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RESEARCH

Sex differences in correlates of obesity indices and blood pressure among Malay adults in Selangor, Malaysia

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Background: Obesity is a risk factor for many chronic diseases and related morbidity and mortality. It is imperative to identify the best index of obesity which has the strongest relationship to blood pressure in various populations. The main aim of this study was to determine the sex differences in correlates of four frequently used obesity indices among Malaysians.
Method: A cross-sectional study which recruited 1 530 Malay respondents was conducted in four villages in a district of Selangor state, Malaysia from June until October 2011. Blood pressure and anthropometric indices were recorded using a structured data sheet and data were analysed using SPSS version 17.0.
Results: The body mass index cut-off point for the general population shows more overweight than obese respondents for both sexes (male [overweight: 30.7%, obese: 13.8%]), (female [overweight: 32.8%, obese: 21.8%]). The body mass index cut-off point for Asians shows more overweight males compared with obese male respondents (35.8% vs 26.1% respectively) and more obese female compared with overweight female respondents (36.1% vs 32.9% respectively). There were more respondents with abdominal obesity by Asians' cut-off point for waist circumference across sexes. Almost half of the male respondents have abdominal obesity by waist circumference with both cut-off points. Female respondents according to Asians' cut-off point have a higher prevalence of abdominal obesity by waist-to-hip ratio compared with women categorised by the general population cut-off point (76.3% vs 55.1% respectively). The majority of the respondents across sexes have a high prevalence of abdominal obesity by waist-to-height ratio. Males had significantly higher mean values for systolic blood pressure, diastolic blood pressure and waist-to-hip ratio compared with female respondents, while females had a significantly higher mean for body mass index and waist-to-height ratio compared with male respondents. There was no significant mean difference for WC between sexes. All indices of obesity were significantly and positively correlated with both systolic blood pressure and diastolic blood pressure. The waist-to-height ratio shows the strongest correlates with systolic blood pressure across sexes (male: $r = 0.291$ and female: $r = 0.294$) compared with diastolic blood pressure. Waist circumference correlates most strongly with diastolic blood pressure among male respondents ($r = 0.266$) and body mass index correlates most strongly with diastolic blood pressure among female respondents ($r = 0.250$).
Conclusion: Waist-to-height ratio performed better than BMI, WC and WHR for its correlates with systolic blood pressure across sexes. Diastolic blood pressure correlates most strongly with waist circumference among male respondents and it correlates most strongly with body mass index among female respondents. The waist-to-height ratio could be a simple and effective tool to screen for high blood pressure among the Malay population. Future research might look into a sex-specific abdominal obesity index for screening of cardiovascular risk factors.

Keywords: blood pressure, body mass index, waist circumference, waist-to-hip ratio, waist-to-height ratio

Introduction

According to the WHO (2012), there were more than 1.4 billion overweight adults aged ≥ 20 years with over 200 million obese men and nearly 300 million obese women in 2008.[1] Obesity has become global epidemic and associated with various co-morbidities such as hypertension (HPT), cardiovascular diseases (CVDs), type 2 diabetes mellitus (T2DM) and other non-communicable diseases (NCDs).[2]

The Framingham Heart Study found a strong relationship between obesity and the risk of CVDs.[3] The study also found that hypertension was about twice as prevalent in both sexes among the obese as among the non-obese.[3] Since excessive weight gain had a strong relationship with CVDs such as HPT, T2DM and coronary heart disease[1–3], it is important to identify which are the most appropriate indices of obesity that should be used to define obesity.

Defining obesity is important since, according to Svetkey[4], weight reduction with lifestyle modification can lower blood pressure levels and thus the risk of developing CVDs.[4–6] There are many indices of obesity such as body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHR). However, it is still not fully clear which obesity indices carry the strongest association with HPT.

Historically, BMI has been used to measure general obesity across populations but, increasingly, the measurements of central obesity like WC, WHR and WHR have been recommended as more accurate to measure obesity related to cardiovascular risk factors.[7] World Health Organization (WHO) classifications of BMI and WC are useful for global comparison.[7,8] However, increased prevalence of CVD risk factors among several Asian countries was found to be below the recommended cut-off points. Thus different cut-off points are used for policy development and management of cases.[7,9] The series of National Health and Morbidity Surveys conducted in Malaysia since 1986 showed increasing prevalence of CVD risk factors.[10–13] A study done in Malaysia found that WC appeared to be a better indicator to predict obesity-related CVD risk in men and women compared with BMI.[14] This study focused on respondents who presented themselves at both public and private primary care clinics.[14] Another study[15] among the Chinese population found that WHR showed better association than BMI with cardiovascular risk and this finding was supported by a meta-analysis.[16]

Some studies found that BMI was a good indicator of HPT risk, especially among women,[17,18] while a study by Nyamdorg[19] in Mauritius found that BMI was as strong as other central obesity indicators in predicting incidence of HPT. There were extensive studies using WtHR as predictor for central obesity and elevated BP among children and adolescents.[20,21] Studies also showed that WtHR is as useful and simple tool to be use in screening CVD risk factors in adult.[22,23] The main aim of the present study was to determine the sex differences in correlates of four frequently used obesity indices (BMI, WC, WHR and WtHR) and blood pressure (BP) among a population predominated by Malay ethnicity in Tanjung Karang, Selangor, Malaysia. The specific objective was to explore which obesity indices correlates most strongly with BP in this population.

Materials and methods

Participants

An observational cross-sectional descriptive study was conducted in four villages in a district of Selangor state, Malaysia from June until October 2011. All houses in the villages were visited and the respondents were selected by convenience sampling method. A total of 1 530 Malay respondents aged 18 years old and above participated in the study. Inclusion criteria required that respondents to be Malaysian citizens residing in the study areas for more than six months. Respondents who were not willing to participate, pregnant women and those not contactable after three attempts at visits during the study were excluded from the study. The study was approved to be conducted as part of the undergraduate medical students' community health teaching module by the Medical Faculty of Universiti Kebangsaan Malaysia. Permission to enter the villages was obtained from the head villagers and the respondents provided verbal informed consent. Data were collected by structured data sheet which was divided into two sections: section A: baseline characteristic (sex), section B: physical examination including BP and anthropometric measurement (weight and height, WC and hip circumference).

Blood pressure (BP) and anthropometric measurement

The medical students were briefed and trained prior to data collection. BP measurement was taken using a certified digital sphygmomanometer. Respondents were advised to sit quietly and rest for five minutes before the measurement was taken. An appropriate cuff size was used and three readings were taken with a five-minute rest period between readings.[24] Systolic BP (SBP) and diastolic BP (DBP) were calculated and recorded as the average of the last two readings.[25]

Anthropometric measurements were performed with the respondents wearing light clothing and no footwear. Body weight was measured to the nearest 0.1 kg using a digital scale, and height was measured to the nearest cm in the standing position using a wallstadiometer.[8] BMI was calculated as body weight divided by height squared. WC and hip circumference were measured by WHO measurement protocol.[7] WC was measured at the end of several consecutive natural breaths, at midpoint between the lower ribs and the iliac crest. Hip circumference was measured horizontally at the level of the largest extension of the hips or over the buttocks. WHR was calculated as WC divided by hip circumference in cm. BMI, WC and WHR cut-off points used were as per the WHO recommendation for the general population and Asians for descriptive purposes of abdominal obesity.[7,9] WtHR was calculated as WC divided by height in cm. A boundary value of WtHR ≥ 0.5 indicates abdominal obesity.[23] All these indices were analysed as both categorical and continuous data.

Statistical analysis

All analyses were conducted by using SPSS Version 17.0. Descriptive and inferential analyses were conducted for the data collected. Mean and standard deviation (SD) were used to describe the continuous data. Frequency and percentage (%) were used for categorical data. For univariable analysis, Student's *t*-test and Pearson's correlation were used. Statistical significance was set at *p*-value < 0.05.

Results

Of the 1 530 Malay respondents, 58.4% were female and 41.6% male. Table 1 shows that, among the male respondents, there were more overweight than obese respondents for both BMI cut-off points. By general population cut-off point, there were more overweight female than obese female respondents as compared with Asians' cut-off point, where there were more obese female respondents. For WC, there were only 10.8% and 45.5% for male and female respondents respectively with abdominal obesity by general population cut-off point as compared with 40.3% and 67.8% for male and female respondents respectively by Asians' cut-off point.

Table 1: Sex differences of obesity indices by different cut-off points

	General population cut-off point		Asian population cut-off point	
	Male	**Female**	**Male**	**Female**
BMI (kg/m^2)	*n* (%)	*n* (%)	*n* (%)	*n* (%)
Underweight	50 (8.0)	72(8.2)	50 (7.9)	72(8.2)
Normal	296 (47.5)	329 (37.3)	191(30.2)	201(22.9)
Overweight	191 (30.7)	289 (32.8)	226(35.8)	289(32.9)
Obese	86 (13.8)	192 (21.8)	165(26.1)	317(36.1)
WC (cm)*	**Male: > 102** 69(10.8)	**Female: > 88** 404(45.5)	**Male: > 90** 256(40.3)	**Female: > 80** 605(67.8)
WHR*	**Male: ≥ 0.90** 304(49.8)	**Female: ≥ 0.85** 470(55.1)	**Male: > 0.90** 304(49.5)	**Female: > 0.80** 657(76.3)
WtHR*	**Male: ≥ 0.5** 405(92.0)	**Female: ≥ 0.5** 671(95.7)	–	–

*Cut-off points for abdominal obesity according to general population and Asians[7,9,23]

Table 2: Sex differences in study variables

Variables	Total (*n* = 1530)	Male (*n* = 637)	Female (*n* = 893)				
	Mean (SD)	Mean (SD)	Mean (SD)	*t*-test (df)	*p*-value	Mean difference	95% CI
SBP (mmHg)	125.86(16.82)	126.88(16.13)	125.13(17.26)	2.01 (1528)	0.044	1.76	0.05,3.46
DBP (mmHg)	81.36(11.92)	82.50(11.43)	80.55(12.20)	3.15(1528)	0.002	1.94	0.73,3.15
BMI (kg/m^2)	25.37(5.33)	24.58(4.83)	25.93(5.60)	–4.94(1528)	< 0.001	–1.36	–1.89,–0.82
WC (cm)	86.09(15.05)	86.69(14.73)	86.95(15.27)	–0.33(1528)	0.744	–0.25	–1.79,1.28
WHR	0.89(0.12)	0.91(0.11)	0.88(0.13)	5.46(1528)	< 0.001	0.03	0.02,0.05
WtHR	0.55(0.10)	0.53(0.09)	0.57(0.10)	–7.91(1528)	< 0.001	–0.04	–0.05,–0.03

Table 3: Sex differences in correlates of obesity indices and BP

	All		Male		Female	
	SBP	DBP	SBP	DBP	SBP	DBP
	r (*p* value)	*r* (*p* value)	*r* (*p* value)	*r* (*p* value)	*r* (*p* value)	*r* (*p* value)
BMI (kg/m^2)	0.225(< 0.001)	0.232(< 0.001)	0.224(< 0.001)	0.237 (< 0.001)	0.239(< 0.001)	0.250(< 0.001)
WC (cm)	0.264(< 0.001)	0.251(< 0.001)	0.285(< 0.001)	0.274(< 0.001)	0.251(< 0.001)	0.239(< 0.001)
WHR	0.191(< 0.001)	0.176(< 0.001)	0.227(< 0.001)	0.169(< 0.001)	0.162(< 0.001)	0.166(< 0.001)
WtHR	0.277(< 0.001)	0.232(< 0.001)	0.291(< 0.001)	0.266(< 0.001)	0.294(< 0.001)	0.246(< 0.001)

For WHR, almost half of the male respondents by both cut-off points had abdominal obesity. However, Asians' cut-off point gave a higher prevalence of abdominal obesity (76.3%) among the female respondents. The majority of the respondents had abdominal obesity by WtHR across sexes (see Table 1).

Male respondents had significantly higher mean values for SBP (126.88[16.13] mmHg), DBP (82.50[11.43]cm and WHR (0.91[0.11] cm) compared with female respondents (see Table 2). Females had a significantly higher mean for BMI (25.93[5.60] kg/m^2) and WtHr (0.57[0.10]) compared with males. There was no significant mean difference for WC between the sexes (Table 2).

Table 3 compares the correlates of obesity indices with BP between male and female respondents. All indices of obesity were significantly and positively correlated with both SBP and DBP. Correlation coefficient values were not strong, with WtHR showing the strongest correlates with overall and across sexes SBP compared with DBP. WC correlates were strongest with DBP among male respondents and BMI correlates strongest with DBP among female respondents.

Discussion

It is prudent to identify which obesity indices have the strongest correlates with BP as this will help in identifying patients at risk for HPT. Numerous measurements such as BMI, WC, WHR and WtHR have been used to measure obesity. BMI was first introduced by Adolphe Quetelet in 1832 and is still used internationally to measure general obesity.[26] Vague introduced the concept of central obesity in 1940 as more important in predicting the risk for diabetes, gout, atherosclerosis and uric calculus disease.[27] Since then interest in the concept of central obesity has been increasing and many studies have compared indices of general and central obesity to predict risk of NCDs in various populations. Most of the studies found a stronger association of HPT prevalence with central obesity than general obesity.[14–16]

In the study reported here, male respondents had significantly higher mean values of SBP and DBP compared with female respondents, while females had significantly higher mean value for BMI and prevalence of overweight/obesity compared with male respondents by general population BMI cut-off point. These findings were similar to a study conducted in another Asian population in which the general population BMI cut-off point was applied in their study.[28] The current study also showed that all obesity indices were significantly correlated with both SBP and DBP. All these findings were supported by another cross-sectional study in Delhi, India which showed higher prevalence of prehypertension and HPT among males, as well as significant correlations of BMI and WHR with BP across sexes.[29] In a study across three populations (Ethiopia, Vietnam and Indonesia), BMI was also found to be significantly correlated with BP with the correlation coefficient ranging from 0.23 to 0.27.[30] The correlates of BMI and BP across sexes in this current study were notably within the same range. However, the prevalence of HPT was higher in females compared with males in the Indonesian population.[30]

This present study shows that WtHR has the strongest association with overall and across-sexes SBP. This is similar to a study conducted among Chinese adults in Beijing which showed that WtHR had the strongest odds ratio with HPT across sexes.[31] A few other researchers have also reported that WtHR was a better index associated with HPT among the male population.[32,33] However, a study among Australian adults showed that, among females, WC had the strongest correlation with not only SBP but also other CVD risk factors such as triglyceride (TG) and high density lipoprotein (HDL).[34]

This present study showed that WC had the highest correlation coefficient values with DBP among male respondents compared with BMI, WHR and WtHR. However, BMI had the highest correlation coefficient values with DBP among female respondents. These findings were in agreement with a cross-sectional study among 1 727 respondents in Turkey. WC was found to be the independent risk factor for blood pressure compared with BMI and WHR among male respondents and BMI was a more important index for females.[35] A study among a Chinese population which did not specify the type of BP also found that BMI had the strongest association with BP among female respondents.[15] However, this study did not specify the type of

BP.[18] Some researchers have suggested WC to be a simple clinical indicator alternative to BMI in detecting obesity-related health risks such as HPT.[36,37] Furthermore, a study by Jacobs et al. found that WC was associated with a higher risk factor for mortality among older adult population compared to BMI.[38]

This study was primarily limited by the cross-sectional nature of the study design, and causal inference cannot be made. Due to multiple missing data on age, no adjustment for age was made. Age is known to be one of the significant independent risk factors for BP across sexes. The widespread inclusion of weight, height and WC in many health surveys enabled the analysis of abdominal obesity to be conducted. However, future studies should incorporate more selective measures of adiposity such as skin-fold thickness as direct measurement of body composition, which will provide additional information. Nevertheless, because of the large sample size in this study, the results can be used as baseline data for future research, especially on the possibility of using WtHR as a screening tool for abdominal obesity.

Conclusion

WtHR performed better than BMI, WC and WHR for its association with SBP across sexes. DBP correlates most strongly with WC among male respondents and it correlates most strongly with BMI among female respondents. WtHR could be a simpler and an effective tool to screen for high blood pressure among the Malay population. Future research might look into a sex-specific abdominal obesity index for screening of cardiovascular risk factors.

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