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Evaluation of waist circumference, waist-hip ratio and waist-length ratio in insulin resistance: Which is a powerful predictor?

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Abstract

Aim: The most important cause of insulin resistance(IR) is obesity. Abdominal adiposity(AA) is more important than general obesity in IR formation. The aim of this study is to evaluate waist circumference (WC), waist-hip ratio (WHR) and waist-length ratio (WLR) as the AA markers, and to question their predictive properties in IR.

Materials and Methods: Individuals diagnosed with IR were retrospectively examined. Seventy patients between 20-65 ages without systemic disease and drug use were included in the study. The patients were evaluated in terms of age, gender, and obesity grades. They were divided into the risk groups according to WC, WHR, WLR and compared each other in terms of HOMA-IR levels.

Results: Of the cases 78.6% were female and 21.4% were male. The mean age was 43.04 years. The mean HOMA-IR level was 5.38. Severe obesity was in 35(50%) patients. WC, in 87.2% of women 60% of men, WHR, in 65.4% of women 93.3% of men, and WLR, in 98.1% of women 93.3% of men were high. HOMA-IR level was found to be statistically different in the WLR risky group compared to the others ($p<0.05$). WLR was more significant and indicated IR with 70% sensitivity and 80% specificity with a HOMA IR level of 3.03 and above.

Conclusion: WLR is a stronger predictor than WC and WHR in all obesity grades for IR. It can be preferred as a powerful predictor for the risk assessment of abdominal obesity and IR status.

Introduction

Insulin resistance (IR) is defined as the deterioration of the biological response to endogenous or exogenous insulin, and its most important cause is obesity [1]. The prevalence of IR varies across countries. It is estimated to be 15.5% among European adults [2], while 23.3% in Thailand, and 39.1% in Texas-US [3,4].

Both obesity and IR are risk factors for dyslipidemia, diabetes mellitus, fatty liver and cardiovascular mortality [5]. Obesity is the state of excessive adipose tissue mass. The body mass index (BMI), which is the first used method to determine obesity by the World Health Organization (WHO), is calculated by dividing the body weight (kg) by the square of the height in meters and it is used both in defining and grading obesity. However, BMI does not predict the weight of increased muscle tissue, the body's water retention, and the distribution of adipose tissue. In recent years, it has been stated that abdominal obesity, so intra-abdominal visseral adiposity is more important than general obesity for IR and cardiovascular mortality. It has been mentioned that waist circumference (WC), waist-hip ratio (WHR), waist-length ratio (WLR), as the markers of abdominal adiposity, are more effective than BMI for the cardiovascular risk assessement. However, there is no concensus on the superiority of any of them, in this subject. The aim of this study is to evaluate BMI, WC, WHR, WLR in patients with IR, to question and to compare their predictive properties in terms of IR.

Materials and Methods

The study was performed retrospectively based on the records of Internal Medicine outpatient clinic in Medical Faculty of University Ordu, Turkey. The records of individuals who applied due to weight problems on 01/02/2022-01/04/2022 were evaluated. Seventy patients between the ages of 20-65 diagnosed with IR, without any systemic disease and drug use were included in the study.

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Body weight, height, waist circumference, hip circumference, BMI, WC, WHR, WLR values and fasting glucose, fasting insulin levels were determined from patient records. IR was assessed using HOMA-IR and its level of 2.5 and above was accepted as IR [6].

Our study was carried out in accordance with the Principles of Helsinki Declaration. The study protocol was approved by Ordu University Clinical Research Ethics Committee with the decision number 2022/10 dated 14/01/2022.

Anthropometric measurements

In the evaluation of anthropometric measurements WHO criterias were followed [7]. Accordingly, BMI was calculated by dividing body weight (kg) by the square of length (m^2). Between 18.5-24.9 kg/m^2, BMI is defined as normal, between 25.0-29.9 kg/m^2 as overweight, $\geq$30 kg/m^2 as obesity, and $\geq$35 as severe obesity. WC was measured from the midpoint of the lateral iliac prominences and the lowest rib while standing. It was high considered as 88 cm and above in women, 102 cm and above in men. Hip circumference was measured around the widest part of the hip, and WHR was calculated by dividing WC(cm) by hip circumference(cm). It was high considered as 0.85 and above in women, 0.90 and above in men. WLR was calculated by dividing WC(cm) by length(cm). WLR of 0.5 and above was considered high for both men and women.

The patients were examined in terms of age, gender, and obesity grades. They were divided into the risk groups according to their WC, WHR, WLR levels and their HOMA-IR levels were compared. The superiority of WC, WHR, WLR in predicting IR were analyzed.

Statistical analysis

Statistical analyzes were performed using IBM® SPSS® 22 (SPSS Inc., Chicago, IL, USA demo version) software. Descriptive analyzes were given as mean±std for normally distributed variables, and median, min-max and IQR for non-normal distributed variables. The Shapiro-Wilk test was used to assess the conformity of the variables to the normal distribution Kolmogorov-Smirnov Test was used as the analytical method for the conformity to the normal distribution of the variables. Descriptive statistics of demographic characteristics were made by giving frequency and percentage values. The Mann-Whitney U test was used to compare anthropometric risk groups in continuous data. Pearson's chi-square test was used in the analysis of categorical data. ROC analysis was used to determine marker variables and to calculate sensitivity, specificity, and cut-off values. p value below 0.05 was considered statistically significant. Power analysis was done with G*Power v.3.1.9.7 program. According to the chi-square analysis, the effect size (w) was determined as 0.5, the β/α ratio was determined as 4, the sample size was 70 and the degree of freedom was 2, and the study was completed with a power of 93.1%.

Results

Of the patients 78.6% were female and 21.4% were male. The mean age was 43.1±9.8 years old. The mean HOMA-IR level was found to be 5.38. No case with normal BMI was detected. Mean BMI was 35.05, WC 101.17, WHR 0.89, and WLR 0.62. Descriptive parameters were shown in Table1. Of the cases, 11(15.7%) were overweight, 24(34.3%) were obese, and 35(50%) were severely obese. In the whole group, WC was high in 57(81.4%), WHR was high in 46(65.7%), and WLR was high in 65(92.9%) pa-

Table 1. Descriptive parameters.

Variables	Minimum	Maximum	Mean ±Std. Dev.	Median
Age (year)	20	64	43.04±10.96	45.5
Glucose (mg/dl)	84	142	102.94±13.36	99
Insulin (IU)	9.84	62.2	20.52±12.62	15.64
Homa-IR	2.53	20.27	5.38±3.86	3.83
Weight (kg)	57.1	125.37	91.50±15.21	91.49
Length(m)	1.37	1.87	1.61±0.08	1.61
BMI (kg/m^2)	25.26	48.96	35.05±5.31	34.93
Waist (cm)	73	138	101.17±11.54	99.5
Hip (cm)	84	144	113.19±11.17	114
Waist/Hip Ratio	0.73	1.16	0.89±0.09	0.87
Waist/Length Ratio	0.44	0.87	0.62±0.08	0.62

Table 2. Anthropometric values by gender.

Variables	Female		Male	
	n	%	n	%
BMI(kg/m^2)				
Overweight	8	14.5	3	27.3
Obese	18	32.72	6	25
Severely Obese	29	52.73	6	17.2
Waist Circumference (cm)				
<88	7	12.8		
$\geq$88	48	87.2		
<102			6	40
$\geq$102			9	60
Waist/Hip Ratio				
<0.85	19	34.6		
$\geq$0.85	36	65.4		
<0.90			1	6.7
$\geq$0.90			14	93.3
Waist/Length Ratio				
<0.5	1	1.9	1	6.7
$\geq$0.5	54	98.1	14	93.3

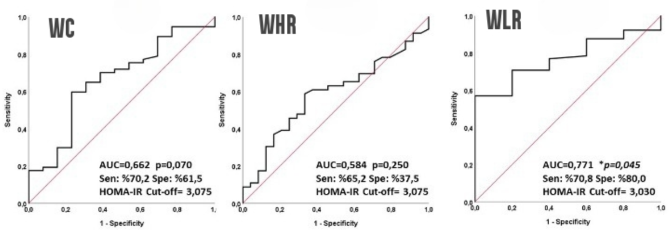

Figure 1. Comparison of WC, WHR, WLR levels with Roc Analysis.

Table 3. HOMA IR values of groups by anthropometric measurements.

Variables	Waist Circumference Risk Status		Waist/Hip Ratio Risk Status		Waist/Length Ratio Risk Status	
	No (n=13)	Yes (n=57)	No (n=26)	Yes (n=44)	No (n=5)	Yes (n=65)
	Median (IQR)		Median (IQR)		Median (IQR)	
HOMA-IR	3.0(2.2)	4.0(3.7)	3.2(2.5)	4.01(3.8)	2.9(0.7)	4.0(3.8)
p	0.070		0.215		**0.045**	

Mann-Whitney U test was used and p<0.05 was considered significant.

tients. 87.2% of women and 60% of men had high WC. 65.4% of women and 93.3% of men had high WHR. 98.1% of women and 93.3% of men had high WLR. The parameters according to gender were shown in Table 2. The patients were divided into groups by the risky levels of WC, WHR, WLR, and compared in terms of IR. HOMA-IR level was found to be statistically different in the WLR risky group compared to the others ($p<0.05$) (Table 3). It was determined by ROC analysis that the WLR was a better predictor of IR, compared to WC and WHR with AUC of 0.771 and p=0.045. WLR indicated IR with 70% sensitivity and 80% specificity in those with HOMA-IR level of 3.03 and above. ROC analyzes were shown in Figure 1.

Discussion

Insulin is known as the strongest anabolic hormone and a powerful metabolic regulator. In addition to providing glucose entry into the cell, it provides storage of glucose, amino acids and fatty acids by stimulating glycogen, lipid and protein synthesis [1]. Obesity is the state of excessive adipose tissue mass and it has been revealed that metabolic and cardiovascular diseases increase as a result of IR cused by the adipose tissue changes. Especially abdominal (visceral and omental) localized adipose tissue is responsible for this increased risk [8-9]. In a recent meta-analysis in Turkey, the mean BMI of the adult population was calculated as 27.3 kg/m^2 (28.0 kg/m^2 for women, 26.5 kg/m^2 for men). These values are accepted as overweight according to the WHO classification. The prevalence of obesity, defined as a BMI over 30 kg/m^2, was detected as 30% in women and 17% in men. Additionally, the prevalence of abdominal obesity was found to be 50.8% in women and 20.8% in men in this meta-analysis [10].

In our study, the mean age was 43 and although they were young, the mean BMI was 35.05 which was within the limit of severe obesity. Of the women 32.7% were obese and 52.7% were severely obese. In men, this rate was 25% and 17.2%, respectively. These rates are higher than the results of the meta-analysis conducted in our country. Moreover, WC in 87.2% of women, WHR in 93.3% of men were found to be higher in this study. As it is mentioned that WC and WHR indicate abdominal adiposity, this study shows that both genders have abdominal obesity. It has been reported anyway in studies that abdominal obesity was mainspring in the pathogenesis of IR [11-13]. It has been reported that not subcutaneous fat accumulation but visceral fat accumulation is more harmful. Accordingly, abdominal adiposity causes an increase in IR resulting in glucose intolerance, hyperinsulinemia, vascular inflammation and cardiovascular events [14,15]. In one study, reduction in abdominal fat mass was associated with improved insulin sensitivity, glucose metabolism, and other measures of metabolic syndrome [16]. The results of this study showed that general and abdominal obesity increase in IR, similar to those in the literature. The studies comparing BMI as an indicator of the obesity grade with anthropometric measurements as the abdominal obesity markers has yielded contradictory results. In a study conducted with women diagnosed with IR and with a BMI of 30-40 kg/m^2, no statistically significant relationship was found between fasting glucose, fasting insülin, HOMA-IR values and BMI, WC, WHR [17]. In another similar study, it was stated that there was no significant relationship between fasting glucose value and anthropometric measurements [18]. On the other hand, in an analysis evaluating the data of four studies in England, it was concluded that BMI, WC, WHR were significantly correlated to body fat mass in diabetes mellitus and coronary artery disease, but they did not have a significant superiority over each other [19].

Although BMI is used both to define and grade obesity, BMI can not predict the quantity of muscle tissue and distribution and degree of adipose tissue. Therefore, it may not be a definitive indicator for abdominal adiposity and IR. In one study, it was stated that WC had a stronger correlation with the amount of visceral adipose tissue associated with the presence of hypertension, type 2 diabetes and dyslipidemia, compared to BMI [20]. In the IDEA study conducted in 63 countries, BMI and WC were evaluated in patients with cardiovascular disease and diabetes mellitus, and it was stated that WC had a much stronger relationship than BMI with them for both genders [21]. As a result of similar studies WHO presented a report emphasizing the importance of WC and WHR in cardiovascular and metabolic events [22].

In this study, WC, WHR and WLR were compared against each other as well as with the BMI. The groups at risk according to WC, WHR, WLR were compared in terms of IR. WHR showed the weakest association with IR, while WC showed a moderate association. The strongest and statistically significant relationship was seen between WLR and IR ($p<0.05$) (Table 3). It was seen that WLR indicated IR with 70% sensitivity and 80% specificity in those with HOMA-IR level of 3.03 and above (Figure 1). In one study, a positive and statistically significant relationship was found between BMI, WC, WHR, WLR, and body fat percentage and the diagnosis of IR, but no superiority was found between these anthropometric measurements in terms of IR [23]. But some studies stated as in our study, that WLR is superior to BMI, WC, WHR in reflecting IR [24,25].

Abdominal obesity has been emphasized in recent years, and WLR is one of the newly examined anthropometric measurements in this regard. All patients had IR in this study, and we found that all of them had varying degrees of obesity and increased WC, WHR, and WLR at varying rates. But we found that WLR showed a risk close to 100% for both genders (98.1% for women, 93.3% for men). However, patients showed a much lower risk in terms of WC and WHR despite the IR status. In clinical practice, WLR is not used as widely as BMI, but it is stated that it shows fat distribution better without society and gender specific cut-off point. In a meta-analysis examining the data of 31 studies, it was stated that WLR was a better predictor for hypertension, metabolic syndrome, type 2 diabetes and cardiovascular disease than BMI[26]. In another systematic review, it was emphasized that WLR may be a predictor for both genders in terms of IR and diabetes [27]. In a study conducted in Turkey, WLR was found to be the best anthropometric parameter in predicting the cardiometabolic risks [28]. In one of the recent studies, it was mentioned that WLR is a significant marker in demonstrating the metabolic syndrome [29].Yet another study stated that WLR is the most effective anthropometric index in demonstrating IR and metabolic disorders [30].

Conclusion

Abdominal obesity is more effective in the origine of IR than general obesity. WLR is a stronger predictor than WC and WHR for the risk assessment of IR in all obesity grades. It can be used as a cheap and practical method regardless of age and gender, to detect individuals at risk for metabolic and cardiovascular diseases in settings where more extended testing such as insulin assays are not available.

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Ethical approval

Our study was carried out in accordance with the Principles of Helsinki Declaration. The study protocol was approved by Ordu University Clinical Research Ethics Committee with the decision number 2022/10 dated 14/01/2022.

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