The Association between Visceral Fat and Blood Pressure in Adults

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ABSTRACT: This cross-sectional study investigates the association between body composition measurements and blood pressure in Malay adults. A total of 296 adults, aged between 18 to 59 years, consisting of 122 males and 174 females underwent measurements of weight and height, waist and hip circumference, body fat and visceral fat, and blood pressure. Body fat and visceral measurements were carried out through bioelectric impedance, using a portable Tanita body fat analyser. Bivariate correlation analysis was used to study the association of each body composition measurement with blood pressure. There was significant association between Body Mass Index (BMI) (r= 0.25, P<0.01), waist circumference (r= 0.27, P<0.01), hip circumference (r= 0.20, P<0.01) and visceral fat (r= 0.29, P<0.01) with blood pressure, respectively. No significant relationship was found between waist hip ratio (WHR) and total body fat with blood pressure. The association between visceral fat and blood pressure is an interesting finding with regards to this community research setting. It is important to further study the affordability, accuracy and application of bioelectrical impedance technology in community research.

Keywords: Body composition, Body Mass Index, blood pressure, obesity, hypertension

Introduction

Malaysia has one of the highest prevalences of overweight and obesity in the Asian region (Ismail, 2002). As Malaysia is escalating towards a developed economy status, overweight and obesity cases in Malaysia are rising rapidly and have become the public health concern (Ismail, 2002). The impact of obesity on public health is reflected by the increasing prevalence of chronic diseases amongst Malaysians (Ismail *et al.*, 2002). The effect of the population's health status will be particularly severe if the sedentary lifestyle of its population continues (Ismail *et al.*, 2002).

Cardiovascular diseases (CVD), cancer, and diabetes mellitus are examples of chronic diseases that are associated with overweight and obesity and which lead to mortality (Rueda-Clausen, Silva and Lopez-Jaramillo, 2008). It has been predicted that CVD will be responsible for 57% of all deaths globally by 2020 (WHO, 2006). China, the most populous country in the world, is also facing an epidemic of diabetes and obesity (Avendano and Mackenbach 2006; Yoon *et al.*, 2006). There are now 40 million people with diabetes in China (Donnelly, Wang and Qu, 2006), where the total population is 1.3 billion.

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In Malaysian adults, 20.7% were overweight and 5.8% obese (0.3% of whom had BMI values of > 40.0 kg/m^2) and obesity was found to be more prevalent in women than men (Ismail *et al.*, 2002). In women, obesity rates were higher in Indian and Malay women than in Chinese women, while Chinese men recorded the highest obesity prevalence followed by their Malay and Indian counterparts (Ismail *et al.*, 2002). There are several risk factors contributing to overweight and obesity for both genders; it is significantly associated with older age, not being in a marriage-like relationship, low education, physical inactivity, and poor dietary intake (Brown and Siahpush, 2007).

Overweight and obese are accountable for numerous diseases. One of the consequences is elevated blood pressure (Pang *et al.*, 2008) which is also known as hypertension. In 1996, the prevalence of high blood pressure (BP >140/90) amongst Malaysian adults aged 30 years and above was estimated to be 29.9%, and since then hypertension has become a major public health issue in the region (National Health and Morbidity Survey 2, 1996).

It is important to identify non invasive measures that are closely associated with indicators of chronic disease risk factors such as blood pressure in community setting. Hence, the aim of this study was to investigate the associations between body measurements and blood pressure among adults living in Tawang, Bachok.

Materials and Method

Study design

This was a cross-sectional study conducted in a rural village in Tawang, Bachok. Field work was conducted from October until December 2008. A systematic random sampling method, using a house-tagging approach in the selected area, was used to obtain subjects. Sample size was calculated using PS Software Version 3.0 (Dupont and Plummer, 1998). The Universiti Sains Malaysia Human Research Ethics Committee approved this study (USMKK/PPP/JEPeM [205.4. (1.3)].

Subjects

All subjects were informed about the research design and signed a consent form according to the regulations of the Ethical Committee. The subjects were gathered at the meeting point, and all measurements were obtained on the same morning. For convenience, participants were recruited from the district of Tawang, Bachok. In this area, communities (villages) were randomly selected as sampling units. The inclusion and exclusion criteria are as following:

i) Inclusion Criteria

a. Adults (Aged between 18 to 59 years old)
b. Completed consent form
c. No history of hypertension
d. Malay proficient

ii) Exclusion criteria

a. Females are currently pregnant or lactating below six months.
b. Mental illness
c. Presence of physical disability

Data collection

Subjects were interviewed using a standard questionnaire comprising of demographic characteristics and medical history. Age, sex, education, occupation and household income were items in the demographic section, whereas diagnosis and treatment of hypertension were items asked in the medical history section.

Body weight was measured using the Innerscan® TANITA body composition analyser model BC545 (Japan). These measurements were taken to the nearest 0.1 kilogram after subjects removed their shoes, wallet, and hat and were wearing light clothing. Body Mass Index (BMI) was calculated using the following formula: Weight (kg)/ [Height (m) X Height (m)] and classified according to the definition as follows (WHO, 1998):

BMI less than 18.5 = underweight
BMI between 18.5 to 24.9 = normal weight
BMI between 25.0 to 29.9 = overweight
BMI more than 30 = obese

Body height was measured using a stadiometer (SECA Bodymeter Model 208, Germany). The accuracy of this instrument is up to 0.05 centimeter. Percent body fat (%BF) and percent visceral fat (%VF) was determined using the Innerscan® TANITA body composition analyser model BC545 (Japan). This portable device is designed to measure total body fat and also visceral fat by the means of bioelectrical impedance.

A measuring tape was used to measure waist and hip circumference. Three waist circumference readings were taken midway between the inferior margin of the last rib and the iliac crest at the end of expiration (Wang and Beydoun, 2007). Three hip circumference readings were measured around the largest portion of the buttocks (Wang and Beydoun, 2007). The International Diabetes Federation (IDF, 2006) ethnic specific criterion for abdominal obesity is used to define abdominal obesity. According to IDF, abdominal obesity is defined as WC ≥ 90cm for men and ≥ 80cm for women. Waist hip ratio (WHR) is calculated using the following formula: Waist circumference (cm)/ hip circumference (cm) (Welborn, Dhaliwal and Bennett, 2003).

Blood pressure was measured after the subject had rested for at least 5 minutes, using an electric sphygmomanometer (Omron, SEM-1, Germany). The subject's right arm was placed at heart level and three readings were taken. The mean of the three measurements was calculated. High blood pressure was defined as an average systolic blood pressure of ≥ 140mmHg, an average of diastolic blood pressure ≥ 90mmHg or both (JNC VI, 1997).

Statistical Analysis

Descriptive statistics, including mean and standard deviation (SD) for continuous variables and proportions for categorical variables were calculated. The dependent variable for this study was established blood pressure. Independent t-test was used for categorical data such as gender. Pearson's correlation coefficient was used to determine the association of each body measurements and blood pressure. Data normality was tested using Kolmogorov-Smirnov test. All analyses were carried out by using Statistical Package for Social Science software for Windows (SPSS) version 12.0. Statistical significance was assigned at $P < 0.05$.

Results

Demographic Characteristics

Results of the demographic data of male and female subjects are presented in **TABLE 1**. A total of 306 subjects, aged between 18 to 70 years agreed to participate in this study. However, only 298 subjects completed all measurements and answered questionnaires. Around 85.1% of subjects (37.8 % male, and 47.3 % female subjects) were married. The majority of subjects (57.1%) had secondary education level (23.0% male subjects and 34.1% female subjects). Around 25.7 % of male subjects were self-employed while 39.52% of female subjects were housewives. The mean age for males and females, respectively, was 49.82±11.74 and 48.58±11.67 years.

TABLE 1- Demographics characteristics of subjects (n=296)

Variables	Male (n =122)		Female (n =174)	
	N	%	N	%
Marital status				
Single	6	2	8	2.7
Married	112	37.8	140	47.3
Divorced	1	0.3	6	2.0
Widowed	3	1.0	20	6.8
Highest education level				
Unschooled	6	2.0	17	5.7
Primary	32	10.8	49	16.9
Secondary	68	23.0	101	34.1
Tertiary	16	5.4	7	2.4
Job title				
Government	20	6.8	14	4.7
Self-employed	76	25.7	29	9.8
Unemployed	11	3.7	11	3.7
Private	15	5.1	3	1.0
Housewife	0	0	117	39.5

Anthropometry and Blood Pressure

Results on anthropometry measurements and blood pressure are shown in **TABLE 2**. Men were significantly taller and heavier than women. Male subjects had significantly higher waist circumferences, higher visceral fat and greater waist hip ratio (WHR) compared to females. On the other hand, women had significantly greater mean hip circumference, body fat, and BMI. The mean values of systolic blood pressure and diastolic blood pressure in males and females were identical.

TABLE 2- Anthropometry and clinical characteristics of the subjects (n=299)

Variables	Male (n =124)		Female (n= 175)		*p* Value
	Mean	SD	Mean	SD	
Age(years)	49.82	11.74	48.58	11.67	0.365
Anthropometric					
Height(m)	1.64	0.06	1.53	.054	0.000
Weight(kg)	66.32	11.42	61.38	11.63	0.000
Waist circumference(cm)	86.26	10.32	82.28	11.67	0.002
Hip circumference(cm)	93.70	7.05	98.01	9.58	0.000
WHR	0.92	0.08	0.84	0.08	0.000
BMI(Kg/m^2)	24.51	3.58	26.27	4.54	0.000
Body fat(%)	20.79	5.92	36.53	7.53	0.000
Visceral fat (%)	11.19	4.69	7.57	2.67	0.000
Blood Pressure (mmHg)					
Systolic	135.86	21.84	134.53	21.84	0.623
Diastolic	79.19	11.05	79.21	11.35	0.985

BMI Categories

TABLE 3 shows the number of overweight and obese subjects. More than half of the respondents were overweight and obese (54.9 %). Around 25.6 % of female subjects were overweight while 10.4% were obese. Male subjects showed a lower prevalence; 16.2% were overweight and 2.7% were obese respectively. In this sub-population, generally more females have excess weight problem compared to male subjects.

TABLE 3- Nutrition status of subjects (n=297)

Nutrition status	Gender	
	Male (n=123) N (%)	Female (n=174) N (%)
Underweight	4(3.3)	7(4.0)
Normal weight	63(51.2)	60(34.5)
Overweight	48(39.0)	76(43.7)
Obesity	8(6.5)	31(1.8)

Waist Hip Ratio of Males and Females

The prevalence of abdominal obesity is presented in **TABLE 4**. In total, WHR >0.9 for male and WHR>0.85 for female were 25.7% and 26.3%, respectively. Results on sex gender is significantly associated with WHR (*P*<0.001) as more females have abdominal obesity compared to male subjects.

TABLE 4- Waist hip ratio in study subjects (n=300)

Variables	Male (n=125) N (%)	Female (n=175) N (%)	p Value
Normal	48 (16.0)	96 (32.0)	<0.001
Over			
Male (>0.9)	77 (25.7)		
Female (>0.85)		79 (26.3)	

Correlation between BP and Anthropometric Indicators

TABLE 5 shows the association of blood pressure and anthropometric indicators. Waist circumference, hip circumference, WHR, BMI, total body fat, and visceral fat were correlated with higher systolic blood pressure. However, only visceral fat and WHR showed a significant association. On the contrary, diastolic blood pressure showed a positive and significant correlation with all anthropometric indicators.

TABLE 5- Correlation between blood pressure and anthropometric indicators (n=298)

Anthropometric variables	SBP (r)	DBP (r)
Waist circumference (cm)	0.109	0.266**
Hip circumference (cm)	0.043	0.199**
WHR	0.154**	0.189**
BMI (kg/m2)	0.114	0.250**
Body fat (%)	0.065	0.197**
Visceral fat (%)	0.221**	0.293**

**Correlation is significant at the 0.01 level (2-tailed)

Discussions

A number of cross-sectional studies have investigated the relationship between CVD risk factors according to multiple measures of adiposity (Wildman *et al.* 2005; Zhu *et al.*, 2005). However, it is yet to be determined as to which anthropometric measurements are strongly associated with blood pressure in adults, particularly Asians (Wildman *et al.*, 2005). In Western populations, most studies have demonstrated that central obesity is more closely associated with cardiovascular risks than general obesity (Janssen *et al.*, 2004; Pi-Sunyer, 2000). In contrast, results in the Asian population are still inconsistent (Kawada 2002).

The Association between Body Mass Index and Blood Pressure in Adults

This study indicates that general obesity and BMI are associated with diastolic blood pressure among adults in Tawang. Consistent with other studies, this analysis shows that being overweight or obese is an important predictor of elevated BP. In the Framingham Study, it was found that a 10% rise in body weight explains a 7 mmHg rise in SBP in the population at large (Pang *et al.*, 2008). It has also been found that every kilogram excess body weight that is lost is associated with decreases of 0.33 and 0.43 mmHg in SBP and DBP, respectively (Stevens, Corrigan and Obarzanek, 1993).

Results in our study also implied that there is significant sexual dimorphism in regional adiposity and blood pressure, irrespective of the level of overall adiposity (BMI). Indech *et al.* (1991) had also found significant sex differences in regional adiposity among young (18–29 years) Punjabi adults of Chandigarh, North India.

The Association between Body Fat Composition and Blood Pressure in Adults

Percentage of body fat is the percentage of total body weight that is fat (Tanita, 2000). This device can also measure visceral fat percentage based on the algorithm set by the manufacturer. This is an important feature as both general fat and visceral fat plays unique role in relation to chronic disease development.

In this study, the Pearson's correlation shows there is a weak correlation between percentages of body fat with systolic blood pressure. However, a significant association was found between percentage body fat and diastolic blood pressure. Women have more body fat than men. By nature, a woman's body is developed to protect a potential fetus. As a result, women have more enzymes for storing fat and fewer enzymes for burning fat. Additionally, women have higher levels of estrogen, which activates fat storing enzymes. estrogen in women activates fat storing enzymes and causes them to multiply (Tanita, 2000). People who got fatter faster also tended to experience of a more rapid rise in blood pressure (Siervogel, 1998). Those with a slower change in body fat tend to have a gradual increase in blood pressure (Siervogel, 1998). Particularly in women, long-term increases in body fat are associated with increases in blood pressure (Siervogel, 1998).

Interestingly, the findings of this study demonstrate a significant correlation between visceral fat and systolic and diastolic blood pressure. This is an important finding as most anthropometric measurements are focusing on measuring subcutaneous fat only. A similar finding was obtained using an ultrasonography technique which is a more sophisticated and expensive method compared to bioelectrical impedance (Faria *et al.*, 2002). Visceral fat may play a more detrimental role in affecting blood flow within the internal organs such as liver and heart. Rattarasarn et al (2003) also found that visceral abdominal fat was correlated with systolic and diastolic blood pressure. Higher odds of hypertension were found in people with both abdominal and truncal obesity compared with persons with either abdominal or truncal obesity (Okosun *et al.*, 2006). A higher amount of visceral fat may show a higher risk of hypertension in older adults especially in lean individuals (Ding *et al.*, 2004)

The Association between Waist Hip Ratio and Blood Pressure in Adults

WHR was not found to be associated with blood pressure in the study group for both sexes. However, in this study, waist circumference only showed a significant correlation with diastolic blood pressure. According to Taylor *et al.* (2000) the WC can express abdominal fat accumulation better than the WHR does. This result may be because the hip may reflect changes in bones and muscles more than changes in fat (Al Sendi, 2003). Among obese adolescents, WC serves as a good index of central (abdominal) obesity (Al Sendi, 2003). In adults, among anthropometric indicators of body fat distribution, WC showed the strongest correlation with SBP (Pouliot, Despres, and Lemieux, 1994). This is particularly important in epidemiological studies, given the ease with which this measurement can be obtained. Whereas, the result indicates that the measurement of waist-to-hip ratio provides no advantage over waist circumference alone.

Previously, there is controversy about the best measure in the assessment of abdominal obesity (Hirani, Zaninotto and Primatesta, 1998). In this study it was revealed that WC is the best measure in the assessment of abdominal obesity rather than WHR. On the other hand, the use of WHR has been criticized as an indicator of abdominal fat. WC is meant to measure predominantly visceral organs and abdominal fat, both subcutaneous and intra-abdominal, while hip circumference may reflect different aspects of body composition, that is, muscle mass, fat mass and skeletal frame (Mollarius and Seidell, 1998). When these two circumferences are combined in a ratio, it is difficult to interpret differences in the ratio between and within individuals. For example, a reduction in weight usually results in a reduction in both waist and hip circumferences and this will not necessarily result in a change in WHR (Caan *et al.*, 1994).

People who are android-shaped, also known as apple-shaped, are more vulnerable to disease than those who are gynoid- or pear-shaped (Tanita, 2000). Premenopausal women typically have a lower body adipose distribution (gynoid) characterized by fat deposition in the gluteofemoral region (Tanita, 2000). In this study, the hip circumference among females was higher than males. On the other hand, waist circumference of males is higher in females. In men, an upper body adipose distribution (android) develops, which is characterized by central fat deposition in the abdominal intraperitoneal and subcutaneous regions (Thomas, 2004). The recognition of central obesity that, assessed by WC in the present study as important factor associated with increased risk of developing elevated BP. As in adolescents, the mechanism by which central fat deposition influences BP appears through changes in insulin sensitivity and its compensatory hyperinsulinaemia. Increased insulin secretion has been shown to be present in adolescent obesity and is related to the amount of intra-abdominal fat (Caprio and Tamborlane, 1999). Excessive insulin secretion leads to sodium and water retention and stimulation of sympathetic activity, which may in turn lead to hypertension (Al Sendi, 2003).

The TANITA body-composition analyser is an automated device used to estimate body fat, based on the principles of bioelectrical impedance (Jebb *et al.*, 2000). The bioelectrical impedance technique has better reproducibility than skinfolds, which makes it more suitable for large studies with multiple measurers. It has proven reliability in interlaboratory comparisons (Deurenberg, Westerterp and Velhuis-Te Wierk, 1994). The procedure has become simpler and faster with the development of analysers that only require the subject to stand bare-footed on metal plates that contain the electrodes (Jebb *et al.*, 2000).

A few limitations in this study must be taken into account in the interpretation of the results. Firstly, as a cross sectional study, directionality of the associations between blood pressure measurements and anthropometric measurements cannot be clearly established. Secondly, the study population was relatively small and predominantly females, which limits the generalizability of the findings.

Conclusion

This study has shown that BMI, WC, hip circumference and visceral fat are anthropometric measurements that are strongly associated with BP. BMI is by far the most widely used measurement to reflect general obesity, while WHR, WC and abdominal sagittal diameters are used as indices of central obesity. The first three measures are commonly used in field research related to obesity but, interestingly, visceral fat which is also an important measure is often overlooked by most researchers. Perhaps, this is due to the higher cost of the device used to measure visceral fat. However, with the enhancement of research and development in science and technology, the price of bioelectrical impedance devices is expected to decrease. Furthermore, the size and portability of these devices may favor researchers involved in community nutrition research where most field work is conducted in remote places. However, more conclusive research needs to be conducted to assess the reliability and validity of bioelectrical impedance devices in providing accurate results in community-based studies.

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