future study may want to examine the causal relationships between WC and physical activity, and dietary behaviour by using an IV regression and a longitudinal data.

The proportion of having a very low, low, high and very high WC did not vary across marital status. However, we found that married and widowed/divorced women were more likely to have a high WC as compared to their single counterparts, and also less likely to have a very low and low WC. The association between marital status and WC was identified in previous studies (7, 14, 15, 16). In two studies of Iranian population, Hajian-Tilaki and Heidari (7) and Emamian et al. (16) found that married people had higher odds of being obese than unmarried people. Based on a nationwide data of Ghana, Tuoyire et al. (15) observed that being married increased the likelihood of being obese. Findings from the data of Nepal suggested likewise (14). Furthermore, Erem et al. (5) found that obesity was more prevalent among widowed than single adults, which was similar in the present study. A high WC among married people could be attributed to the fact that marriage increases food consumption as there is a tendency to consume more food after marriage (9, 15). Furthermore, since there was a positive relationship between being widowed/divorced and WC, we concluded that people who had been married did consume more food as well. There appear to be evidences suggesting that single individuals tend to consume less food, such as red meat, poultry and confectioneries than married individuals (38).

Results of bivariate and multivariate analyses showed that WC varied by ethnicity. Among males, Indians and Chinese were more likely to have a higher WC than the Bumiputera, and also less likely to have a very low WC. Females from other ethnic groups were less likely to have a high and very high WC compared to their Bumiputera counterparts. Our findings seem to contradict the findings of previous studies (9, 11). In particular, the authors found that Malays were more likely to be obese compared to Chinese and Indians. The justification could be that Mohd Sidik and Rampal (9) and Tan et al. (11) used BMI to measure body fat, whereas we used WC. Using different measure of body fat may yield dissimilar results. Owing to data limitation, it is not plausible to identify the actual reasons that explain the relationship between ethnicity and WC. Nonetheless, we are able to conclude that culture, religion or ethnic privilege may play an important role in determining WC. Additionally, as pointed out by Heymsfield et al. (39), who conducted a critical review of studies related to ethnic determinants of BMI, genetic factor could explain ethnic differences in adipose tissue and skeletal muscle mass. Future qualitative and clinical researches may need to study these factors thoroughly.

Although the present study used a large sample and took into account all the important sociodemographic variables, there were some limitations. First, owing to cross-sectional data, the causal relationships between sociodemographic factors and WC were not well-established. The present study could only determine the associations. Second, the information on all the explanatory variables was self-reported by respondents and errors may occur. Third, environmental variables, such as access to sports facilities and health care centres were not included in the present study because the MANS 2014 did not collect information on these variables. Fourth, the four ordinal categories of WC used in the present study have not been validated in Malaysia. Future studies are suggested to use a longitudinal data to do this validation.

CONCLUSION

Based on the ordered probit, the present study found that several sociodemographic factors, such as age, income, ethnicity and marital status played an important role in determining WC. The groups of males that were likely to have a high or very high WC were those aged ≤29 years, those with monthly income of RM2000-2999 or RM3000-3999, Chinese, as well as Indians. For females, those who were married, widowed/divorced and Bumiputera had a higher likelihood of having a high or very high WC. These findings may assist government in formulating a better intervention measure to promote an ideal WC among adults. Males and females who were likely to have a high or very high WC should be given

special attention. For instance, in order to reduce the number of males having a high or very high WC, focus should be devoted to those aged ≤29 years more than those aged 40-49 years. However, age is not a factor if the objective of the policy is to reduce the prevalence of having a high or very high WC among females. Moreover, in an effort to lower the prevalence of high WC among males, special attention should be paid to Chinese and Indians, whereas if the target group is females, concern should be given to Bumiputera.

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REFERENCES

1. Institute for Public Health. National Health and Morbidity Survey 2015 (NHMS 2015). Putrajaya: Ministry of Health Malaysia, 2015.
2. Institute for Public Health. National Health and Morbidity Survey 2011 (NHMS 2011). Putrajaya: Ministry of Health Malaysia, 2011.
3. Yosuke I, Bo Q, Jennifer P, Rebeccah S, Penny GL. Epidemiology of obesity in adults: Latest trends. Curr Obes Rep. 2018;7(4):276-288.
4. Schoepp TN. Obesity in Malaysia: Unhealthy easting is as harmful as smoking. Penang: Penang Institute, 2017.
5. Erem C, Arslan C, Hacihasanoglu A, et al. Prevalence of obesity and associated risk factors in a Turkish population (Trabzon City, Turkey). Obes Res. 2004;12(7):1117-1127.
6. Carter AO, Hambleton IR, Broome HL, Fraser HS, Hennis AJ. Prevalence and risk factors associated with obesity in the elderly in Barbados. J Aging Health. 2006;18(2):240-258.
7. Hajian-Tilaki KO, Heidari B. Prevalence of obesity, central obesity and the associated factors in urban population aged 20-70 years, in the north of Iran: A population-based study and regression approach. Obes Rev. 2007;8:3-10.
8. Zhang X, Sun Z, Zhang X, et al. Prevalence and associated factors of overweight and obesity in a Chinese rural population. Obes. 2008;16:168-171.
9. Mohd Sidik S, Rampal L. The prevalence and factors associated with obesity among adult women in Selangor, Malaysia. Asia Pac Fam Med. 2009;8(2).
10. Katulanda P, Jayawardena MAR, Sheriff MHR, Constantine GR, Matthews DR. Prevalence of overweight and obesity in Sri Lankan adults. Obes Rev. 2010;11:751-756.
11. Tan AKG, Dunn RA, Abdul Samad MI, Feisul MI. Sociodemographic and health-lifestyle determinants of obesity risk in Malaysia. Asia-Pacific J Public Health. 2011;23(2):192-202.
12. Dalvand S, Koohpayehzadeh J, Karimlou M, et al. Assessing factors related to waist circumference and obesity: Application of a latent variable model. J Environ Public Health. 2015;893198.
13. Islam Saeed KM. Prevalence and associated risk factors for obesity in Jalalabad city – Afghanistan. Alexandria J Med. 2015;51:347-352.
14. Rawal LB, Kanda K, Mahumud RA, et al. Prevalence of underweight, overweight and obesity and their associated risk factors in Nepalese adults: Data from a Nationwide Survey, 2016. PLoS ONE. 2018;13(11):e0205912.
15. Tuoyire DA, Kumi-Kyereme A, Doku DT. Socio-demographic trends in overweight and obesity among parous and nulliparous women in Ghana. BMC Obes. 2016;3(44).
16. Emamian MH, Fateh M, Hosseinpoor AR, Alami A, Fotouhi A. Obesity and its socioeconomic determinants in Iran. Econ Human Biol. 2017;26:144-150.
17. Al Kibria GM. Prevalence and factors affecting underweight, overweight and obesity using Asian and World Health Organization cutoffs among adults in Nepal: Analysis of the Demographic and Health Survey 2016. Obes Res Clin Pract. 2019;13:129-136.
18. Mohd Zaki NA, Omar A, Salleh R, et al. Trends in obesity and abdominal obesity among Malaysian adults: Findings from the National Health and Morbidity Surveys of 2006, 2011 and 2015. Southeast Asian J Trop Med Public Health. 2018;49(6):1091-1102.
19. Norafidah AR, Azmawati MN, Norfazilah A. Factors influencing abdominal obesity by waist circumference among normal BMI population. Mal J Public Health Med. 2013;13(1):37-47.
20. Janssen I, Katzmarzyk PT, Ross R. Waist circumference and not body mass index explains obesity related health risk. Am J Clin Nutr. 2004;79:379-384.
21. Savva SC, Tornaritis M, Savva ME, et al. Waist circumference and waist-to-height ratio are better predictors of cardiovascular disease risk factors in children than body mass index. Int J Obes. 2000;24:1453-1458.
22. Bigaard J, Tjonneland A, Thomsen BL, Overvad K, Heitmann BL, Sorensen TIA. Waist circumference, BMI, smoking, and mortality in middle-aged men and women. Obes Res. 2003;11(7):895-903.
23. Jitnarin N, Kosulwat V, Rojroongwasinkul N, Boonpraderm A, Haddock CK, Poston WSC. Prevalence of overweight and obesity in Thai population: Results of the National Thai Food Consumption Survey. Eat Weight Disord. 2011;16(4):e242-e249.

24. Pujilestari CU, Nystrom L, Norberg M, Weinehall L, Hakimi M, Ng N. Socioeconomic inequality in abdominal obesity among older people in Purworeja District, Central Java, Indonesia – a decomposition analysis approach. Int J Equity Health. 2017;16(214).
25. Fauziana R, Jeyagurunathan A, Abdin E, et al. Body mass index, waist-hip ratio and risk of chronic medical condition in the elderly population: Results from the Well-being of the Singapore Elderly (WiSE) study. BMC Geriatr. 2016;16(125).
26. Bray GA. Don't throw the baby out with the bath water. Am J Clin Nutr. 2004;79:347-349.
27. Ananth CV, Kleinbaum DG. Regression models for ordinal responses: A review of methods and applications. Int J Epidemiol. 1997;26(6):1323-1333.
28. Institute for Public Health. National Health and Morbidity Survey 2014: Malaysian Adult Nutrition Survey (MANS) 2014. Putrajaya: Ministry of Health Malaysia, 2014.
29. Cheah YK, Azahadi M, Phang SN, Abd Manaf NH. Vigorous and moderate physical activity among overweight and obese adults in Malaysia: Sociodemographic correlates. Obes Med. 2019;15:100114.
30. Wooldridge JM. Introductory econometrics: A modern approach. Boston, MA: Cengage Learning; 2016.
31. StataCorp. Stata Statistical Software: Release 16.0. College Station, TX: Stata Corporation; 2019.
32. Bigaard J, Thomsen BL, Tjonneland A. Does waist circumference alone explain obesity-related health risk? Am J Clin Nutr. 2004;80(3):791-792.
33. Ahmad N, Mohamed Adam SI, Mohammed Nawi A, Hassan MR, Ghazi HF. Abdominal obesity indicators: Waist circumference or waist-to-hip ratio in Malaysian adults population. Int J Prev Med. 2016;7(82).
34. Cheah YK, Poh BK. The determinants of participation in physical activity in Malaysia. Osong Public Health Res Perspect. 2014;5(1):20-27.
35. Gunderson EP. Childbearing and obesity in women: Weight before, during, and after pregnancy. Obstet Gynecol Clin North Am. 2009;36(2):317-332.
36. Karastergiou K, Smith SR, Greenberg AS, Fried SK. Sex differences in human adipose tissues – the biology of pear shape. Biol Sex Differ. 2012;3(13).
37. Cheah YK, Tan AKG. Determinants of leisure-time physical activity: Evidence from Malaysia. Sing Econ Rev. 2014;59(2):1450017.
38. Fraser GE, Welch A, Luben R, Bingham SA, Day NE. The effect of age, sex, and education on food consumption of a middle-aged English cohort – EPIC in East Anglia. Prev Med. 2000;30:26-34.
39. Heymsfield SB, Peterson CM, Thomas DM, Heo M, Schuna Jr. JM. Why are there race/ethnic differences in adult body mass index – adiposity relationships? A quantitative critical review. Obes Rev. 2016;17(3):262-275.