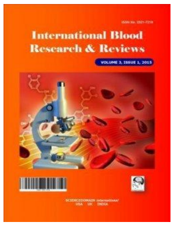

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Relationship between Glucose Level, Lipid Profiles, and Waist to Height Ratio (WHtR)

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Authors' contributions

This work was carried out in collaboration between all authors. Author HAS designed the study, wrote the protocol, and wrote the first draft of the manuscript. Authors AMB and ZNK managed the literature searches, data collection, data entry and data analyses. All authors read and approved the final manuscript.

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ABSTRACT

A cross sectional study was carried out to determine the relationship between glucose level, lipid profiles, and waist to height ratio (WHtR) among adults in a workplace setting. Respondents were recruited from government staff in two ministries, each from the federal territories of Kuala Lumpur and Putrajaya, Malaysia. Socio-demographic information was collected using a set of questionnaire and anthropometric measurement including weight, height, percent body fat, and waist and hip circumference were measured. Antropometric assessments were measured and blood sample was collected in the morning before 10 AM, after the respondents undergone 12 hours of overnight fasting. A fingerpick blood sample was collected to measure blood glucose and lipid profiles. A total of 210 respondents were recruited for this study. The majority of the respondents (81.9%) were aged 34 years and younger. Approximately 16.8% were obese and 25.1% overweight. Based on WHtR, 47.1% of the respondents were classified as having WHtR≥0.5. Based on odds ratio, having a high WHtR (≥0.5) was found to be related to increased risk of having high BMI (OR=18.125; 95% CI 8.583-38.276), high triglyceride (OR=6.202; 95% CI 2.517-15.281), elevated blood pressure (systolic OR=4.351; 95% CI 2.026-9.344, diastolic OR=4.932; 95% CI 1.571-15.484), high blood glucose (OR=3.084; 95% CI 1.186-7.831) and low HDLC (OR=3.506; 95% CI 1.862-6.600). For the

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subjects of this study, WHtR was found to be significantly related to lipid profile and blood glucose level.

Keywords: WHtR; lipid profile; glucose; odds ratio.

1. INTRODUCTION

Obesity is a condition where the body has excessive levels of fat. The relationship between obesity and health risk has been studied by many researchers and it has been established that obesity causes increases in many risk factors. Excess body fat has been shown to be related to several conditions such as diabetes, cardiovascular disease (CVD), dyslipidaemia, hypertension metabolic syndrome, dyslipidaemia, inflammation, thrombosis and certain cancers [1-4].

Several methods can be used to estimate body composition and its relation to disease risk, such as computed tomography, magnetic resonance imaging, dual energy X-ray absorptiometry, and bioelectrical impedance analysis. In large epidemiological studies, Body Mass Index (BMI), waist circumference (WC), waist to hip ratio (WHR) and body fat percentage (%BF) are the most popular indicators used in assessing the relationship between disease risk and body composition. The nature and strength of association between each indicator and risk of disease varies.

Obesity, as measured by BMI, has been reported in many studies to be related to risk of premature death [5], CVD [6], type II diabetes [7] and colon cancer [8]. On the other hand, WC and WHR, indicators of abdominal fat accumulation in the body, are better indicators than BMI for all obesity-related causes of mortality [9]. Among subjects with Coronary Artery Disease, Coutinho et al. [10] reported that WC and WHR is directly associated with mortality, but not BMI.

The relationship between CVD risk and body composition, as represented by BMI, WHR, WC and WHtR classifications, has been described at length in the literature, and the majority of sources suggested central adiposity (WC, WHR & WHtR) to be superior to BMI in predicting CVD risk [11]. A publication by Lee, Huxley, Wildman and Woodward [12] further showed that the best discriminator for hypertension, diabetes, and dyslipidaemia in both sexes is WHtR, as compared to BMI and WC. However, a review paper by Qiao and Nyamdorj [13] surmised that, based on prospective studies, risk of type II diabetes is equally associated with all anthropometric measures of BMI, WC, WHR and the WHtR.

Although there are many comparative studies carried out on the relationship between BMI, WHR, WHtR and WC with the risk of disease, studies reported on WHtR in Malaysia is still limited. Most published studies involving WHtR and its relationship with disease risks were carried out among western populations, and research among people in Asia were focused on populations in Japan, China, Hong Kong, Taiwan, Bangladesh and several Arab countries. Therefore this study was performed to describe waist circumference to height ratio (WHtR) among a sample of government staff in Malaysia, and to assess the relationship between WHtR and health risks, such as lipid profile and glucose level.

2. METHODS AND MATERIALS

2.1 Respondents

The respondents of this study were recruited from one ministry in Putrajaya and another in Kuala Lumpur, Malaysia. Invitation to participate in this study was distributed to all staff in these ministries between 18 to 60 years old, without any physical impairment and not pregnant. All procedures performed were in accordance with the ethical standards and ethical approval to conduct this study was granted from the Medical Research Ethics Committee, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia. All subjects were briefed about the study and signed a consent form to participate in this study.

2.2 Measurements

2.2.1 Questionnaire

A structured questionnaire was used to obtain information on sociodemographic characteristics, such as gender, age, monthly income, education level and work position in the agency. Physical Activity level was measured using the International Physical Activity Questionnaire (IPAQ) Short and Malay version. The IPAQ Scoring Protocol was used to calculate MET/min and classification of physical activity level was made based on IPAQ [14].

2.2.2 Anthropometric measurements and blood pressure

Antropometric assessments were determined and blood sample was collected in the morning (before 10 AM) after the respondents undergone 12 hours of overnight fasting. Anthropometric measurements were carried out, including weight, height, and waist and hip circumference. Height was measured accordingly and followed methods as described by Gibson [15], using a Seca Bodymeter (Model 201, Germany) to the nearest 0.1 cm. Weight and percent body fat were measured using a Tanita Body Fat Analyser (Model 418, Japan) in light clothing and without shoes and socks. To minimize errors in body fat analysis, using a Tanita Body Fat Analyser and via the 8-electrode segmented BIA technique, all measurement procedures as well as subject preparation instructions described in the Tanita Body Composition Analyser BC418 manual, were followed. BMI was calculated automatically by the Tanita Body Fat Analyser and classified based on standards suggested by the World Health Organization [16]. Body fat percentage was classified according to the classifications suggested by the American College of Sports Medicine [17]. Waist (midpoint between the lower margin of the last rib and the top of the iliac crest) and hip (widest portion of the buttocks) circumference were measured to the nearest 0.1 cm with non-stretchable measuring tape. Classification of WC was based on WHO/IASO/IOTF [18] and WHR was calculated as ratio of waist circumference to hip circumference; individuals were classified as having central obesity if WHR≥0.9 for males and ≥0.8 for females, respectively (World Health Organization, 1999 [19]. WHtR was determined from waist circumference (cm) divided by height (cm) and classified according to Ashwell & Hsieh [20], proposing the boundary value of WHtR≥0.5 to indicate increased risk for adult males and females. Blood pressure was measured after 5 minutes of sitting and resting, using an Omron blood pressure monitors (Model HEM-780, Japan).

2.2.3 Biochemical assessments

A capillary blood sample was collected by using a finger prick technique. A total of 30 μl of blood sample was collected using capillary tubes for measurement of blood glucose level. Micro blood collection tubes- K2EDTA were used to collect 0.5 ml of blood from the respondent. The blood sample was centrifuged at 3000 rpm and the resulting plasma sample was used to determine the level of triglyceride (TG) and high density lipoprotein cholesterol (HDLC). Reflotron Test Reagent Strips was used to measure the level of total cholesterol, TG, and HDLC using the Reflotron plus Clinical Chemistry Analyzer (Germany). Low density lipoprotein cholesterol (LDLC) was calculated automatically by the Reflotron plus Chemistry Analyzer based on the Friedewald formula. One of the respondents had a TG concentration >4.5 mmol/l.A standard LDL analysis was performed with an automatic chemical analyser. Blood glucose, lipid profile and blood pressure were classified based on the American Diabetes Association [21], the National Cholesterol Education Program [22] and Ministry of Health Malaysia [23] respectively.

2.3 Statistical Analysis

Data was analyzed using IBM SPSS Statistics version 19. Univariate analysis, including frequency, percentage, mean, and standard deviation, were applied to the sociodemographic, anthropometric, and blood profiles. A t-test was performed to determine the mean difference between two groups, specifically WHtR<0.5 and WHtR≥0.5. The association between variables studies was determined by using Pearson's correlation and odds ratio. An alpha level of 0.05 was set as significant level.

3. RESULTS

A total of 210 respondents were recruited in this study and almost 70% were female respondents. Table 1 showed the distribution of respondents according to sociodemographic characteristics, anthropometric characteristics, blood pressure glucose level, lipid profile and physical activity level. About 60% of the respondents were between 25-35 years of age and about the same proportion had received up to tertiary education (college/university).Mean age of the respondents was 31.18±8.43 years. About one in four respondents was classified as overweight and another 16.8% as obese. Percentages of overweight and obese individuals were higher among males, as compared to females. More than 70% of the respondents were classified as having high body fat percentage and high risk, as classified by waist to hip classification. About one in four respondents had elevated blood pressure (classified as systolic blood pressure ≥135 mmHg and/or diastolic blood pressure ≥85 mmHg).

Approximately 11.8% of the respondents exhibited elevated blood glucose and the percentage was higher among males as compared to females. Similar trends were observed for total cholesterol, triglyceride and LDLC, but with different percentages. The percentage of respondents classified as having high total cholesterol was almost the same for males (7.4%) and females (8.3%) in this study. Low HDLC was more prevalent among females (39%), as compared to males (3.8%). About one third of the respondents were sedentary, more so among females than males. Central obesity, as classified as WHtR≥0.5, was more prevalent among males (67.2%) than females (38.2%).

Table 2 showed distribution, mean, and standard deviation of WHtR, according to socio-demographic and anthropometric characteristics, blood pressure, blood glucose level, lipid profile and physical activity level. Mean WHtR was significantly higher among males compared to females, as well as among older compared to younger, but not significantly different in terms of occupational status. Mean WHtR was also significantly higher among respondents with elevated blood pressure and significantly higher among respondents with elevated total cholesterol, triglyceride and LDLC. WHtR was significant lower among respondents with HDLC ≥1.03 mmol/l as compared to groups with HDLC <1.03 mmol/l. There was no significant difference in mean WHtR between sedentary and non-sedentary respondents ($p>0.05$).

WHtR and BMI were moderately correlated with percent body fat and blood pressure. Correlation between WHtR and BMI with lipid profiles and blood glucose were weak but significant. WHtR and BMI were not significantly correlated with physical activity level of the respondent. Based on odds ratio, having high WHtR was found to be related to increased risk of having high blood glucose, triglyceride, blood pressure, and low HDLC. For lipid profile and blood glucose, odds ratio of having high blood glucose and low HDLC were three times higher among respondent with WHtR≥0.5, compared to respondent with WHtR <0.5. The highest odds ratio among lipid profiles was odds of having high triglyceride, which was equal to 6.2 among respondents with WHtR≥0.5 as compared to respondents with WHtR<0.5. Odds of having elevated systolic and diastolic blood pressure were 4 times higher among respondents with WHtR≥0.5 compared to respondents with WHtR<0.5. Based on calculated odds ratio, percent body fat was not significantly related to WHtR.

4. DISCUSSION

Ashwell and Hsieh [20] suggested that the waist-to-height ratio (WHtR) is more useful for assessing health risk than BMI for several reasons, such as WHtR is more sensitive, cheaper, and easier to measure and calculate than BMI. Further, a cut off value of WHtR≥0.5 indicates increased risk for both males and females across ethnic and population groups. WHtR may also allow the same cut off values for children, adolescents and adults.

In this study, the mean WHtR was significantly higher among male respondents, and the percentage of respondent with WHtR≥0.5 was higher among males as compared to females. This is in line with BMI results that showed that the percentages of overweight and obesity (BMI ≥25 kg/m^2) were higher among males as compared to females. The mean WHtR was significantly higher among older respondents as compared to younger ones, but not significantly different between work positions (professional vs. non-professional). These results contradict those of a study conducted by Flora et al. [24] in Bangladesh, which found that females had a higher risk of having a WHtR greater than males (OR = 7.898; 95% CI 7.110-8.774). However, our study was in agreement with this study in terms of the risk of having high WHtR was higher among the older than the young. However, in terms of employment, Flora et al. [24] showed that the risk was higher among the professional and business people compared to other fields of work.

The prevalence of overweight and obesity among adults in Malaysia, based on the latest National Health and Morbidity Survey of 2011, was 44.5% (females 45.4% vs. males 43.6%), and abdominal obesity was also higher among females (54.1%) than males (37.4%) [25]. A study among 1,530 respondents in one state in Malaysia showed that WHR also followed a similar trend (females 76.3% vs. males 49.5%) [26]. In this study, based on BMI, obesity and overweight occurred more frequently in males than in females. Whereas, based on waist circumference, the prevalence of abdominal obesity also showed similar trend. In contrast, based on fat percentages, prevalence of high body fat was lower (17.2%) among males compared to females (93.9%). Each of the indices of obesity projected differences in prevalence, even though all are clustered as obesity indices. Differences in prevalence, as shown above, indicated that each indicator used in assessing obesity and its relationship with disease risk is unique and may differ in terms of its role and association in the prediction of disease. This requires researchers to conduct further studies to identify the most sensitive and accurate indicators related to risk of chronic diseases, such as diabetes and CVD.

Table 1. Distribution of respondents according to sociodemographic and anthropometric characteristics, blood pressure, blood glucose level, lipid profile and physical activity level

	Male n (%)	**Female n (%)**	**Total n (%)**
Sex	64 (30.5)	146 (69.5)	210 (100)
Age (years)			
<25	13 (20.3)	37 (25.3)	52 (23.8)
25-34	37 (57.8)	85 (58.2)	122 (58.1)
35-44	7 (10.9)	8 (5.5)	15 (7.1)
>44	7 (10.9)	16 (11.0)	23 (11.0)
Education level			
Primary school	3 (4.7)	18 (12.3)	21 (10.0)
Secondary school	12 (18.8)	23 (15.8)	35 (16.6)
Upper Secondary School	7 (10.9)	15 (10.3)	22 (10.5)
Collage/ University	42 (65.6)	90 (61.6)	132 (62.9)
Occupation			
Non-professional	44 (68.8%)	99 (67.8%)	143 (68.1%)
Professional	20 (31.3%)	47 (32.2%)	67 (31.9%)
BMI (kg/m^2)			
Underweight (<18.5)	1 (1.7)	11 (8.3)	12 (6.3)
Normal Weight (18.5-24.9)	24 (41.4)	75 (56.4)	99 (51.8)
Overweight (25-29.9)	19 (32.8)	29 (21.8)	48 (25.1)
Obese (≥30)	14 (24.1)	18 (13.5)	32 (16.8)
Fat Percentage			
Normal (male<25%/ female <32%)	48 (82.8)	8 (6.1)	56 (29.6)
High (male ≥25%/ female ≥32%)	10 (17.2)	123 (93.9)	133 (70.4)
Waist circumference (cm)			
Normal (<90 for male or <80 for female)	31 (53.4)	88 (67.2)	119 (63.0)
High risk (≥ 90 for male or ≥80 for female)	27 (46.6)	43 (32.8)	70 (37.0)
WHR			
Normal (<0.9 form male and <0.80 for female)	36 (62.1)	109 (83.2)	145 (76.7)
High risk (≥0.9 form male and ≥0.80 for female)	22 (37.9)	22 (16.8)	44 (23.3)
Systolic blood pressure (mmHg)			
Normal (<135)	32 (55.2)	114 (87.7)	146 (77.7)
Elevated (≥135)	26 (44.8)	16 (12.3)	42 (22.3)
Diastolic blood pressure (mmHg)			
Normal (<85)	50 (86.2)	120 (91.6)	170 (89.9)
Elevated (≥85)	8 (13.8)	11 (8.4)	19 (10.1)
Systolic blood pressure ≥135 mmHg and/or diastolic blood pressure ≥85mmHg			
Normal blood pressure	32 (58.2%)	110 (84.6%)	142 (76.8%)
Elevated blood pressure	23 (41.8%)	20 (15.4%)	43 (23.2%)
Total glucose (mmol/l)			
<5.6	44 (80.0)	113 (91.9)	157 (88.2)
5.6-6.9	8 (14.5)	8 (6.5)	16 (9.0)
>6.9	3 (5.5)	2 (1.6)	5 (2.8)
Total cholesterol (mmol/l)			
<5.17	36 (66.7)	80 (66.7)	116 (66.7)
5.17-6.19	14 (25.9)	30 (25.0)	44 (25.3)
>6.19	4 (7.4)	10 (8.3)	14 (8.0)
Triglyceride (mmol/l)			

	Male n (%)	Female n (%)	Total n (%)
<1.69	31 (58.5)	103 (89.6)	134 (79.8)
1.69-2.25	18 (34.0)	7 (6.1)	25 (14.9)
2.26-5.64	4 (7.5)	5 (4.3)	9 (5.4)
>5.64	-	-	-
LDLC (mmol/l)			
<2.59	11 (22.0)	43 (37.4)	54 (32.7)
2.59-3.35	20 (40.0)	46 (40.0)	66 (40.0)
3.36-4.13	12 (26.0)	17 (14.8)	30 (18.2)
4.14-4.90	2 (4.0)	8 (7.0)	10 (6.1)
>4.90	4 (8.0)	1 (0.9)	5 (3.0)
HDLC (mmol/l)			
>1.54	20 (37.7)	54 (45.8)	74 (43.3)
1.03-1.54	2 (3.8)	46 (39.0)	48 (28.1)
<1.03	31 (58.5)	18 (15.3)	49 (28.7)
Physical Activity Level (IPAQ)			
Sedentary	13 (21.7)	55 (39.0)	68 (33.8)
Moderate	26 (43.3)	63 (44.7)	89 (44.3)
High	21 (35.0)	23 (16.3)	44 (21.9)
WHtR			
<0.5	19 (32.8)	81 (61.8)	100 (52.9)
≥0.5	39 (67.2)	50 (38.2)	89 (47.1)

Based on previous studies, diabetes, hypertension, high total cholesterol, high triglycerides, and low HDL-cholesterol can be predicted by WHtR significantly better than by BMI or WC Li et al. [27]. Among Americans, non-Hispanic Whites and non-Hispanic Blacks, WHtR was associated with higher odds of type 2 diabetes compared to the odds of having type 2 diabetes based on WC. These results were in line with a study among adults in Taiwan that reported the adjusted ORs for any CVD risk factors in male and female are highest when assessed using WHtR as a filter, followed by WC, BMI, then WHR, respectively, and all are statistically significant (p<0.001) for both genders [28]. A study by Ashwell, Gunn and Gibson [29] also reported the results of discriminatory power analysis of BMI, WC, and WHtR data in differentiating adults with type-2 diabetes, dyslipidaemia, hypertension, metabolic syndrome and general CVD outcomes, clearly showing that WHtR had significantly greater discriminatory power compared with WC and BMI.

However, other meta-analysis, focused on hypertension, concluded that BMI, WHR, WC, or WHtR were not systematically better than others at the discrimination of hypertension [30]. On the other hand, Liu et al. [31] reported that among 772 Chinese adult subjects, BMI, waist circumference and WHtR may equally predict multiple metabolic risk factors, such as blood pressure (systolic and diastolic blood pressure) and dyslipidaemia (triglyceride, HDL-C and plasma glucose). The relationship between WHtR, BMI, WC, and WHR with disease risk is still unclear; some of the studies found WHtR to be the best predictor compared to others, while other studies showed different results.

In our study, mean values of blood pressure, glucose level, and lipid profiles were higher among respondents with WHtR≥0.5, except for HDLC, which showed different results from expected. All of these factors were statistically significant. Results of this study showed that odds ratio of having high fasting glucose, triglyceride, systolic and diastolic blood pressure, and low HDLC were significantly higher among respondent with WHtR≥0.5 as compared to respondent with WHtR<0.5. Our study did not assess odds ratio of those risk factors with BMI, WHR, and WC, and therefore we could not compare the relationship between risk factors with studies measuring other indicators of obesity (WC, WHR, BMI).

Table 2. Mean, and standard deviation of waist to height ratio (WHtR), according to sociodemographic characteristics, anthropometric characteristics, blood pressure, blood glucose level, lipid profile, and physical activity level

	Mean	SD	p-value
Sex			
Male	0.540	0.080	.000
Female	0.497	0.064	
Age (year)			
<30	0.496	0.068	.001
≥30	0.533	0.073	
Occupation			
Non-professional	0.508	0.072	.516
Professional	0.515	0.072	
BMI (kg/m^2)			
Underweight & Normal Weight (<25)	0.468	0.040	.000
Overweight & Obese (≥25)	0.570	0.065	
Fat Percentage			
Normal (<25% for male/ < 32% for female)	0.500	0.063	.207
High (≥25% for male/ ≥32% for female)	0.514	0.076	
Systolic Blood Pressure (mmHg)			
Normal (<135)	0.495	0.065	.000
Elevated (≥135)	0.561	0.076	
Diastolic Blood Pressure (mmHg)			
Normal (<85)	0.503	0.069	.000
Elevated (≥85)	0.572	0.074	
Systolic blood pressure ≥135 mmHg and/or diastolic blood pressure ≥85 mmHg			
Normal blood pressure	0.493	0.063	0.00
Elevated blood pressure	0.563	0.078	
Total Cholesterol (mmol/l)			
<5.17	0.500	0.063	.033
≥5.17	0.526	0.081	
Total glucose (mmol/l)			
<5.6	0.501	0.066	.001
≥5.6	0.555	0.080	
Triglyceride (mmol/l)			
<1.69	0.496	0.064	.000
≥1..69	0.569	0.078	
LDLC (mmol/l)			
<2.59	0.490	0.066	.010
≥2.59	0.520	0.071	
HDLC (mmol/l)			
≥1.03	0.534	0.076	.000
<1.03	0.488	0.059	
Physical Activity Level (IPAQ)			
Sedentary	0.499	0.067	.180
Moderate & Active	0.514	0.074	

Table 3. Correlation between glucose level, lipid profile, selected anthropometric indicators, blood pressure, physical activity level, with waist to height ratio (WHtR) and body mass index (BMI)

	Correlation (WHtR)	Correlation (BMI)
Percent body fat	0.538*	0.638*
Systolic blood pressure	0.509*	0.465*
Diastolic blood pressure	0.378*	0.402*
Triglyceride	0.396*	0.420*
HDLC	-0.384*	-0.430*
LDLC	0.254*	0.242*
Glucose level	0.186*	0.218*
Total cholesterol	0.174*	0.149*
Physical activity level	0.079	0.104

$p<0.05$

Table 4. Relationship between glucose level, lipid profile, selected anthropometric indicators, blood pressure, physical activity level, and waist to height ratio (WHtR).

	Odds ratio	Low	High
Percent body fat	0.752	0.402	1.408
Systolic blood pressure	4.351*	2.026	9.344
Diastolic blood pressure	4.932*	1.571	15.484
Triglyceride	6.202*	2.517	15.281
HDLC	3.506*	1.862	6.600
LDLC	1.742	0.892	3.399
Glucose level	3.084*	1.186	7.831
Total cholesterol	1.843	0.973	3.488
Elevated blood pressure	4.162*	1.970	8.792
Physical activity level	0.839	0.452	1.556

$p<0.05$

This study was cross sectional in nature and subjected to the limitations of cross sectional design. Limited sample size and sampling procedure suggested that the results of this study should not be generalized to others, but only respondents in this study. The uniqueness of our study is that we have shown that obesity prevalence as assessed by BMI, WHtR, WHR, and WC have portrayed differences as predictors. However, there is still uncertainty about which indicators are most sensitive and accurate among the population studies in relation to the disease risk, especially for chronic diseases.

5. CONCLUSION

About half of the respondents in this study were classified as high risk, based on WHtR as an indicator. The prevalence was higher among males compared to female respondents. The relationships between WHtR and lipid profile as well as fasting blood glucose were significant. Therefore, the results of the present study have supported the utility of the WHtR in relation to disease risk, specifically as they relate to lipid profiles and blood glucose.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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