

Short Research Article

RELATIONSHIP BETWEEN GLUCOSE LEVEL, LIPID PROFILES, AND WAIST TO HEIGHT RATIO (WHtR)

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. Sociodemographic information was collected using a set of questionnaire and anthropometric measurement including weight, height, percent body fat, and waist and hip circumference were measured. A fasting 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 $WHtR \geq 0.5$. 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 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*

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

27 to several conditions such as diabetes, cardiovascular disease (CVD), dyslipidaemia,
28 hypertension metabolic syndrome, dyslipidaemia, inflammation, thrombosis and certain
29 cancers [1-4].

30

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

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

45

46 The relationship between CVD risk and body composition, as represented by BMI, WHR,
47 WC and WHtR classifications, has been described at length in the literature, and the majority
48 of sources suggested central adiposity (WC, WHR & WHtR) to be superior to BMI in
49 predicting CVD risk [11]. A publication by Lee, Huxley, Wildman and Woodward [12]
50 further showed that the best discriminator for hypertension, diabetes, and dyslipidaemia in
51 both sexes is WHtR, as compared to BMI and WC. However, a review paper by Qiao and

52 Nyamdorj [13] surmised that, based on prospective studies, risk of type II diabetes is equally
53 associated with all anthropometric measures of BMI, WC, WHR and the WHtR.

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

63

64 **Methods and Materials**

65 *Respondents*

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

72

73 *Measurements*

74 *Questionnaire*

75 A structured questionnaire was used to obtained information on sociodemographic
76 characteristics, such as gender, age, monthly income, education level and work position in the

77 agency. Physical Activity level was measured using the International Physical Activity
78 Questionnaire (IPAQ) Short and Malay version. The IPAQ Scoring Protocol was used to
79 calculate MET/min and classification of physical activity level was made based on IPAQ
80 [14].

81

82 *Anthropometric measurements and blood pressure*

83 Anthropometric measurements were carried out, including weight, height, and waist and hip
84 circumference. Height was measured by using a Seca Bodometer (Model 201, Germany) to
85 the nearest 0.1 cm. Weight and percent body fat were measured using a Tanita Body Fat
86 Analyser (Model 418, Japan) in light clothing and without shoes and socks. BMI was
87 calculated automatically by the Tanita Body Fat Analyser and classified based on standards
88 suggested by the World Health Organization [15]. Waist and hip circumference were
89 measured to the nearest 0.1cm with non-stretchable measuring tape. Classification of WC
90 was based on WHO/IASO/IOTF [16] and WHR was calculated as ratio of waist
91 circumference to hip circumference; individuals were classified as having central obesity if
92 $WHR \geq 0.9$ for males and ≥ 0.8 for females, respectively (World Health Organization, 1999
93 [17]. WHtR was classified according to Ashwell & Hsieh [18], proposing the boundary value
94 of $WHtR \geq 0.5$ to indicate increased risk for adult males and females. Blood pressure was
95 measured after 5 minutes of sitting and resting, using an Omron blood pressure monitor
96 (Model HEM-780, Japan).

97

98 *Biochemical assessments*

99 A capillary blood sample was collected in the morning (before 10 AM) after the respondents
100 undergone 12 hours of overnight fasting by using a finger prick technique. A total of 30 μ l of
101 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 and HDLC. Reflotron Test Reagent Strips was used to measure the level of total cholesterol, triglyceride, and high density lipoprotein cholesterol (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. Blood glucose and lipid profile was classified based on the American Diabetes Association [19] and the National Cholesterol Education Program [20] respectively.

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.

Results

A total of 210 respondents were recruited in this study and almost 70% were female respondents. Table I 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 sociodemographic 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 was highly correlated with BMI, but only moderately correlated with percent body fat and blood pressure. Correlation between WHtR with lipid profiles and blood glucose was weak but significant. WHtR was 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, BMI, 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 $WHtR \geq 0.5$, 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 $WHtR \geq 0.5$ as compared to respondents with $WHtR < 0.5$. Odds of having elevated systolic and diastolic blood pressure were 4 times higher among respondents with $WHtR \geq 0.5$ compared to respondents with $WHtR < 0.5$. Odds of having $BMI \geq 25 \text{ kg/m}^2$ was 18.125 among respondents with $WHtR \geq 0.5$ compared to respondents with $WHtR < 0.5$. Based on calculated odds ratio, percent body fat was not significantly related to WHtR.

Discussion

Ashwell and Hsieh [18] 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 $WHtR \geq 0.5$ 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 $WHtR \geq 0.5$ was higher among males (67.2%) as compared to females (38.2%). This is in line with BMI results that showed that the percentages of

overweight and obesity ($\text{BMI} \geq 25 \text{ kg/m}^2$) 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.* [21] in Bangladesh, which found that females had a higher risk of having a WHtR greater than males ($\text{OR} = 7.898$; 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.* [21] showed that the risk was higher among the professional and business people compared to other fields of work.

In this study, based on BMI, obesity and overweight occurred in 56.9% of males and 34.3% of female respondents. Whereas, based on waist circumference, the prevalence of abdominal obesity was 46.6% among males and 32.8% among females. In contrast, based on fat percentages, prevalence of high body fat was 17.2% among males and 93.9% among females. 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.

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.*, [22]. 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 [23]. A study by Ashwell, Gunn and Gibson [24] 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 [25]. On the other hand, Liu *et al.* [26] 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 $WHtR \geq 0.5$, 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 $WHtR \geq 0.5$ 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).

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.

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.

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- 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 (<80 for female or <90 for male)	31 (53.4)	88 (67.2)	119 (63.0)
High risk (≥80 for female or ≥ 90 for male)	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)

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	Male n(%)	Female n(%)	Total n(%)
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)			
<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)
Active	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)

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 ≥85mmHg			
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 :Relationship between glucose level, lipid profile, selected anthropometric indicators, blood pressure, physical activity level, and waist to height ratio (WHtR).

	Correlation	Odds Ratio	Low	High
Body Mass Index	0.888*	18.125*	8.583	38.276
Percent Body Fat	0.538*	0.752	0.402	1.408
Systolic Blood Pressure	0.509*	4.351*	2.026	9.344
Diastolic Blood Pressure	0.378*	4.932*	1.571	15.484
Triglyceride	0.396*	6.202*	2.517	15.281
HDLC	-0.384*	3.506*	1.862	6.600
LDLC	0.254*	1.742	0.892	3.399
Glucose Level	0.186*	3.084*	1.186	7.831
Total Cholesterol	0.174*	1.843	0.973	3.488
Elevated Blood Pressure	-	4.162*	1.970	8.792
Physical Activity Level	0.079	0.839	0.452	1.556

*p<0.05