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The utilization of BMI in patients with high WHtR as to cardiovascular risk

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ABSTRACT

Introduction: A waist to height ratio (WHtR) greater than 0.5 may be a global screening tool for cardiovascular disease (CVD) and diabetes. However, it is unclear whether WHtR could be used instead of BMI. This study aimed to evaluate the role of BMI regarding CVD and diabetes in a subset of Turkish adults with WHtR greater than 0.5.

Material and Method: The cross-sectional study involved 118 participants with WHtR>0.5, 18 years and older who applied to the endocrinology and metabolism disease outpatient clinic between September 2019 and February 2020. WHtR and BMI were calculated.

Results: The prevalence of hypertension and hyperlipidemia increased with BMI. WHtR was correlated with FBG. BMI was significantly associated with TG, HDL-c, SBP, and DBP in linear regression analysis, but not with FBG. On the other hand, there was a significant association between WHtR and FBG.

Conclusion: This study confirmed that the simple value of '0.5' for WHtR was associated with diabetes risk. The cut-off value of 35 for BMI was effective categorizing participants with high blood pressure and lipid levels in paticipants with high WHtR. Further population-based studies in Turkish adults are needed to evaluate whether WHtR could be used independent from BMI as an early warning of cardiovascular risks for preventive interventions.

Keywords: Body mass index, waist to height ratio, obesity, cardiovascular risk

INTRODUCTION

The prevalence and incidence of obesity have increased and tripled since 1975. In 2016, 39% of adults were overweight, and 13% were obese. Turkey had the highest prevalence of obesity in Europe in 2016, according to the World Health Organization (WHO) (1). Compared with TURDEP-I, the prevalence of obesity increased by 40% in TURDEP-II among Turkish adults within twelve years and reached to 32% (2,3). Obesity is defined as an excessive fat collection that might damage health and is diagnosed at a body mass index (BMI) ≥30 kg/m^2 (4). Increased BMI is a significant risk factor for cardiovascular diseases, diabetes, musculoskeletal disorders, and cancers (5-7). The World Obesity Federation has stated obesity as a chronic progressive disease, instead of a significant risk factor for other non-communicable diseases (8).

BMI has been used for the diagnosis of obesity. However, recently marks of abdominal obesity (waist-hip ratio [WHR] and waist circumference [WC]) have increasingly been related to higher cardiometabolic risk than BMI. In the mid-1990s, the waist to height ratio (WHtR) was first proposed for detecting abdominal obesity and associated health risks (9-11). It has been suggested that WHtR greater than 0.5 may be a global screening tool for cardiovascular disease and diabetes (12). In 73% of the studies, WHtR revealed a significant correlation between anthropometric indexes and cardiometabolic risk. That was greater than that for BMI (66%) and WC (64%) (12). So, the health message 'keep your WC to less than half your height' is disclosed (13). This boundary value is useful in many populations, and WHtR is supported as a simple and effective anthropometric index for identifying health risks (6,14,15). In recent guidance of The National Institute for Health and Care Excellence (NICE), waist circumference has been advised to be used in addition to BMI in people with a BMI less than 35 kg/m^2 (16). The UK National Diet and Nutrition Survey data show

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that a simple boundary value for WHtR (0·5) is more beneficial to identify more people at 'early health risk' than the combination of BMI and WC within the adult UK population (17). So, a new section was published as 'Identification and classification of overweight and obesity' by NICE (18). Related to its previous clinical guidance on obesity (CG189), this remarks new evidence and expert feedback showing the superior discriminatory benefit of WHtR as an alternate measure of adiposity (18).

It is unclear whether WHtR could be used instead of BMI, especially in different populations. A cut-off point of '0.5' was recommended for categorizing WHtR to predict people at high cardiovascular risk for preventive actions in Turkish adults (19).

This study aimed to evaluate the role of BMI regarding cardiovascular disease (CVD) and diabetes in a subset of Turkish adults with WHtR greater than 0.5.

MATERIAL AND METHOD

The study protocol was approved by the Clinical Researches Ethics Committee of the Marmara University Medical School (Date: 07.05.2021, Decision No: 09.2021.580). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Participants

Data on 118 adult subjects, 82 (69.5%) women and 36 (30.5%) men who applied to the endocrinology and metabolism disease outpatient clinic were evaluated between September 2019 and February 2020. Subjects under 18-year-old, pregnant, or with a chronic disease that might alter the body composition or metabolic condition (e.g., hypothalamic disease, chronic hepatitis, and cirrhosis) were eliminated from the analysis. All the subjects had central obesity with WHtR ≥0.5, as it was suggested as a universal cut-off (17). Participants were divided into two groups; BMI less than 35 kg/m^2 and BMI more than 35 kg/m^2.

Anthropometric Measurements

Height was measured as stood erect, barefoot, with feet together, while looking forward. Weight was measured with an automatic scale as subjects wore light clothes. BMI was calculated by dividing weight in kg by height in meters squared (kg/m^2). WC was measured at the midpoint between the rib cage's lower border and the iliac crest at the end of expiration (20). WHtR was calculated by dividing WC by height, and the cut-off of 0.5 was used for WHtR (13). Blood pressure (BP) was measured after 10-min of rest as seated using a standard sphygmomanometer placed on the subject's right arm. Blood samples were taken in the morning after at least 8 hours fasting. Fasting blood glucose (FBG), total cholesterol, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-c) levels were measured enzymatically. Serum insulin was measured using chemiluminescent immunoassays. Hemoglobin A1C (HbA1c) was determined by an ion-exchange HPLC method. Homeostasis model assessment of insulin resistance (HOMA-IR) was calculated. Hypertension was described as systolic BP (SBP) ≥130 mmHg or diastolic BP (DBP) ≥85 mmHg. Hyperglycemia was described as fasting glucose ≥100 mg/dL, and hypertriglyceridemia was described by fasting triglyceride level ≥150 mg/dL. Decreased HDL-c was described by a level of < 40 mg/ dL for man and and of < 50 mg/dL for woman (21,22).

Statistical Analyses

All analyses were performed using commercial statistical software (version 22.0; IBM SPSS). Descriptive statistics were given as mean and standard deviation for continuous data , and percentages and frequency for categorical data. Continuous variables were analyzed for homogeneity of variance using the Kolmogorov-Smirnov test, and those with normal distribution were analyzed with the t-test. In contrast, those with uneven distribution were analyzed with the Mann-Whitney U test. The Chi-square test or Fisher's exact test analyzed categorical data. The correlation between anthropometric indices and cardiometabolic risk factors analyzed with Pearson's correlation coefficients. The determinants of BMI and WHtR were evaluated by performing a sex-and age-adjusted linear regression analysis.

RESULTS

The characteristics of the patients and the prevalence of cardiovascular risk factors, according to gender, are shown in **Table 1**. The mean age was 43.4 years in both men and women, and the mean BMI was 35.7±5.8 kg/m^2 in women and 35.5±6.7 kg/m^2 in men (p: 0.90). The mean WC was 107.9±11.3 cm in women and 115.1±13.1 cm in men (p:0.003), and the mean WHtR was 0.67±0.07 in women and 0.65±0.07 in men (p:0.29). The percentage of diabetes mellitus (p:0.29), hypertension (p:0.66) , hyperlipidemia (p:0.15), and coronary heart disease (CHD) (p:0.27), did not differ according to gender. Triglyceride levels were higher in men than women but were not statistically significant (p:0.07). The percentage of hypothyroidism is significantly higher in women than men (p:0.04).

Table 2 summarizes the clinical characteristics of patients grouped by BMI. In patients with BMI>35, the prevalence of hypertension and hyperlipidemia were higher than patients with BMI<35 (p:0.001; p:0.04, respectively). Also, SBP and DBP were higher in this group (p:0.001, p:0.02, respectively). FBG, insulin, and HbA1c did not differ according to BMI, and HOMA-IR was also similar between the groups. FBG, insulin, HbA1c, and HOMA-IR were high in both BMI groups, indicating the association between WHtR and diabetes risk independent from BMI.

Table 1. Clinical and cardiometabolic characteristics of the patients according to gender

	WOMEN (n=82)	MEN (n=36)	P Value
Age (years)	43.4±12.5	43.2±12.1	0.94
BMI (kg/m^2)	35.7±5.8	35.5±6.7	0.90
WC (cm)	107.9±11.3	115.1±13.1	0.003
WHtR	0.67±0.07	0.65±0.07	0.29
SBP (mmHg)	129.7±18.8	131.8±13.8	0.55
DBP (mmHg)	79.1±13.4	83.1± 8.7	0.10
FBG (mg/dl)	130.06±67.85	129.65±52.06	0.97
Insulin (mg/dl)	17.67±7.01	19.02±8.25	0.36
HOMA-IR	5.03±3.08	5.81±3.08	0.20
HbA1c	6.4±1.7	6.6±1.6	0.54
TC (mg/dl)	204.85±48.38	218.7±54.7	0.17
TG (mg/dl)	170.7±183.1	263.4±382.4	0.07
HDL-C (mg/dl)	49.6±11.4	48.7±25.3	0.80
LDL-C (mg/dl)	124.2±40.2	126.5±45.7	0.78
Diabetes mellitus, n (%)	27 (32.9%)	16 (44.4%)	0.29
Hypertension, n (%)	24 (29.3%)	12 (33.3%)	0.66
Hyperlipidemia, n (%)	28 (34.1%)	18 (50%)	0.15
CHD, n (%)	6 (7.3%)	5 (13.0%)	0.27
Hypothyroidism, n (%)	19 (23.8%)	3 (8.3%)	0.04

Values are means±SD or n (%). P values are from t-tests or chi-square tests for analysis of variance for continuous variables and categorical variables.
BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; FBG, fasting blood glucose; HOMA-IR, Homeostasis model assessment of insulin resistance; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low- density lipoprotein cholesterol. CHD, coronary heart disease

The correlation coefficients between BMI and TG, SBP, and DBP were statistically significant. The correlation between BMI and HDL-c was also significant but represented minor magnitude (**Table 3**). WHtR was correlated with FBG, and WHtR was also significantly correlated with SBP with a lesser degree than BMI (**Table 4**).

On linear regression analysis adjusted for age and gender, BMI was significantly associated with TG (p:0.004), HDL-c (p:0.014), SBP (p:0.003), DBP (p:0.007) but not with FBG (p:0.07) (**Table 5**). On the other hand, there was a significant association betweeen WHtR and FBG (p:<0.001) on linear regression analysis adjusted for age and gender. WHtR was also associated with TG, HDL-c, SBP, DBP (p:<0.001) (**Table 6**).

Table 2. Clinical and cardiometabolic characteristics of the patients according to BMI

BMI	>35 (n=59)	<35 (n=59)	P Value
AGE	44.4±13.2	42.2±11.4	0.34
No. of male/female	17/42	19/40	0.6
BMI (kg/m^2)	40.4±4.7	30.9±2.6	<0.001
WC (cm)	117.9±10.8	102.3±8.2	<0.001
WHtR	0.72±0.65	0.61±0.04	<0.001
SBP (mmHg)	135.4±18.5	125.3±14.7	0.001
DBP (mmHg)	82.8±14.1	77.8±9.6	0.02
FBG (mg/dl)	129.6±68.5	130.2±58	0.95
İnsulin (mg/dl)	19.5±7.5	16.6±6.9	0.03
HOMA-IR	5.3±2.9	5.2±3.2	0.86
HbA1c	6.5±1.6	6.4±1.7	0.88
TC (mg/dl)	211.7±56.7	206.4±43.9	0.57
TG (mg/dl)	234.5±345.3	163.5±130.2	0.14
HDL-C (mg/dl)	47.9±16.6	50.7±16.9	0.35
LDL-C (mg/dl)	124.7±40.6	125.1±43.3	0.96
TSH	2.3±1	2.6±1.9	0.36
Diabetes mellitus, n (%)	23 (39%)	20 (33.9.%)	0.56
Hypertension, n (%)	26 (44.1%)	10 (16.9%)	0.001
Hyperlipidemia, n (%)	28 (47.5%)	18 (30.5%)	0.04
CHD, n (%)	5 (8.5%)	6 (10.2%)	0.50
Hypothyroidism, n (%)	14 (24.1%)	8 (13.8%)	0.11

Values are means±SD or n (%). P values are from t-tests or chi-square tests for analysis of variance for continuous variables and categorical variables.
BMI, body mass index; WC, waist circumference; WHtR, waist-to-height ratio; FBG, fasting blood glucose; HOMA-IR, Homeostasis model assessment of insulin resistance; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; LDL-C, low- density lipoprotein cholesterol; CHD, coronary heart disease

Table 3. Correlation coefficients between BMI and cardiovascular risk factors

	Correlation coefficient	P Value
FBG	0.049	0.50
TG	0.231	0.007
HDL-C	-0.191	0.028
SBP	0.287	0.001
DBP	0.231	0.007

FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; BMI, body mass index

Table 4. Correlation coefficients between WHtR and cardiovascular risk factors

	Correlation coefficient	P Value
FBG	0.190	0.029
TG	0.088	0.316
HDL-C	-0.118	0.175
SBP	0.272	0.002
DBP	0.170	0.05

FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; BMI, body mass index

Table 5. Independent determinants of BMI on linear regression analysis adjusted for age and gender

	Adjusted R^2	P Value
FBG	0.030	0.074
TG	0.076	0.004
HDL-C	0.057	0.014
SBP	0.080	0.003
DBP	0.068	0.007

FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; BMI, body mass index

Table 6. Independent determinants of WHtR on linear regression analysis adjusted for age and gender:

	Adjusted R^2	P Value
FBG	0.120	<0.001
TG	0.121	<0.001
HDL-C	0.120	<0.001
SBP	0.137	<0.001
DBP	0.129	<0.001

FBG, fasting blood glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TG, triglycerides; HDL-C, high-density lipoprotein cholesterol; BMI, body mass index

DISCUSSION

WHtR, an indicator of abdominal obesity, is accepted as a superior tool for establishing obesity-related cardiovascular risk than BMI. However, alterations in measurement levels (23), different cut-off values among gender and between various ethnic groups (24) and the possibility of wrong measurements by physicians may limit its effectiveness (10). The present study used the simple value of 0.5 for WHtR as a cut-off point associated with diabetes risk. The cut-off value of 35 for BMI was effective categorizing participants with high blood pressure and lipid levels in paticipants with high WHtR.

Many studies confirm the superiority of WHtR compared to other indices; nevertheless, the optimal cut-off point is controversial (19). One study showed that 0.55 was the optimal cut-off point for both sexes (19). Another study from Turkey recommended the optimal cut-off point for Turkish adults as 0.59 (25). Some studies from different populations that recommend 0.5 as the optimal cut-off point. In two different studies on Chinese adults, 0.5 was the optimal cut-off point (26,27), similar to a study performed in Iran (28). A review that considers anthropometric indices across fourteen countries, 0.5 as an optimal boundary was recommended (12).

Among Turkish adults, a cut-off point of '0·5' for WHtR can be useful to categorize people at high cardiovascular risk for preventive actions. WHtR persisted significantly associated with the risk of CHD even after adjusting for age, sex, and BMI (19). The interaction between BMI and WHtR was also evaluated in this study. The odds ratios of high WHtR in assessing cardiovascular risk were classified according to BMI. High WHtR was significantly correlated to cardiovascular risk in each BMI category. There was no interaction between BMI and WHtR (19). In contrast, we found a positive correlation between BMI and high blood pressure.

Two extensive prospective studies from the USA have shown that WHtR is better than BMI in predicting diabetes risk (29) in all adult age groups. Similar results have been found in Korea (30).

In Japan, 6141 men and 2137 women took part in a study in which hypertension, elevated blood glucose, elevated TG, and reduced HDL-c were evaluated as coronary risk factors. Participants with two or more risk factors were classified as high risk. WHtR showed the highest correlation, and BMI showed the lowest correlation with coronary risk factors for both genders. Additionally, WHtR showed larger area under a receiver operating characteristic (ROC) curve (31) for identifying any coronary risk factors in this study. Furthermore, because of the balance between sensitivity and specificity in the discovery of coronary risk factors and the importance of assessing people with higher via simple measurements, WHtR > 0.5 may be the most effective anthropometric index for Japanese adults for determination of public health action (32).

In a study from Turkey, 571 men (34 %) and 1121 women (66 %) participated in which the best anthropometric index for predicting cardiometabolic risk factors in Turkish adults was investigated. It was found that WHtR was the best indicator for predicting most of the cardiometabolic risk factors. The study confirmed WHtR as a better anthropometric index to predict most cardiometabolic risk factors. Although a little difference was found between BMI, WC and WHtR considering CVD risk factors in correlation analyses, AUC in ROC curve analyses indicated that WHtR was superior to predict hypertension, diabetes and metabolic syndrome than other indices (33). The present study showed that the correlation between WHtR and FBG was superior to BMI and FBG. Furthermore, WHtR was significantly associated with FBG and, BMI was related to high blood pressure and lipid levels, vice versa.

A meta-analysis that aimed to compare the performance of BMI against waist circumference, WHR, and WHtR in the discrimination of hypertension in ethnically diverse populations concluded that 'no anthropometric index was systematically better than others at the discrimination of hypertension' (34). Bell et al. (35) showed a stronger association between BMI and hypertension in Chinese than Caucasians and non-Hispanic Blacks than Caucasians and Mexican-Americans. Caucasian populations demonstrated a positive association between BMI and blood pressure in both cross-sectional and prospective studies (36-38). Another large, population based study from Italy also showed the relation between BMI and hypertension (39). There was also a positive association between BMI and blood pressure on the basis of our results, suggesting a causative relation according to ethnic differences.

Strengths and Limitations of the Study

A significant limitation of the present study is its cross-sectional design, which prevents determining a cause-and-effect relationship between anthropometric measurements and CVD risk. Another limitation is the small sample size from a population of well-educated, white-collar workers, leading to a selection bias. On the other hand, evaluating participants with high WHtR for BMI cut-off for the first time might be counted as the study's strength, leading to further studies with larger sample sizes.

CONCLUSION

This study confirmed that the simple value of '0.5' for WHtR was associated with diabetes risk. BMI classification was practical to recognize participants with high blood pressure and lipid levels. Further population-based studies in Turkish adults are needed to evaluate whether WHtR could be used independent from BMI as an early warning of over-all cardiovascular risks for preventive interventions.

Abbreviations: BMI, body mass index; CVD, cardiovascular disease; CHD, coronary heart disease; DBP, diastolic blood pressure; FBG, fasting blood glucose; HDL-C, high-density lipoprotein cholesterol; HOMA-IR, Homeostasis model assessment of insulin resistance; LDL-C, low- density lipoprotein cholesterol; NICE, The National Institute for Health and Care Excellence; SBP, systolic blood pressure; TC, total cholesterol; TG, triglycerides; WHO, World Health Organization; WC, waist circumference; WHtR, waist-to-height ratio; WHR,waist-hip ratio

ETHICAL DECLARATIONS

Ethics Committee Approval: The study was carried out with the permission of the Marmara University Medical School Noninvasive Clinical Ethics Committee (Date: 07.05.2021, Decision No: 09.2021.580).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The author has no conflicts of interest to declare.

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Author Contributions: The author declared that she has participated in the design, execution, and analysis of the paper and that has approved the final version.

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