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Which is a Better Anthropometric Indicator of Cardiovascular Risk Factors in Type 2 Diabetes Mellitus Patients? Waist Hip Ratio or Body Mass Index?

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ABSTRACT

Introduction: The increasing prevalence of adiposity is associated with the development of type 2 diabetes mellitus (T2DM). The two most popular methods to measure adiposity are body mass index (BMI) and waist-hip-ratio (WHR), which measure the overall and abdominal adiposity, respectively. The aim of this study was to determine whether BMI or WHR was more strongly associated with macronutrient intakes and lipid profiles in T2DM patients. **Methods:** In this cross-sectional study, a total of 210 T2DM patients, mean age of 56.73(SD 10.23) years, were recruited from Penang. Information on socio-demographic, body measurements (height, weight, waist circumference and hip circumference)and macronutrient intakes (three 24-hour dietary recalls) were recorded. Routine laboratory tests (fasting blood glucose, HbA1c, LDL, HDL, triglyceride and total cholesterol) were performed according to standard procedure. **Results:**Among the respondents, 84% had abdominal and 63% had overall adiposity respectively.There was a significant correlation between WHR and the total calorie(r=0.27; p<0.001), carbohydrate (r=0.30; p<0.001) and protein intakes(r=0.18; p=0.009). WHR was significantly associated with serum triglycerides(r=0.18; p=0.011) and the HDL levels (r=-0.20; p=0.003). On the other hand, neither lipid profiles nor dietary intakes showed significant correlation with BMI. **Conclusion:** In T2DM, WHR is more strongly associated with macronutrient intakes, HDL and triglyceride compared with BMI. Hence, WHR is a better anthropometric indicator of plasma lipids in T2DM.

Keywords: Adiposity, body mass index, lipid profiles,macronutrient intakes, type 2 diabetes mellitus, waist hip ratio

INTRODUCTION

The prevalence of adiposity is increasing worldwide and constitutes a threatening public health issue to both industrialised and developing countries. In 2005, approximately 1.6 billion individuals aged 15 and above were overweight and at least 400 million were obese (WHO, 2009). These figures are expected to double by 2015 (WHO, 2009). In 1996, the National Health and Morbidity Survey II (NHMS II) reported that 20.7% of adults were overweight and 5.5% obese (IPH, 1996). In the subsequent ten years, prevalence of overweight and obesity had increased to 29.1% and 14.0%

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respectively (IPH, 2006). Meanwhile, the overall national prevalence of abdominal adiposity among Malaysian adults was up to 17.4% (Kee *et al.*, 2008).

Adiposity is defined as a circumstance where there is an excess of body fat (Razak *et al.*, 2005). Adiposity is strongly associated with increasing risk of type 2 diabetes mellitus (T2DM)(Mehmood *et al.*, 2011) besides glycaemic control, lipid profiles, sedentary lifestyle and age. In healthy Caucasian populations, numerous studies have reported that a positive family history of T2DM is correlated with increased body mass index (BMI) (Vaag, Thye-Ronn & Groop (2001). Previous studies conducted in Malaysia also showed that the majority of T2DM patients had overweight and obesity problems (Hazizi *et al.*, 2009). Insulin resistance happens among individuals with adiposity due to the increased amount of non-esterified fatty acids, glycerol hormones and pro-inflammatory cytokines in adipose tissue (Kahn, Hull & Utzschneider, 2006). The rising trend of T2DM in Malaysia could be associated with the increased prevalence of adiposity among the adult population.

Several simple anthropometric measurements have been used as measurements of adiposity and have more practical values in large-scale epidemiological studies and clinical practice (Wu *et al.*, 2007). The two most common methods are BMI which measures lean tissue as well as overall adiposity, and waist hip ratio (WHR) which assesses abdominal adiposity. Both assessments have been used to characterise the association between adiposity and T2DM. They were shown to have the ability to predict the level of glycosylated haemoglobin (HbA1c) in a previous study (Yoshida, Toyomura & Fukumoto,2009). Overall adiposity used to be the strongest environmental risk factor for T2DM and BMI was a standard predictor of glycaemic status in T2DM patients. However, in recent years, some studies have criticised BMI as it is unable to identify body fat distribution and it reflects both fat and lean body mass (Mason, Craig & Katzmarzyk, 2008). Furthermore, some recent studies have shown that patients with abdominal adiposity have a higher risk of T2DM as compared to patients with overall adiposity (Janssen, Katzmarzyk & Ross, 2004). The association of overall adiposity with lipid profiles and dietary intakes in T2DM patients as compared to abdominal adiposity has not been well studied in Malaysia. The purpose of this study was to determine whether BMI or WHR is more strongly associated with macronutrient intakes and lipid profiles in T2DM patients.

METHODS

This cross-sectional study was carried out in the Sungai Bakap Hospital, Penang. The study group comprised 210 Malaysian adult respondents. Formal permission to conduct the study in the chosen hospital was obtained from the Ministry of Health, Malaysia. The study protocol was reviewed and approved by the Human Research Ethics Committee of UniversitiSains Malaysia. Written informed consent was obtained from the respondents before participation. Respondents were selected using non-probability convenience sampling method. Only T2DM patients who were able to communicate were included. T2DM patients who were receiving insulin injections, type 1 diabetes mellitus patients and pregnant women were excluded from the study. Socio-demographic data such as sex, age, educational level and occupation of the respondents were collected using a socio-demographic questionnaire.

Anthropometric measurements

The anthropometric measurements were performed according to standard procedures, with the respondents barefooted, wearing minimal clothing and in a pre-prandial state. Body weight and height were measured by the same investigator using a Fat Analyzer Scale Model HBF-356 (Omron, Japan) and a wall-mounted microtoise tape (Secabodymeter 208, Hamburg, Germany) to the nearest 0.1kg and 0.1cm respectively. BMI classification was based on the World Health Organization (WHO)guideline (WHO, 2004). The waist was measured immediately above the iliac crest and the hip was recorded at the widest part of the hips (NHNES III, 1994). The cut-off points of the WHR for female and male were 0.85 and 0.9 respectively (WHO, 2008).

Macronutrient intakes

Nutrient intakes were assessed by using three 24-hour dietary recalls which appear to be optimal for estimating calorie and macronutrients intakes, compared to single 24 hour dietary recall (Yunsheng *et al.*, 2009). All the respondents were asked to recall all of the food and drink consumed on three non-consecutive days, including 2 weekdays and 1 weekend day. Dietary recall was carried out with extensive probing, using table ware items such as bowls, dishes, spoons and glasses in commonly-used sizes. Food models and pictures of common foods were used to assess food intake and portion sizes. It was carried out by a trained dietitian, who had been working in Ministry of Health since year 2007. The information received was carefully checked in order to avoid omitted or misreported data. Calorie and macronutrient intakes for the three days were determined by using Nutritionist Pro software (Axxya Systems, United States).

Blood collection

All the respondents fasted for at least 8 hours prior to blood collection. Ten ml blood was collected into an EDTA (ethylene-diamine-tetra-acetate) tube and immediately inverted gently five times. The blood plasma was then drawn off and transferred into a bullet tube and stored at -20°C in a freezer. Eventually, all of the plasma samples were accumulated in a cool ice box and taken to the School of Health Sciences, Universiti Sains Malaysia for further analysis by a research officer. The collected blood was used to measure fasting blood glucose (FBG) and lipid profiles such as total cholesterol, triglyceride, lowdensity lipoprotein (LDL) and high density lipoprotein (HDL). Principle measurements for fasting blood glucose and HbA1c were UV hexokinase and high performance liquid chromatography (HPLC) respectively, while the principle measurement for HDL and LDL was homogenous. In addition,the principle measurement for total-cholesterol and triglyceride was enzymatic. Percentage of HbA1c was analysed by Bio-Rad D10 Hemoglobin A1c Analytical, and the remaining tests were analysed by Chemistry AnalyserUnicel DXC 600. The normal range of biochemical results for the study respondents were based on International Diabetes Federation guidelines (IDF, 2005)

Statistical analyses

All statistical analyses were performed by using the programme, Statistical Package for Social Sciences SPSS version 19. A 2-tailed value of $p<0.05$ was considered significant. Distribution of the data was assessed by descriptive analysis. Each variable was examined for normality of frequency distribution based on the histogram. Normally distributed data were expressed as mean (Standard deviation) and skewed data were expressed as medium (Inter-quartile Range or IqR). The Pearson's test was conducted to determine the association between anthropometric measurements with the lipid profiles and macronutrient intakes.

RESULTS

A total of 210 T2DM patients with the mean age of 56.51(SD 9.88) years, ranging from 31 to 78 years old, were involved in this study. Percentages of males and females were 44% and 57% respectively. More than half of the respondents were married women (56%), who were housewives (50%) and with low educational level (40%). A total of 87% of respondents were non-smokers.

Anthropometric measurements, blood results and dietary data are shown in Table 1. The overall mean BMI was 27.50 (SD 5.03) kg/m^2, ranging from 17.00 kg/m^2 to 44.40 kg/m^2. Meanwhile, the overall mean WHR was 0.91 (SD 0.07). There was a significant difference in WHR (p=0.006) between the male and the female respondents.It was noted that 78% of males had WHR > 0.9 and 88% of females had WHR > 0.85. The prevalence of abdominal adiposity was significantly higher (p<0.001) among the females compared with that of the males (Table 2). Only small proportions of the respondents were normal weight (35%)and had normal waist hip ratio (16%). In contrast, more than half (63%) (Table 3) of the respondents were overweight and obese, based on WHO BMI cut-off points, whereas 84% had excess abdominal adiposity based on WHO WHR cut-off point. Similarly only small proportions of respondents had normal FBG (13%) and HbA1c (4%), while a majority of the respondents showed abnormal lipid profiles (66%) (Table 3).

The overall mean total energy intake was 1647 (SD 564) kcal, ranging from 518 kcal to 4262 kcal. Meanwhile, percentage contributions to total energy from dietary carbohydrate, protein and total fat intake was 60%, 16% and 24% respectively. Only 17% of the respondents were found to have

Table 1. Anthropometric measurements, blood results and dietary intakes of respondents (n=210)

	Total (n=210) mean (SD)	*Male (n=92) mean (SD)*	*Female (n=118) mean SD*	*p-value[1]*
Age	56.51 (9.88)	56.96 (10.71)	56.17 (9.22)	0.076
Anthropometry				
Body mass index (kg/m^2)	27.50 (5.03)	26.98 (4.44)	27.90 (5.43)	0.075
Waist hip ratio	0.91 (0.07)	0.94 (0.50)	0.89 (0.07)	0.006
Blood result				
Fasting blood glucose (mmol/L)	9.97 (3.69)	9.78 (3.41)	10.12 (3.90)	0.375
HbA1c (%)	8.52 (1.73)	8.44 (1.63)	8.57 (1.81)	0.265
Total cholesterol (mmol/L)	5.06 (1.15)	5.03 (1.18)	5.09 (1.12)	0.888
Low density lipoprotein (mmol/L)	3.29 (0.90)	3.26 (0.77)	3.31 (0.99)	0.051
High density lipoprotein (mmol/L)	1.00 (0.35)	0.92 (2.55)	1.03 (0.28)	0.284
Triglyceride (mmol/L)	1.89 (1.20)	2.06 (1.30)	1.76 (1.10)	1.209
Nutrient intake				
Calorie (kcal)	1647 (564)	1866 (558)	1476 (510)	0.414
Protein(g)	67.40 (22.93)	75.87 (21.78)	60.79 (21.67)	0.465
Carbohydrate (g)	240.73 (92.63)	268.31 (99.78)	219.23 (80.76)	0.315
Fat (g)	46.92 (23.41)	51.74 (23.32)	43.17 (22.89)	0.659

SD: Standard deviation; [1]Independent T-test; Normal range of fasting blood glucose: 4.4-6.1; HbA1c: 4.4-6.4; Total cholesterol: <4.5; LDL: <2.5; Triglyceride: <1.5; HDL: >1.0

Table 2. Prevalence of abdominal adiposity according to waist hip ratio of the study respondents (n=210)

Abdominal adiposity	*Male (n=92)*	*Female (n=118)*	*P-value[1]*
	n (%)	*n (%)*	
No	20 (21.7)	14 (11.9)	<0.001
Yes	72 (78.3)	104 (88.1)	

[1] Chi-square test

Table 3. Body mass index, fasting blood glucose, HbA1c and lipid profiles of study respondents in proportion (n=210).

	Male (n=92)		*Female (n=118)*		*Total (n=210)*	
	n	*%*	*n*	*%*	*n*	*%*
Body Mass Index						
Underweight	1	1.1	2	1.7	3	1.4
Normal	36	39.1	38	32.2	74	35.2
Overweight	34	37.0	41	34.7	75	35.7
Obese grade I	14	15.2	25	21.2	39	18.6
Obese grade II	6	6.5	9	7.6	15	7.1
Obese grade III	1	1.1	3	2.5	4	1.9
Fasting blood glucose						
Normal	15	16.3	12	10.2	27	12.9
High	77	83.7	106	89.8	183	87.1
HbA1c						
Normal	5	5.4	4	3.4	9	4.3
High	87	94.6	114	96.6	201	95.7
Total cholesterol						
Normal	28	30.4	43	36.4	71	33.8
High	64	69.6	75	63.6	139	66.2
LDL						
Normal	33	35.9	41	34.7	74	35.2
High	59	64.1	77	65.3	136	64.8
HDL						
Normal	27	29.3	60	50.8	87	41.4
High	65	70.7	58	49.2	123	58.6
Triglyceride						
Normal	35	38.0	64	54.2	99	47.1
High	57	62.0	54	45.8	111	52.9

LDL: Low density lipoprotein; HDL: High density lipoprotein

met the daily energy requirement levels recommended by the Malaysia Recommended Nutrition Intake (RNI) tables, while 64% of respondents achieved the daily protein requirement levels recommended by the RNI.

The correlations between WHR and BMI with lipid profiles are presented in Figure 1 and Figure 2, whereas the correlations between anthropometric measurements and nutrient intakes are presented in Table 4. WHR was inversely correlated with HDL (r=-0.20; p=0.003), and directly correlated with serum triglyceride (r=0.18; p=0.011), total calorie intake (r=0.27; p<0.001), carbohydrate intake (r=0.30; p<0.001) and protein intake (r=0.18; p=0.009). On the other hand, no significant correlation was shown between BMI with lipid profiles and macronutrient intakes.

DISCUSSION

Our results showed that the majority of the T2DM respondents had BMI more than 24.9 kg/m² and demonstrated abdominal obesity. These findings are similar to the previous studies which have shown that overweight and abdominal obesity imposed detrimental effects on the patients with T2DM (Golay & Ybarra, 2005; Wilks*et al.*, 2001). Female respondents showed significantly higher prevalence of abdominal adiposity compared with the male

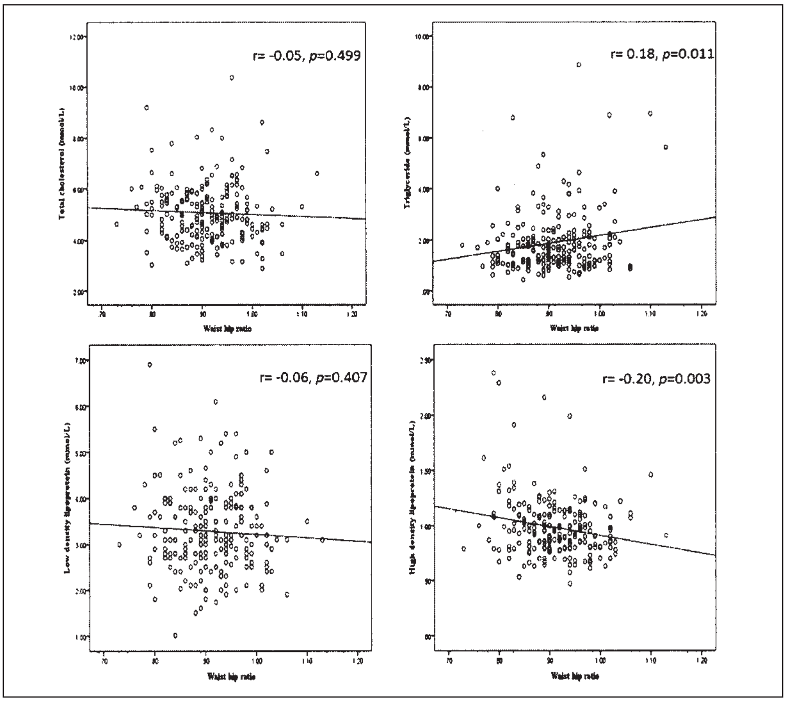

Figure 1. Correlation between waist hip ratio and lipid profiles (n=210)

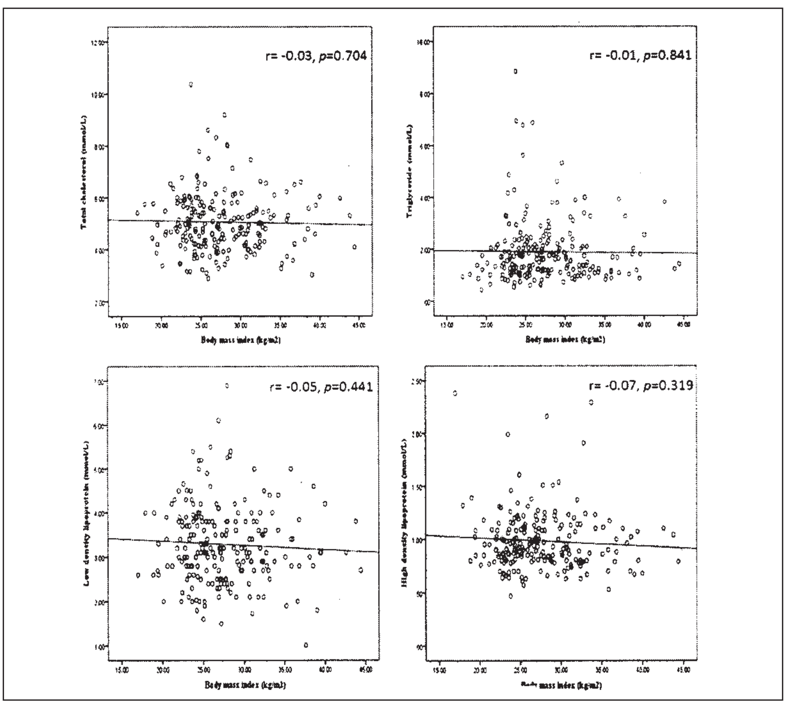

Figure 2. Correlation between body mass index and lipid profiles (n=210)

Table 4. Correlation between body mass index and waist hip ratio with nutrient intake (n=210)

Nutrient intake	*Body mass index*		*Waist hip ratio*	
	r	*p-value*	*r*	*p-value*
Calorie (kcal)	0.01	0.848	0.27	<0.001
Carbohydrate (g)	0.09	0.212	0.30	<0.001
Protein (g)	-0.15	0.056	0.18	0.009
Fat (g)	-0.07	0.324	-0.12	0.078

respondents.These results are consistent with a previous study done in Malaysia (Hamid Jan *et al.*, 2011). In females, fat is accumulated in the buttocks, hips and thighs. This typical female fat storage is important for normal reproductive function. However, once a female reaches menopause and the estrogen produced by ovaries decreases, fat storage will migrate from the buttocks, hips and thighs, to the belly (Razay, Vreughenhil & Wilcock, 2006). In the present study, the mean age of the female respondents was 56.17 years, most of whom had reached the menopause phase. This may be the cause for the higher prevalence rate of abdominal adiposity among the female respondents.

Most of the respondents who participated in this study had abnormal lipid profiles. Similar studies done earlier showed that patients with T2DM had aberrant lipid metabolism (Albrki*et al.*, 2007; Lorenzo *et al.*, 2010 and Idogun *et al.*, 2007). Abnormalities of lipid profiles are common among T2DM and contribute to a significant association with several complications. An increase in LDL in T2DM is due to the increased availability of glucose for LDL synthesis and a decrease in lipoprotein lipase activity leading to a decrease of LDL uptake from peripheral circulation (Manu *et al.*, 2007). Thus, diabetic dyslipidaemia management is a key element in the multifactorial approach to prevent cardiovascular disease in T2DM patients.

The relationship between nutrition and the prevalence of T2DM, depends mainly on the distribution of the macronutrients (Moy & Suriah, 2002). This study revealed that the percentage of carbohydrate, fat and protein distribution in the total energy intake of the respondents is consistent with the Malaysian Medical Nutrition Therapy guidelines (2005). However, the majority of the respondents were either overweight or obese. This discrepancy between the total calories intake and their anthropometry measurements could be due to the limitations of the three 24-hour dietary recalls. Three 24-hour dietary recalls are important for depicting the distribution of total calories and macronutrient intakes; however, some errors are unavoidable which include daily variation of subjects' diet, under-estimation from either the interviewer or respondents, or due to false information being given by the respondents about their daily food intake and social desirability response bias (Moy & Suriah, 2002).

We found no significant association between BMI and total cholesterol, HDL, LDL and triglyceride. On the other hand, WHR was negatively correlated with HDL and positively correlated with triglyceride ($r=0.18$; $p=0.011$). Compared to BMI, WHR appeared to be a stronger predictor of HDL and triglyceride among T2DM respondents. This finding is consistent with several previous studies (Lin *et al.*, 2006; Idzior *et al.*, 2001 and Eddelyn *et al.*, 2011). The present study revealed that WHR was a crucial determinant of HDL and triglyceride levels among T2DM patients. It is an anthropometric measurement of adiposity with the greatest correlation with cardiovascular risk factors in T2DM patients. This simple measure of abdominal obesity should be incorporated into cardiovascular risk assessments in T2DM patients (Lujain *et al.*, 2010). Dietary carbohydrate, protein and total calories intake was shown to be positively correlated with WHR. This study has showed that WHR is not only a strong determinant in lipid profiles among T2DM patients, but also macronutrient intakes. Earlier studies have stated that abdominal adiposity is a better indicator for the prediction of T2DM when compared with overall adiposity (Vazquez *et al.*, 2007; Cheng *et al.*, 2010). Moreover, WHR was shown to correlate with an increased risk of developing T2DM, despite the BMI being within the normal limits (Duc *et al.*, 2005). This is because overall adiposity has considerable limitations in predicting intra-abdominal fat accumulation, and it does not account for the wide variation in body fat distribution (Mason *et al.*, 2008).

The limitation of this study is the convenience sampling method which would have caused a selection bias.Due to the problems inherent in dietary recall, it is possible that some respondents could have misreported their dietary intakes, either under-reporting or over reporting of food intake.

CONCLUSION

Abdominal obesity measure (WHR) is a better anthropometric measurement that is associated with macronutrient and lipid parameters when compared to the BMI measures among patients with T2DM. This implies that medical and healthcare professionals should advise the patients with T2DM to control or reduce excess waist line in addition to controlling overall body weight by selecting a healthy diet and performing regular physical activity.

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