ORIGINAL ARTICLE

Can neck circumference measurement predict insulin resistance than waist circumference?

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Summary. *Objective:* There is a high correlation between insulin resistance and abdominal obesity. Although there are many anthropometrical measurements to determine obesity, neck circumference measurement has started to be used in recent years in addition to other anthropometrical measurements. This research has been conducted in order to assess the relationship between the neck circumference and insulin resistance parameters of the individuals with insulin resistance diagnosis. *Material-Method:* This study was conducted with 101 individuals who applied to endocrinology or internal medicine clinics, and were diagnosed with insulin resistance. Demographical features of the individuals were questioned with a questionnaire form; and anthropometrical measurements such as body weight, height, waist, and neck circumference were taken by the researcher. The body compositions of the individuals were evaluated with the Bioelectrical Impedance Analysis (BIA). HOMA-IR indexes were calculated by recording the fasting blood glucoses and fasting plasma insulin values from the files of the individuals. *Results:* According to World Health Organization criteria, 21.2% of the participating women, and 18.7% of the men were overweight; 76.5% of the women, and 81.3% of the men were obese. The mean neck circumference was 38.1±2.4 cm in women, while it was 44.9±3.1 cm in men. It was determined that there was a high correlation between the neck circumference and the other anthropometrical measurements of women; and that there was a strong positive relationship between the neck circumference and body weight, waist circumference, and fat-free body mass of men. A significant relationship was identified between neck circumference measurement and fasting plasma insulin, and HOMA-IR, which are one of the insulin resistance parameters. *Conclusion:* It was observed that two thirds of the individuals with insulin resistance were obese, and all of their waist and neck circumference levels were high that propose risk for metabolic diseases. A positive but low correlation was found between neck circumference and all other anthropometrical measurements, fasting plasma insulin and HOMA-IR index, which are indicators of insulin resistance. Therefore, neck circumference, too, may be an anthropometrical measurement that can be used in diagnosing the insulin resistance as an indicator of obesity just like waist circumference and Body Mass Index.

Key words: insulin resistance, neck circumference, obesity

Introduction

Obesity is a globally significant public health problem (1). Conducted epidemiologic researches showed 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 are overweight; 300 million women and 200 million men are 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). Insulin resistance is defined as degenerated biological response to exogen or endogen insulin. A resistance to insulin is formed when insulin cannot work effectively in muscles, liver, and adipose tissue as a result of abdominal obesity (8). The strong correlation between insulin resistance and obesity was demonstrated in the studies performed (9-11).

Although Body Mass Index (BMI) is a value used frequently in determining obesity, it is not a favorable indicator for abdominal obesity and central obesity (1). Waist circumference, waist/hip ratio, and waist/height ratio are among the measurements often used to determine central obesity (12). Neck circumference measurement has become increasingly important in identifying obesity and abdominal obesity in recent years, for it is easy, not time-consuming, and a more accurate indicator of central obesity than BMI (13). That the neck circumference is related to visceral obesity and BMI is reported in Firmingham Heart Study (14). In a study performed with young and old adults, it is stated neck circumference measurement is more effective than waist circumference according to metabolic syndrome criteria (15). Epidemiological studies based on the relation between insulin resistance and obesity showed that there is a positive relationship between insulin resistance and neck circumference (16-18). The objective of this study was to evaluate the relationship between neck circumference and insulin resistance indicators in individuals who have insulin resistance.

Material and Method

Participants

This study was conducted with 101 individuals (85 women, 16 men) between 19-65 years of age who have applied to Erzincan Mengücek Gazi Training and Research Hospital Dietetic Clinic in March-June 2014 after being diagnosed with insulin resistance by an endocrinologist and/or internal diseases specialist.

Insulin resistance was determined with "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 (19).

Individuals who have any cardiac, renal, hepatic or endocrinal disease (thyroid, cushing etc.), Type 1 or Type 2 diabetes, who are on medical treatment that affects the plasma glucose levels and insulin sensitivity; and pregnant or breast-feeding women were excluded from the study. This study was approved by the Ethics Committee of the Faculty of Medicine, Erzincan University, Erzincan, Turkey (Approval number 03/14).

Questionnaire

Questionnaire was administered with face to face interview method to learn the demographical features of the individuals.

Anthropometric measurements

All anthropometric measurements were performed without shoes and with clothes as light as possible. Body weight was measured with a regularly calibrated SECA digital scale (with ±0.1 kg accuracy), 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. Body Mass Index (BMI) was calculated using the weight/height formula in kg/m² units, and was evaluated according to the classification of WHO as underweight (<18.5 kg/m²), normal weight (18.5-24.9 kg/m²), overweight (25.0-29.9 kg/m²), and obese (≥ 30 kg/m²) (20). Body fat percentage (%), body fat mass (kg), and fat-free body mass (kg) of the individuals were determined with TANITA BC420 analysis monitor in order to assess the body composition. Subjects were instructed to avoid food or liquid intake and vigorous exercise for 4 hours prior to the measurement, and not to wear any metallic objects during the measurement.

Waist circumference was measured with a non-elastic measuring tape as the circumference of the midpoint between the lowest rib and iliac crest. Waist circumference values ≥94 cm for men and ≥80 cm for women are defined as risk, and ≥102 cm for men, and ≥88 cm for women as high risk (13).

Neck circumference was measured with a non-elastic tape from the most protrusive point of the thyroid cartilage when the head was upright, the eyes were straight, and shoulders were held loosely (18). Neck circumference of >37 cm for men, >34 cm for women were accepted as the threshold values to indicate the existence of central obesity (13).

Biochemical parameters

Venous plasma glucose and insulin level measurements of individuals after a fasting period of 12 hours have been recorded from patient files. In the study, insulin resistance was determined with "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 (19).

Statistical analysis

In the study, descriptive statistics (mean, standard deviation) were used in the evaluation of quantitative data. The relationship between neck circumference and other anthropometric measurements was evaluated with Pearson correlation test. In addition, linear regression analysis was used to determine relationship between neck circumference and insulin resistance parameters. SPSS (Statistical Package for Social Sciences) Windows 21.0 package software was used for statistical analyses. The results were evaluated in a 95% confidence interval, and significance level of $p < 0.05$.

Results

84.2% of 101 individuals participated in the study were women, 15.8% were men. The median age of women were 34.0 (min 18-max 59 year), while of men were 32.4±8.3. The mean values of anthropometric measurements of the individuals were given in Table 1.The mean weight was 88.2±14.08 kg, the mean height was 160.6±5.78, and the mean BMI was 34.2±5.64 kg/m² for the women those participated in the study, while these values were 107.4±15.76 kg, 176.7±4.36 cm, and 34.3±4.36 kg/m² respectively for the men.

According to BMI classification, 21.2% of the women and 18.8% of the men were overweight, while 76.5% of the women and 81.3% of the men were obese (Table 2). The mean waist circumference of the women were 105.2±11.45 cm, and of the men were 115.9±9.87 cm. The percentages of the women and the men who have waist circumference values regarded as high risk were 97.6%, and 93.8%, respectively. The mean neck circumference was 38.1±2.46 cm for the women, 44.9±3.1 cm for the men. The neck circumference of 97.6% of the women, and all of the man that participated in the study was higher than the standard values (Table 2).

The correlation between the anthropometric measurements and neck circumference was given in the Table 3. While there was a high positive correlation between neck circumference and all anthropometric measurements of the women, a strong positive relationship were detected between the neck circum-

Table 1. Anthropometric measurements of participants

Anthropometric measurements	Women (n=85)		Men (n=16)	
	$\bar{X}$	SD	$\bar{X}$	SD
Height (cm)	160.6	5.78	176.7	4.36
Weight (kg)	88.2	14.08	107.4	15.76
BMI (kg/m²)	34.2	5.64	34.3	4.36
WC (cm)	105.2	11.45	115.9	9.87
NC (cm)	38.1	2.46	44.9	3.1
Body fat (%)	40.8	5.31	32.0	7.96
Fat mass (kg)	36.7	10.32	35.1	13.16
Lean body mass (kg)	51.5	5.03	71.9	8.06

BMI: Body Mass Index; WC: Waist Circumference; NC: Neck Circumference; SD: Standard Deviation.

Table 2. Body mass index, waist and neck circumference of participants

	Women (n=85)		Men (n=16)	
	n	%	n	%
BMI<24.9 kg/m²	2	2.3	-	-
BMI 25.0-29.9 kg/m²	18	21.2	3	18.7
BMI ≥ 30.0 kg/m²	65	76.5	13	81.3
WC (women ≥88 cm, men ≥ 102 cm)	83	97.6	15	93.8
NC (woman ≥34 cm, man ≥37 cm)	83	97.6	16	100.0

BMI: Body Mass Index; WC: Waist Circumference; NC: Neck Circumference

Table 3. Correlation between neck circumference and other anthropometric measurements of participants

	Neck circumference (cm)			
Antropometric measurements	Women (n=85)		Men (n=16)	
	r	p	r	p
Weight (kg)	0.686	<0.001	0.659	0.005*
BMI (kg/m²)	0.685	<0.001	0.745	0.001*
WC (cm)	0.531	<0.001	0.569	0.021*
Body fat (%)	0.586	<0.001	0.176	0.514
Fat mass (kg)	0.647	<0.001	0.369	0.160
Lean body mass (kg)	0.612	<0.001	0.682	0.004*

*Pearson correlation, *p <0 .05*

ference, body weight (r=0.659), waist circumference (r=0.569), and fat-free body mass (r=0.682) of the men.

Participants' biochemical findings were given in the Table 4. The mean fasting blood glucose and the mean fasting plasma insulin of the women were 87.4±9.61 mg/dL and 21.6±6.34 U/mL; and as for the men 90.9±10.99 mg/dL and 27.7±12.42 U/mL respectively. HOMA-IR value was 4.7±1.47 for the women and 6.2±2.89 for the men.

When the relationship among the insulin resistance parameters such as neck circumference, fasting plasma insulin, and HOMA-IR values were analyzed, a low positive correlation was stated between the neck circumference and insulin resistance parameters of the women (Table 5). In the linear regression analysis, a significant relationship was detected between the neck circumference and fasting plasma insulin, HOMA-IR values of the women (r^2=0.87, p<0.05).

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 (21).

Obesity used to be a rare condition until the 20th century, however in 1997, WHO officially acknowledged obesity as a worldwide epidemic. Sixty-five percent of world population live in countries where overweight and obesity are more prevalent death causes than underweight according to WHO reports (22,23).

In 2011-2012, the prevalence of obesity in the United States was 34.9% in adults (24). According to the study of the NHANES, the ratio of obese adults in America increased two fold from 15% in between

Table 4. Biochemical parameters of participants

Biochemical parameters	Women (n=85)		Men (n=16)	
	X	SD	X	SD
Fasting blood glucose (mg/dL)	87.4	9.61	90.9	10.99
Fasting plasma insulin (U/mL)	21.6	6.34	27.7	12.42
HOMA-IR	4.7	1.47	6.2	2.89

Table 5. Correlation between neck circumference and insulin resistance parameters

| | Neck Circumference (cm) | | | |
	Women (n=85)		Men (n=16)	
	r	p	r	p
Fasting Plazma Insülin (U/mL)	0.290	0.006*	-0.026	0.924
HOMA-IR	0.264	0.015*	-0.105	0.699

Pearson correlation, *p <0 .05

1971-1974 to 34% in between 2003-2006. A parallel shift is also visible in countries like Japan and Korea where obesity rates are the lowest of the world (25).

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/m² and overweight (BMI=25.0-29.9 kg/m²) were 30.3% and 34.6%, respectively (7).

Several methods exist that can be used for the evaluation of overweight and obesity. The most commonly used point of reference is BMI; however, it is not a favorable measurement to evaluate the fat distribution in body. Waist circumference, waist/hip ratio, and neck circumference are techniques that are used to evaluate central obesity. Waist circumference is an index for central obesity, and can also determine overweight and obesity. Anthropometric measurements such as neck circumference can also be employed to specify body fat distribution. Neck circumference, which is an indicator of adipose tissue distribution of the superior part of the body, is a genuine, simple, and non-time consuming measurement for the evaluation of obesity and overweight. 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 (13,26,27).

The study proposes the unrealized significance of neck circumference 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 adults with insulin resistance.

In the present study, the mean BMI was 34.2±5.64 kg/m² for women 34.3±4.36 kg/m² for men. According to WHO criteria, the 21.2% of the women and 18.8% of the men were overweight (BMI= 25.0-29.9 kg/m²) and 76.5% of the women and 81.3% of the men were obese (BMI≥30 kg/m²). Moreover, 97.6% of women and 93.8% of men had high waist circumference. This study findings were similar to the results of Saka et al. (28) (2014) who reported high waist circumference and waist/hip ratio among Turkish adults.

In the present study, the mean NC of the men and women were 44.90±3.10 cm, 38.10±2.46 cm respectively. These findings were higher than the results of Onat et al. (15) who reported 38.8±2.9 cm in men, 34.8±2.75 cm in women. The all of the men and 97.6% of women had NC ≥37 cm and ≥34 cm respectively (Table 2). These differences may be due to the BMI values of Onat's study had been lower than the people participated in the present study. In women, neck circumference correlated positively with body weight, waist circumferences, hip circumferences, waist/hip ratio and BMI (p<0.05). Similarly in the present study, there was statistically significant positive correlation

between NC and other anthropometric measurements in diabetic and non-diabetic groups according to Aswathappa et al. (29) as well as Ben-Noun et al. (13) who demonstrated that neck circumference is a valid marker for identifying obese individuals and correlated well with other anthropometric measurements.

Yang et al. (30) have shown 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 finding, a positively correlation was found between neck circumference and insulin resistance in our study. This finding was consistent with the results of Laakso et al. (31) who reported that neck circumference was associated with the metabolic disorders related to insulin resistance.

Conclusion

In this study, it is observed that two thirds of the individuals with insulin resistance were obese, and all had waist and neck circumferences higher than the cut-off values proposed for the metabolic syndrome. A positive but low correlation was found between neck circumference and all anthropometrical measurements, fasting plasma insulin and HOMA-IR index, which are indicators of insulin resistance. Therefore, neck circumference may be an additional anthropometric surrogate marker for insulin resistance and obesity just like waist circumference and BMI.

Limitation

There are some constraints of this study. The most prominent one is the inadequacy of the number of participants. In a study conducted in larger populations, the correlation between insulin resistance parameters and NC may be found higher.

Acknowledgements

Authors' contributions

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