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Original article

Is neck circumference a simple tool for identifying insulin resistance: a hospital-based study in Turkey

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Summary. *Aim:* To make it clear whether neck circumference (NC) can be a valid and efficient method for distinguishing obesity and insulin resistance (IR) in Turkish adults. *Material and Method:* A total of 527 women, in the age range of 20 to 49, were recruited into the study and classified as normal-weight (n=130, 24.7%), overweight (n=172, 32.7%) and obese (n=225, 42.6%). Anthropometrical measurements such as body weight, height, waist circumference (WC), WHtR and NC were taken by the researcher. Serum fasting blood glucose, fasting blood insulin, triglyceride, high-density lipoprotein cholesterol, serum low-density lipoprotein cholesterol, were analyzed. Insulin resistance was determined by "Homeostasis model assessment IR index (HOMA-IR)". *Results:* A total of 130 women were normal-weight, 172 women were overweight and 225 were obese. 66.8% of the overweight and 95.6% of the obese women's WC is more than 88 cm. According to the WHtR, it has been detected that 70.9% of the overweight women are in the risk group for chronic diseases whereas 88.4% of obese women are in the high risk group. While the majority (86.2%) of the normal-weight women's NC is less than 34 cm, that of 88.4% of the obese women is higher than this value. A positive, strong relationship among body weight (r=0.654), BMI (r=0.653), WC (r=0.574), Waist/height ratio (r=0.541) and NC was determined. According to the findings, 82.9% of the women with NC higher than 34 cm have IR and being in the risk group regarding NC increases the risk of having IR 4.7 times. *Conclusion:* In women, NC, BMI, WC and WHtR have a positive correlation. Therefore, it is beneficial to use NC as a valid indicator for both overall and central obesity.

Key words: neck circumference, obesity, insulin resistance

Introduction

Obesity is a globally significant public health problem (1). Conducted epidemiologic researches revealed that increased body weight and abdominal body fat accumulation cause metabolic and cardiovascular diseases such as Type 2 diabetes, insulin resistance, dyslipidemia, hypertension, and coronary heart disease (2-4). World Health Organization (WHO) reported in 2008 that 1.4 billion adults were overweight; 300 million women and 200 million men were obese worldwide (5). According to the data obtained from Turkey Nutrition, Health and Food Consumption research conducted in 1974, obesity prevalence was 7.6% for men, and 25% for women, while the prevalence reported in 2010 was 20.5% and 41.0%, respectively in a similar countrywide research (6,7). IR is defined as degenerated biological response to exogen or endogen insulin. A resistance to insulin emerges when insulin cannot work effectively in muscles, liver, and adipose tissue as a result of abdominal fattening (8). The strong correlation between IR and obesity was demonstrated in the studies performed (9-11).

It has been proved that NC measurement, which demonstrates upper body fat distribution and onset of central obesity, is an easy screening method to distinguish between the obese and the overweight people in Israeli population (12,13).

Being one of the markers of visceral obesity, NC is also recorded to be more significantly linked with IR than WC in the European population (14). However, whether NC can be a credible indicator of identification of the central obesity and IR is still a matter of debate in Turkish population. The aim of this study is to detect whether NC is a practical and effective method for women with central obesity and IR.

Methodology

Study population and design

The cross-sectional study was conducted between March 2012-May 2013. A total of 527 women, at the age of 20 to 49, were recruited into the study and classified as normal-weight (BMI=18.5-24.9 kg/m^2, n=130, 24.7%), overweight (BMI= 25.0-29.9 kg/m^2, n=172, 32.7%) and obese (BMI=≥30 kg/m^2, n=225, 42.6%) women, who attended to the İzmir Bozyaka Training and Research Hospital Internal Medicine, Endocrinology and Diet Outpatients Clinics. BMI calculations were performed according to WHO criteria (15).

Written consent was obtained from all participants at the beginning of study which was approved by the Ethics Committee of the Faculty of Medicine, İzmir Katip Çelebi University, İzmir, Turkey (Approval number 03/07/2014-135).

Exclusion criteria

Women having any of the following conditions were excluded from the study: women aged under 20 years and over 49 years, pregnant, lactating, postmenopausal, underweight (BMI<18.5 kg/m^2), with chronic diseases such as diabetes mellitus, bone, renal and liver failure.

Anthropometric measurements

Anthropometric measurements were conducted by a researcher dietitian according to the criteria suggested by WHO (16). Bioelectrical impedance analyzer (TANITA TBF 300, Tanita Corp., Tokyo, Japan) was used to measure body weight. Subjects were instructed to avoid food or liquid intake, have vigorous exercise for 4 hours prior to the measurement and not to wear any metallic objects during the measurement. Body height was measured using a tape measure while women standing barefoot, keeping their shoulders in a relaxed position, arms hanging freely and head in Frankfort horizontal plane (17,18). Body Mass Index (BMI) is calculated with the help of the weight/height formula in kg/m^2 units, and is evaluated according to the classification of WHO as underweight (<18.5 kg/m^2), normal-weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), and obese (≥ 30 kg/m^2) (16). WC was measured by a non-elastic measuring tape as the circumference of the midpoint between the lowest rib and iliac crest. WHO waist circumference (≥88 cm for women) was used and women with WC ≥88 cm were evaluated as abdominal obese (12).

Waist circumference to height ratio is used in risk assessment regarding chronic diseases. The ratio is accepted as normal if it is between 0.4 and 0.5, as risky if ≥ 0.5-0.6 and as high risk if ≥0.6 (19).

NC was measured with a non-elastic tape from the most protrusive point of the thyroid cartilage when the head was upright, eyes straight and shoulders held loosely (20). NC of >34 cm for women were accepted as the threshold values to indicate the existence of central obesity (12).

Biochemical parameters

Following an 8-hour overnight fast, blood samples were collected between 08.30 and 10.30 am. Routine blood tests including serum fasting blood glucose (FBG), fasting blood insulin (FBI), triglyceride (TG), high-density lipoprotein cholesterol (HDL-C), serum low-density lipoprotein cholesterol (LDL-C), were analyzed in the İzmir Bozyaka Training and Research Hospital laboratory. In the study, IR was determined through "Homeostasis model assessment IR index (HOMA-IR)" method using the [(Fasting Plasma Glucose x Fasting Plasma Insulin)/405] formula. HOMA-IR ≥2.7 is accepted as insulin resistance (21).

Statistical analysis

SPSS (Statistical Package for Social Sciences) Windows version 21.0 (SPSS Inc., Chicago, IL, USA) package software was used for statistical analyses. Descriptive statistics (means, standard deviations, frequencies) were used in the evaluation of quantitative data. Normality of the data distribution was determined with the Shapiro-Wilk test.

One way analysis of variance (ANOVA, for normally distributed variables) and Kruskal-Wallis test (for non-normally distributed variables) were used to compare continuous variables. Pearson chi-square test was used to compare the qualitative data between the groups. Pearson correlation test was used to determine the relationship between NC and anthropometric measurements, HOMA-IR. The odds ratios (OR, 95% confidence intervals) were calculated to detect the relationship between NC and IR. Two-sided p values were calculated and $p<0.05$ was noted as statistically significant.

Results

The mean values of anthropometric measurements of the women were given in Table 1. A total of 130 women were with normal weight, 172 women were overweight and 225 were obese. The mean BMI for normal-weight, overweight and obese women were 22.7 kg/m^2, 27.4 kg/m^2 and 35.6 kg/m^2, respectively. The median NC was 32.0 cm, 35.0 cm and 35.0 cm for normal-weight, overweight and obese women ($p<0.001$). Normal-weight, overweight and obese women had an average WC of 80.0 cm, 91.0 cm and 104.2 cm respectively.

It has been detected that more than a half of the normal-weight women's (58.5%) WC is less than 80 cm. In addition, 66.8% of the overweight and 95.6% of the obese women's WC is more than 88 cm (Table 2). According to the WHtR, it has been detected that 70.9% of the overweight women are in risk group for chronic diseases whereas 88.4% of obese women are in high risk group.

While the majority (86.2%) of the normal-weight women's NC is less than 34 cm, that of 88.4% of the obese women is higher than 34 cm (Table 2).

As expected, FBG, FBI, HOMA-IR, TG, and LDL increased with BMI while HDL decreased as BMI declined in women (Table 3). Moreover, a positive, strong relationship among body weight ($r=0.654$), BMI ($r=0.653$), WC ($r=0.574$), waist/height ratio ($r=0.541$) and NC was determined ($p<0.001$) (Table 4).

In Table 5 is the distribution of the women diagnosed with IR according to HOMA-IR values. It has been determined that the majority of the women (95.6% and 85.5%, respectively) with BMI lower than 25.0 kg/m^2 and between 25.0-29.9 kg/m^2 haven't been diagnosed with IR (HOMA-IR <2.7), while more than a half of them (64.4%) with BMI ≥ 30 kg/m^2 have been diagnosed with it (HOMA-IR ≥2.7). According to the findings, 82.9% of the women with NC higher than 34 cm have IR and being in the risk group in terms of the NC increases the risk of having IR 4.7 times (OR 4.70 [2.76-7.99] $p<0.001$) (Table 6).

Discussion

The definition of overweight and obesity is immoderate fat accumulation in the body whose adverse influence on health may result in a decline in life expectancy and an incline in health problems. Diabetes, cardiovascular diseases, and cancer are among the chronic diseases for which overweight and obesity are major risk factors (22).

Obesity used to be a rare condition until the 20th century, however in 1997, WHO officially acknowledged obesity as a worldwide epidemic. 65% of world population live in countries where overweight and obesity are more prevalent death causes than underweight according to WHO reports (23,24).

In 2011-2012, the prevalence of obesity in the United States was 34.9% in adults (25). According to the study of the NHANES, the ratio of obese adults in America increased two fold from 15% between 1971-1974 to 34% between 2003 and 2006. A parallel shift is also visible in countries like Japan and Korea where obesity rates are the lowest of the world (26).

In the Turkish Nutrition and Health Survey 2010, obesity was highlighted as an important public health problem, since the reported percentages for obesity (BMI≥30 kg/m^2) and overweight (BMI=25.0-29.9 kg/m^2) were 30.3% and 34.6%, respectively (7).

Wide range of methods such as BMI, waist and waist-hip ratio can be used in identifying obesity. Central obesity was detected most commonly by WC

Table 1. Anthropometric measurements of the participants

	BMI (kg/m²)	X	SD	Median	Min	Max	p
Age (year)							
	BMI<25.0 (n=130)	30.2	7.40	30	17	48	
	BMI 25.0-29.9 (n=172)	31.6	7.51	31	19	48	0.000**
	BMI≥30 (n=225)	34.7	7.82	35	15	50	
Height (cm)							
	BMI<25.0 (n=130)	163.3	6.06	163	150.0	183.0	
	BMI 25.0-29.9 (n=172)	161.1	6.86	160.5	143.0	183.0	0.001*
	BMI≥30 (n=225)	160.6	6.53	160.0	155.0	175.0	
Weight (kg)							
	BMI<25.0 (n=130)	60.6	6.92	61.4	42.3	80.5	
	BMI 25.0-29.9 (n=172)	71.3	6.98	70.9	56.6	93.0	0.000**
	BMI≥30 (n=225)	92.1	13.5	90	67.9	153.7	
BMI (kg/m²)							
	BMI<25.0 (n=130)	22.7	1.86	23.2	16.1	24.9	
	BMI 25.0-29.9 (n=172)	27.4	1.47	27.4	28.0	29.9	0.000**
	BMI≥30 (n=225)	35.6	4.67	34.7	30.1	56.9	
WC (cm)							
	BMI<25.0 (n=130)	80.0	6.99	78.0	69.0	110.0	
	BMI 25.0-29.9 (n=172)	91.0	7.85	90.0	73.0	125.0	0.000**
	BMI≥30 (n=225)	104.2	10.3	104.0	80.0	144.0	
NC (cm)							
	BMI<25.0 (n=130)	32.3	1.99	32.0	28.0	38.0	
	BMI 25.0-29.9 (n=172)	35.4	2.82	35.0	35.0	39.0	0.000**
	BMI≥30 (n=225)	37.1	2.63	37.0	28.0	49.0	
WHtR							
	BMI<25.0 (n=130)	0.49	0.04	0.48	0.41	0.73	
	BMI 25.0-29.9 (n=172)	0.56	0.04	0.56	0.44	0.74	0.000**
	BMI≥30 (n=225)	0.64	0.06	0.64	0.48	0.85	

WC: Waist circumference NC: Neck circumference WHtR: Waist to hip ratio
**ANOVA p<0.05 **Kruskal Wallis p<0.05*

Table 2. Classification of the participants according to WC, NC, and WHtR

	BMI < 25.0 kg/m² (n=130)		BMI 25.0-29.9 kg/m² (n=172)		BMI ≥ 30 kg/m² (n=225)		
	n	%	N	%	n	%	p
WC (cm)							
<80	76	58.5	8	4.7	-	-	
80-88	41	31.5	49	28.5	10	4.4	0.000*
≥88	13	10.0	115	66.8	215	95.6	
WHtR							
0.4-0.5	82	63.1	10	5.8	1	0.4	
≥ 0.5-0.6	41	31.5	122	70.9	38	16.9	0.000*
≥ 0.6	7	5.4	40	23.3	186	82.7	
NC (cm)							
< 34	112	86.2	86	50.0	26	11.6	0.000*
≥ 34	18	13.8	86	50.0	199	88.4	

WC: Waist circumference, NC: Neck circumference *Pearson chi-square p<0.05

Table 3. Biochemical parameters of the participants

	BMI (kg/m²)	X	SD	Median	Min	Max	p
FBG (mg/dL)							
	BMI<25.0 (n=130)	85.7	8.08	86.0	67.0	109.0	
	BMI 25.0-29.9 (n=172)	88.0	8.32	87.0	63.0	106.0	0.000**
	BMI≥30 (n=225)	90.9	13.05	90.0	70.0	205.0	
FBI (mU/L)							
	BMI<25.0 (n=130)	6.7	2.83	6.5	1.4	7.65	
	BMI 25.0-29.9 (n=172)	8.8	6.72	7.6	3.0	8.2	0.000**
	BMI≥30 (n=225)	12.2	8.09	10.0	1.25	56.2	
HOMA-IR							
	BMI<25.0 (n=130)	1.41	0.61	1.35	0.26	1.80	
	BMI 25.0-29.9 (n=172)	1.92	1.39	1.70	0.58	16.6	0.000**
	BMI≥30 (n=225)	2.80	2.06	2.1	0.28	15.59	
TG (mg/dL)							
	BMI<25.0 (n=130)	82.7	31.63	72.5	32.0	182.0	
	BMI 25.0-29.9 (n=172)	106.3	59.3	86.0	39.0	378.0	0.000**
	BMI≥30 (n=225)	122.6	70.30	103.0	26.0	564.0	
LDL (mg/dL)							
	BMI<25.0 (n=130)	109.1	31.88	104.0	50.0	217.0	
	BMI 25.0-29.9 (n=172)	114.5	36.50	109.0	57.0	260.0	0.004**
	BMI≥30 (n=225)	119.2	38.98	115.0	130.0	453.0	
HDL (mg/dL)							
	BMI<25.0 (n=130)	60.9	14.05	60.0	33.0	87.0	
	BMI 25.0-29.9 (n=172)	55.6	14.6	54.0	29.0	121.0	0.000**
	BMI≥30 (n=225)	50.2	12.38	48.0	25.0	98.0	

FBG: Fasting blood glucose, FBI: Fasting blood insulin, TG: Triglycerides

Table 4. Correlation between NC and anthropometric measurements

	NC	
Anthropometric measurements	r	p
Weight (kg)	0.654	0.000*
BMI (kg/m2)	0.653	0.000*
WC (cm)	0.574	0.000*
WHtR	0.541	0.000*

**Pearson chi-square, p<0.05*

index among the methods. However, WC is an insufficient criterion to determine whether central obesity stems from abdominal subcutaneous adipose tissue or visceral adipose tissue. As revealed by the previous researches, rather than the subcutaneous adipose tissue mass, the visceral adipose tissue mass was significantly associated with IR, type 2 diabetes and cardiovascular diseases (27-30). Furthermore, as predicted by NC, upper-body subcutaneous adipose tissue was detected to be correlated with type 2 diabetes and IR (31,32). For this reason, NC can also be as an easy and quick method as WC in determining obesity and IR. NC≥37 cm for men and ≥34 cm for women were the best cut-off levels for determining the subject with BMI≥25 kg/m² (12,13,33).

The study proposes the unrealized significance of NC as a sign of overweight and obesity. The objective of this study was to establish whether NC is a credible measurement that serves its purpose or without taking WC measurement and BMI calculation in women with overweight or obesity.

In the present study, the mean BMI for normal-weight, overweight and obese women were 22.7 kg/m², 27.4 kg/m² and 35.6 kg/m², respectively. According to WHO criteria, 24.7% of the women were normal weight (BMI= 18.5-24.9 kg/m²), 32.7% of the women were overweight (25.0-29.9 kg/m²) and 42.6% of the women were obese (BMI≥30 kg/m²). Moreover, 66.8%

Table 5. Classification of the participants according to HOMA-IR

	BMI < 25.0 kg/m² (n=130)		BMI 25.0 – 29.9 kg/m² (n=172)		BMI ≥ 30 kg/m² (n=225)		
HOMA-IR	n	%	n	%	n	%	p
<2.7	124	95.6	147	85.5	145	64.4	
≥2.7	6	4.6	25	14.5	80	35.6	0.000*

**Pearson chi-square, p<0.05*

Table 6. Relationship between the neck circumference and HOMA-IR

	HOMA-IR					
	HOMA-IR < 2.7		HOMA-IR ≥2.7			
	n	%	n	%	p	Odds Ratio
NC (cm)						
<34	205	49.3	19	17.1		
≥34	211	50.7	92	82.9	0.000*	4.70 (2.76 – 7.99)
Total	416	100.0	111	100.0		

**Pearson chi-square, p<0.05*

of overweight and 95.6% of obese women had high WC. Findings of this study were similar to the results of Saka et al. (34) who reported high WC and waist/hip ratio among Turkish adults.

One of the anthropometric index used in the evaluation of central obesity, WHtR is recorded by imaging techniques to have a strong correlation with central obesity (35). WHtR was proven to be a prospering measurement which can detect health risks (36,37). WC and BMI exhibited significantly lower correlation with diabetes than WHtR in industrial population of India (38). Radzeviciene et al. (35) and Hadaegh F et al. (39) stated that WHtR, which is a sound indicator of abdominal obesity, is associated with type 2 diabetes. Also in this research, that the number of the women in BMI≥30 kg/m² group who have chronic disease risks regarding WHtR (82.7%) is high can be associated with that 35.6% of the women have HOMA-IR≥2.7. In the present study, the median NC was 32.0 cm, 35.0 cm and 35.0 cm for normal-weight, overweight and obese women respectively. In addition, half of the overweight women and majority of the obese women's (88.4%) neck circumference is higher than 34 cm. These findings were similar with the results of Onat et al. (40) who reported 34.8±2.75 cm in women.

In women, neck circumference correlated positively with body weight, waist circumferences, waist/height ratio and BMI (p<0.05). Similarly in the present study, there was a statistically significant positive correlation between NC and other anthropometric measurements in diabetic and non-diabetic groups according to Aswathappa et al. (41) as well as Ben-Noun et al. (12) who demonstrated that neck circumference is a valid marker for identifying obese individuals and correlated well with other anthropometric measurements.

Yang et al. (14) have revealed that NC has surpassed other anthropometric measurements as a powerful marker of both visceral adipose tissue (VAT) and insulin resistance. Similar to Yang et al's (14) finding, a positive correlation was found between neck circumference and insulin resistance in our study. This finding was consistent with the results of Laakso et al. (42) who reported that neck circumference was associated with the metabolic disorders related to insulin resistance.

Conclusion

In women, NC, BMI, waist circumference and WHtR have a positive correlation. Therefore, it is beneficial to use NC as a valid indicator for both overall and central obesity.

Recommendations

Measuring NC was proven to be a fruitful test for determining IR. High risk of progressing metabolic disorders including diabetes and dyslipidemia is thought to be related with large number of NC.

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