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Correlation Between Body Mass Index (BMI) and Waist to Hip Ratio (WHR) among Undergraduate Students

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Abstract: Body mass index (BMI) is a common, inexpensive and simple method to categorize individuals as underweight, normal weight, overweight, obese I and obese II. However, this method does not reflect body shape and fat distribution. Waist to hip ratio (WHR) is a more recent and accurate method to measure body fat distribution and can be used routinely. The purpose of this study was to compare BMI and WHR of Malaysian undergraduate medical students. The weight, height, waist line and hip line of 82 undergraduate medical students studying at SEGi University, Malaysia were measured and used to calculate BMI and WHR using the standard formula. For males, the highest mean BMI was recorded for Indian students followed by those for Malay and Chinese. However, for males, the highest mean WHR was recorded for Malay followed by those for Chinese and Indian. For females, both mean BMI and WHR were highest for Malay, followed by those for Indian and Chinese. No correlation was found between BMI and WHR among the overall and male participants respectively. However significant correlation was present between BMI and WHR among female participants (r value = 0.623). In conclusion, in this research, there was correlation between BMI and WHR in female population. Therefore the Malaysian females, specially Malay females should be more aware of their health, their food intake and they should take better care of their health, do more physical activity in order to have healthier life and get less exposed to diseases caused by high BMI and WHR.

Key words: Body mass index, waist to hip ratio, obesity

INTRODUCTION

Obesity is the condition of excessive fat deposition in the body and is further classified as abdominal obesity (around the waist and trunk) or gynoid obesity (peripherally deposited fat) (Chan *et al*., 2003; Per, 2001; Ofei, 2005; Kelly, 2006; Martinez, 2000; Hu, 2008). Obesity may lead to chronic diseases such as type 2 diabetes mellitus, cardiovascular disease and cerebrovascular diseases. Risk factors which contribute to obesity are genetic factors, diet, rate of metabolism, physical activity and environment interactions. Reduced physical activity and high intake of simple carbohydrates and fats are the most common causes of obesity in the absence of other causes (Ofei, 2005).

Body mass index (BMI), waist to hip ratio (WHR), fat distribution, skinfold thickness, densitometry and bio-impedance are some of the methods available to measure obesity and body fat (Chan *et al*., 2003; Hu, 2008). BMI and waist to hip ratio are among the most popular methods to measure obesity due to their simplicity, ease of execution and low cost (Chan *et al*., 2003; Hu, 2008). BMI is calculated by dividing the weight in kilograms by the square of height in meters (Dagan *et al*., 2013). The validity of BMI measured by reference method is well-displayed in different sex and racial groups. BMI also acts as an indicator to predict disease incidence and mortality. It is a simple to use scale, as it provides a standardized cut-off value to classify obesity in the adult population (Hu, 2008).

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Despite being popular and simple to use, BMI has some limitations. It is an indirect and imperfect measure for body fat because it does not differentiate between fat mass and lean body mass components. BMI does not reflect body shape and it can be misleading in cases of high proportion of lean muscle mass in a person. In elderly, BMI is a less valid predictor of body fat than in middle-aged adults (Dagan *et al*., 2013). According to a study carried out to determine the sensitivity and specificity of BMI in US adult population, BMI had limited diagnostic performance to identify individuals who were overweight, particularly for people with BMI between 25 to 30 kg/m^2, for men and elderly people. It has been found that BMI has a good specificity, but a low sensitivity to diagnose obesity (Annals of Human Biology, 2009; Gahagan *et al*., 2011; Abel *et al*., 2008, 2007).

WHR is a more accurate measure of distribution of body fat (abdominal fat) although it is less commonly used (Brown, 2009). It can be used to classify body types into two main categories: Apple and pear. Apple shaped body type is more common among men and is caused by abdominal obesity. Women usually accumulate fat around the hip and the thighs to develop a pear shaped body type (Ashwell, 2009). Apple shaped fat distribution is considered more dangerous than Pear shaped fat distribution because of the accumulation of fat in the deep abdominal area around the visceral organs. This hidden fat can lead to development of metabolic disorder, diabetes type II and increases cardiovascular risk. If the waist circumference in women is $\geq$80 cm and in man is $\geq$94 cm, it may lead to development of insulin resistance and arterial hypertension (Marie *et al*., 2012; Marcin *et al*., 2014). Increased hip circumference is associated with increased hip subcutaneous fat, gluteal muscle and total leg muscle mass (Marie *et al*., 2012; Marcin *et al*., 2014; Lawrence *et al*., 2007; Odenigbo *et al*., 2011).

Some Asian studies have reported association between BMI and waist to hip ratio. An exploratory study from Singapore carried out among a multiethnic Asian population (English, Chinese, Malay and Tamil speaking) reported that obese individuals have the worst health-related quality of life (HRQoL) compared to normal weight and pre-obese individuals. In short, obese people have significantly higher chances of getting health-related problems such as cardiovascular diseases (CVD) (Hwee *et al*., 2008). Other studies have examined the association between BMI and risk of total knee replacement among Chinese (Hokkien and Cantonese dialect) in Singapore and concluded that BMI was a strong risk factor for total knee replacement (Leung *et al*., 2015). Correlation study between BMI and waist circumference in patients with metabolic syndrome study showed that the presence of the overweight in men (BMI 25.84 kg/m^2) and normal weight in woman (BMI 21.62 kg/m^2) corresponds with the increased volume of visceral tissue around abdomen area with high chances to develop diabetes mellitus type 2 and CVD (Marcin *et al*., 2014).

It has been previously reported that the Malaysian adults with obesity (BMI cut-off values of 23.3 to 24.1 kg/m^2 in men and 24.0 to 25.4 kg/m^2 in women) were more at risk for hypertension, dyslipidemia, diabetes and cardiovascular diseases (Cheong *et al*., 2013). Obesity in Malaysia was prevalent among the Malays, Indians and Chinese, respectively (Azmi *et al*., 2009). A study carried out in University of Science Malaysia in 2010 involving 624 students reported that BMI value in Malaysia was high in Malay followed by Indian and Chinese, respectively (Nurul and Ruzita, 2010). This may indicate the emergence of obesity that would lead to CVD and cancer related mortality in the future (Cheong *et al*., 2013; Azmi *et al*., 2009; Nurul and Ruzita, 2010; Abdullah *et al*., 2011; Norafidah *et al*., 2013; Guadalupe *et al*., 2004). Therefore, there is paucity of literature exploring the correlation between BMI and WHR.

We believe that this research is beneficial to give a measure of both BMI and WHR among university students. Hence, this study was designed to determine the correlation between the BMI and WHR of medical undergraduate students of SEGi University Kota Damansara.

MATERIALS AND METHODS

Ethical approval was obtained from the ethical review board of SEGi University. We used two parameters in this research; BMI and waist to hip ratio. A convenience sample of 82 participants were used from the undergraduate medical course students (first year and the second year). After obtaining the consent, participants were requested to fill their information in the forms provided to them. They were then briefed about the purpose of research and the procedure involved. Thereafter, their measurements were obtained in the physiology laboratory at the Faculty of Medicine of SEGi University.

Participants were asked to remove their shoes and step on weighing scale for their weight measurement. For measuring the height, they were asked to stand straight and measurement was taken from the tip of their heads until the tip of their toes using a stadiometer. The BMI was computed by using the standard formula. Table 1 shows the guideline for BMI classification (Gahagan *et al*., 2011; Odenigbo *et al*., 2011).

Waist circumference (cm) was measured using a measuring tape, from mid-point of the costal margin to the iliac crest in the mid-axillary line or above the belly button after instructing the participant to stand and breathe normally. The hip measurement was taken by measuring their widest point of the greater trochanter. The waist to hip ratio was then being calculated by the waist measurement divided by the hip measurement. Table 2 shows the guideline for waist to hip ratio (Odenigbo *et al*., 2011). The statistical analyses were done using SPSS (IBM Corp, 2012 version 22.0).

RESULTS

Data interpretation for mean body mass index (BMI) based on gender and races: Table 3 shows the demographic data. Out of the 82 study participants, 37 were males (15 Malay, 12 Chinese and 10 Indian) and 45 were females (20 Malay, 10 Chinese and 15 Indian). It is evident from Fig. 1 that amongst males, Indian had the highest BMI value followed by Malay and Chinese. Further, BMI value for Indian was greater than that for Malay by 4.94% while BMI value for Indian was greater than that for Chinese by 9.17%. The BMI of Malay was greater than that of Chinese by 4.46%.

With respect to females, Malay had the highest BMI value followed by Indian and Chinese. BMI value for Malay was greater than that for Indian by 6.61% while BMI value for Malay was greater than that for Chinese by 7.62% and BMI value for Indian was greater than that for Chinese by 1.08%.

Data interpretation for mean waist to hip ratio (WHR) on gender and races: It is clear from Fig. 2 that amongst males, Malay had the highest WHR value followed by Chinese and Indian. WHR value for Malay was greater than those for Chinese and Indian by 2.35% and 2.24% respectively. While the WHR of Chinese was greater than that of Indian by 0.24%.

With respect to females, Malay had the highest WHR values followed by Indian and Chinese. The WHR value for Malay was greater than those for Indian and Chinese by 13.24% and 14.61% respectively. While the WHR of Indian was greater than that of Chinese by 1.58%.

Data interpretation of correlation between body mass index (BMI) and waist to hip ratio (WHR) for overall male and female: It is quite evident from the scatter plot of Fig. 3 that there was no significant correlation between BMI and WHR among the overall participants where n = 0.926 and p>0.05 with C.I = 95% (r value = 0.010).

Data interpretation of correlation between body mass index (BMI) and waist to hip ratio (WHR) for male: As is evident in Fig. 4, there was no significant correlation between BMI and WHR among the male participants, where n = 0.466 and p>0.05 with C.I = 95% (r value = 0.124).

Data interpretation of correlation between body mass index (BMI) and waist to hip ratio (WHR) for female: There was a significant correlation between BMI and WHR among the female participants as shown in Fig. 5, where n = 0.000 and p≤0.05 with C.I = 95% (r value = 0.623).

DISCUSSION

In the present study, it was found that in females the BMI and WHR were highest in Malay followed by those in Indian and Chinese. A similar finding was observed but with overall population of students amongst university students in Malaysia (Nurul and Ruzita, 2010). However contradicting results were found in our study for males, in which Indian showed highest BMI value followed by Malay and Chinese. With regard to WHR in females, Malay showed highest readings followed by Indian and Chinese. This finding of our study is in confluent with a study done on overall Malaysian population (Norafidah *et al*., 2013). However, in the males, the WHR in Malay was found to be the highest in our study followed by those for Chinese and Indian, respectively.

A positive correlation was also found in our study between BMI and WHR in females and the results are in accordance with a study carried out on Mexican women in the USA. Hence, there is a definite need for intervention development in females (Guadalupe *et al*., 2004).

The findings of our studies in females are attributed to several components which influences energy expenditure in our body such as; energetic cost of physical activity, basal metabolic rate (BMR) and thermic effect of food (Rising *et al*., 1994). The main contributing factor to obesity is lowered activity-related energy expenditure. There is an inversely proportional relationship between lifestyle (active or passive) with BMI (Martinez, 2000).

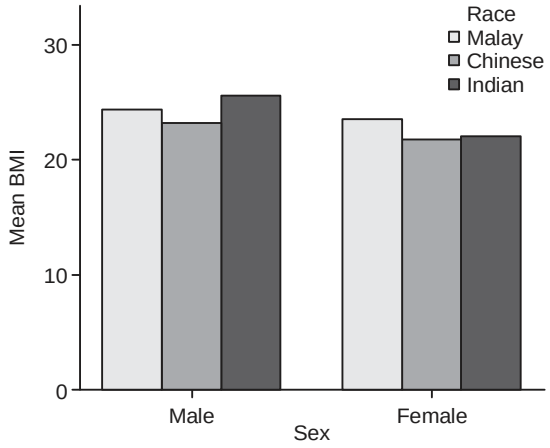

Fig. 1: Data interpretation for mean body mass index (BMI) based on gender and races: In males, Indian had the highest BMI value followed by Malay and Chinese. BMI value for Indian was greater than that for Malay by 4.94% while BMI value for Indian was greater than that for Chinese by 9.17% and the BMI value for Malay was greater than that for Chinese by 4.46%. In females, Malay had the highest BMI value followed by Indian and Chinese. BMI value for Malay was greater than that for Indian by 6.61% while BMI value for Malay was greater than that for Chinese by 7.62% and the BMI value for Indian was greater than that for Chinese by 1.08%

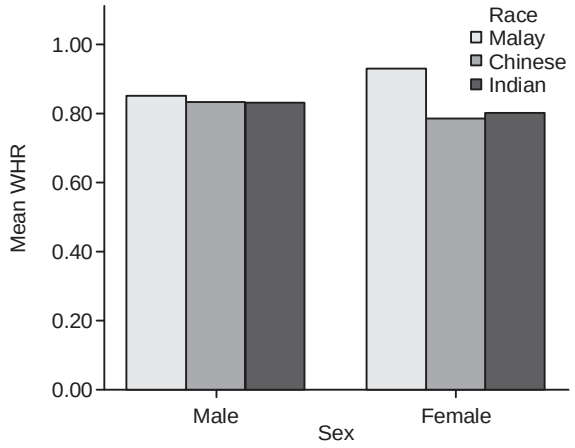

Fig. 2: Data interpretation for mean waist to Hip ratio (WHR) based on gender and races: In males, Malay had the highest WHR value followed by Chinese and Indian. WHR value for Malay was greater than that for Chinese by 2.35% while WHR value for Malay was greater than that for Indian by 2.24% and WHR value for Chinese was greater than that for Indian by 0.24%. In females, Malay had the highest WHR value followed by Indian and Chinese. WHR value for Malay was greater than that for Indian by 13.24% while WHR value for Malay was greater than that for Chinese by 14.61% and WHR value for Indian was greater than that for Chinese by 1.58%

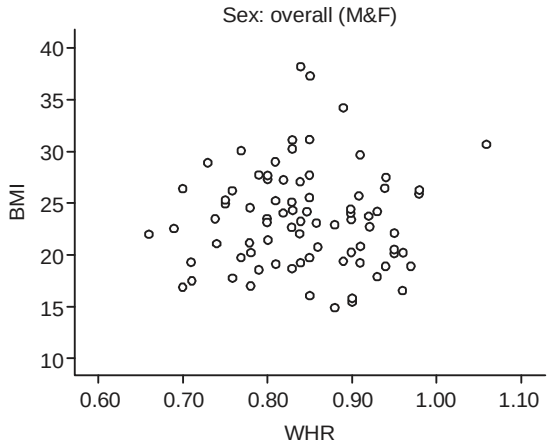

Fig. 3: Data interpretation of correlation between body mass index (BMI) and waist to hip ratio (WHR) for overall male and female: The scattered plot shows that there was no significance in the correlation between BMI and WHR among the overall male and female participants, where n = 0.926 and p>0.05 with C.I = 95% (r value = 0.010)

Previous study also reported that skipping breakfast was significantly associated with being overweight (Guadalupe

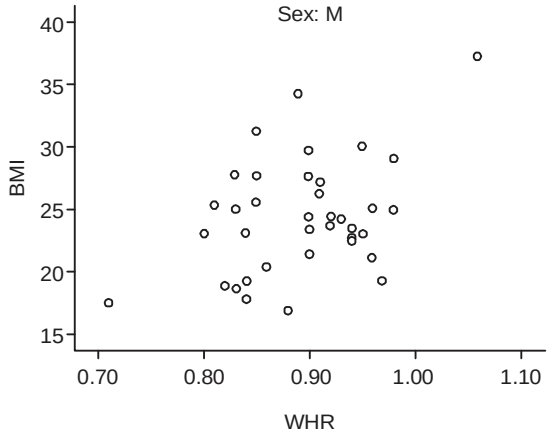

Fig. 4: Data interpretation of correlation between body mass index (BMI) and waist to hip ratio (WHR) for male: The scattered plot shows that there was no significance in the correlation between BMI and WHR among the male participants, where n = 0.466 and p>0.05 with C.I = 95% (r value = 0.124)

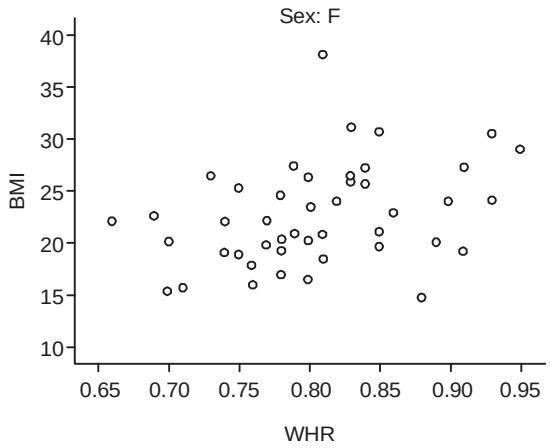

Fig. 5: Data interpretation of correlation between body mass index (BMI) and waist to hip ratio (WHR) for female: The scattered plot shows that there was a significance in the correlation between BMI and WHR among the female participants, where n = 0.000 and p≤0.05 with C.I = 95% (r value = 0.623)

Table 1: Guideline for body mass index (BMI) classification

Classification	BMI (kg/m^2)
Underweight	<18.5
Normal weight	18.5-22.9
Overweight	23-24.9
Obese I	25-29.9
Obese II	≥30

Table 2: Guideline for waist to hip ratio (WHR)

Men waist to hip ratio	Women waist to hip ratio
<0.95	<0.80

Table 3: Demographic data (82 participants)

Gender	Mean	SD	Frequency	Percentage
Male	Nil	Nil	37	45.1
Female	Nil	Nil	45	54.9
Ethnicity				
Malay	Nil	Nil	35	42.7
Chinese	Nil	Nil	22	26.8
Indian	Nil	Nil	25	30.5
Height	63.79	15.512	Nil	Nil
Weight	1.64	0.099	Nil	Nil
BMI status				
Underweight			10	12.2
Normal			27	32.9
Overweight			31	37.8
Obese 1			12	14.6
Obese 2			2	2.4
Waistline	78.28	11.802	Nil	Nil
Hipline	92.69	11.173	Nil	Nil
WHR status				
Low risk			49	59.8
High risk			33	40.2

et al., 2004; Rising *et al*., 1994; Abolfotouh *et al*., 2007). On the contrary, similar relationship between the frequency of breakfast consumption and obesity was reported by other studies (Cockcroft *et al*., 1994). The direct linkage between stress on abdominal obesity reported in a study carried out in non-human primate. During stress, hypothalamic-pituitary-adrenal axis will be activated to produce adrenocorticotropic hormone (ACTH). The release of ACTH produces cortisol which is believed to be related with obesity (Baker *et al*., 2002). Rosmond *et al*. (2001) reported a significant correlation between postprandial salivary cortisol and BMI, waist-to-hip ratio (WHR), fasting glucose, insulin, triglycerides, cholesterol and blood pressure in men. A similar correlation was observed between morning salivary cortisol levels, BMI and WHR (Soma *et al*., 2009). Further studies with larger samples should be conducted identifying the potential causes for the development of obesity in such a susceptible female population so that appropriate strategies may be employed in preventing chronic medical problems such as hypertension and diabetes mellitus.

Conclusions: In conclusion, for BMI in males, the Indian had the highest mean BMI value followed by Malay and Chinese. In females, Malay had the highest mean BMI value followed by Indian and Chinese. With respect to WHR in males, Malay showed the highest mean WHR scores followed by Chinese and Indian. In females, Malay showed the highest mean WHR scores followed by Indian and Chinese. For females, both mean BMI and WHR were highest for Malay, followed by Indian and Chinese. There was a significant correlation between BMI and WHR for females but there was no significant correlation between BMI and WHR for males and overall participants. Thus, this study implies a higher chance of developing obesity amongst female community than amongst male community in Malaysia. Further, it would be worthwhile to modify the lifestyle in Malaysian females, specially Malay females, by giving them dietary instructions and advice to perform more physical activities in the form of exercises. These would provide them less likelihood of their getting chronic illness such as hypertension and diabetes type II.

Competing interests: The authors declare they have no competing interests.

Author contributions: Conceived and designed the experiments: SRD NSS Performed the experiments: NM NFR MSMK NWA NSTKZ. Analyzed the data: NM NFR MSMK NWA NSTKZ MB SAM. Wrote the paper: SRD KRG RS NSS. Revised the paper: SRD KRG RS KAJ MI MES KTZ NHL WML VA SYAK RM WAC AY RSYW VK JN NSFS HTD MNH NMHM ATK HH SAY CPWT SARA FF MAE SAM MM NSS. All authors read and approved the final manuscript to be published.

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