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Evaluation of the Relationship between Neck Circumference and Metabolic Parameters in Women with Insulin Resistance

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ABSTRACT

Objectives: The aim of this study was to evaluate the relationship between neck circumference (NC), other anthropometric measurements, and metabolic parameters in women with insulin resistance (IR).

Methods: This study is a descriptive study carried out with volunteer female patients with IR who applied to the obesity outpatient clinic at a tertiary hospital. Patients with homeostasis model assessment of insulin resistance (HOMA-IR) ≥2.5 were included. A demographic questionnaire was applied, and anthropometric measurements, such as height, weight, body fat mass, body muscle mass, NC, waist circumference (WC), hip circumference, and middle-upper arm circumference, and body mass index (BMI), were all carried out by the researchers. Metabolic parameters were obtained from the patients' files after the necessary permission had been received.

Results: A total of 105 patients were included in this study. The mean NC was found to be 37.2±3.1 cm. NC showed a moderately positive correlation with BMI, WC, and body muscle mass (kg) (r=0.568, p<0.001; r=0.572, p<0.001; and r=0.589, p<0.001, respectively). It was also found that NC correlated positively with C-peptide, HOMA-IR, and triglyceride (r=0.194 p=0.048; r=0.199 p=0.043; and r=0.201, p=0.040, respectively). An association was found between NC and HOMA-IR after adjusting for age, triglyceride, total cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol with multiple linear regression analysis (p=0.027).

Conclusion: In conclusion, the NC of women with IR has a correlation with other anthropometric measurements as well as some metabolic parameters. When consulting IR patients, all anthropometric measurements should be recorded, including NC.

Keywords: Anthropometry, insulin resistance, neck

INTRODUCTION

Insulin resistance (IR) is a suboptimal response to the insulin hormone in cells that are insulin-dependent, such as adipocytes and cardiomyocytes. The leading cause of IR is obesity.[1] Although the exact underlying etiology of IR is still unclear, inflammation, oxidative stress, mitochondrial dysfunction, endoplasmic reticulum stress, and insulin receptor mutation are all thought to contribute to its occurrence.[2]

In a retrospective study conducted with 2746 healthy volunteers, it was determined that waist circumference (WC) measurement could be used to define IR, and WC <100 cm in both genders could be used to exclude IR.[3] Despite the common use of WC in the assessment of metabolic disorders and in patient follow-up, there are some limitations in its use in clinical settings, such as time of the day, the state of hunger/satiety of the patient, menstrual cycle, and edema in the body.[4] Neck circumference (NC) was first described by Vague et al. in 1956 and reported as a parameter that can be used to evaluate upper body fat accumulation for both genders and all age ranges.[5] Abdominal obesity is characterized by upper body fat accumulation and is associated with metabolic disorders, such as glucose intolerance, IR, type 2 diabetes mellitus (T2DM), hypertriglyceridemia, and nonalcoholic fatty liver disease.[6] Studies have shown that NC is closely related to metabolic syndrome factors and is more affected by the variability of metabolic risk factors in women than in men.[7,8] NC measurement is a simple technique that helps achieve results without the need for more complex methods.[9] It is important to establish the ease of use of NC measurement, as the neck is easily accessible and quick to measure, the measurement does not change according to the time of the day, and it can be used at any age.[10] It has been found that NC measurement, similar to other anthropometric measurements, has a high correlation with obesity and the risk of developing obesity-related metabolic diseases.[11]

The fact that NC measurement is an easy measurement for the evaluation of abdominal obesity and is not affected by conditions such as hunger and satiety suggests that NC can be used in evaluating patients in primary health care services.[8,9] From a preventive health perspective, determining the correlation of NC with IR is valuable in preventing T2DM.

The aim of this study was to evaluate the correlation of NC with other anthropometric measurements and metabolic parameters in women with IR.

METHOD

The study presented is a descriptive study that was carried out between May 2021 and December 2021 in the Obesity polyclinic of the Endocrinology department at Istanbul Goztepe Prof. Dr. Suleyman Yalcin City Hospital. Of the patients who applied to the obesity outpatient clinic, women aged between 18 and 45 years, who had their blood work for metabolic parameters checked in the last 15 days and who had IR, were included. IR was determined by homeostasis model assessment of insulin resistance (HOMA-IR). Questionnaires were used for data collection and were carried out in face-to-face interviews. The questionnaire used in this study included questions such as age, educational and marital status, and family history of T2DM. Metabolic parameters checked in the previous 15 days were taken from the patient's files. These parameters were fasting plasma glucose (FPG), fasting plasma insulin, C-peptide, HbA1c, total cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), and triglyceride. The HOMA-IR value was calculated from the formula [fasting plasma insulin (mg/dL) × FPG (mg/dL)]/405], and values ≥2.5 were accepted as indicating IR.[12]

All anthropometric measurements were carried out by the researchers when the patients visited the outpatient clinic. The height of the patients was measured with a fixed height meter with 0.5 cm intervals; the measurement was taken without shoes. WC was measured after normal exhalation, with an inflexible tape measure at the umbilicus level and without clothes in the area.[13] Hip circumference (HC) was measured from the widest area with an inflexible tape measure between the waist and the thigh.[13] The waist-to-hip ratio (WHR) and the waist-to-height ratio (WHtR) were calculated. Middle-upper arm circumference (UAC) was measured on the left arm of the patients using an inflexible tape measure. While measuring, the arm was bent 90˚ from the elbow, the midpoint between the acromial process on the shoulder and the olecranon process on the elbow was determined, and the circumference was measured.[14] NC was measured with an inflexible tape measure, with shoulders in the free position. Measurement was taken from the point where the thyroid cartilage is most protruding, with the head upright and eyes looking straight ahead.[15] For body analysis, an 8-electrode bioelectrical impedance device Tanita MC 780 MA (Tartı Medikal, Turkey), which performs segmental analysis, was used. Patients were asked to remove all metal items (e.g., rings, earrings, bracelets, watches, and phones), any heavy clothing, shoes, and socks before stepping on the device. The device was set to -1.0 kg for the remaining clothes. From these measurements, body weight, body fat (kg), body fat percentage (%), body muscle (kg), and body water (kg) values were recorded. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared and classified into five groups according to the World Health Organization. The BMI was considered normal if it was 18.5–24.9 kg/m^2, overweight if the BMI was 25.0–29.9 kg/m^2, obese class I if the BMI was 30.0–34.9 kg/m^2, obese class II if the BMI was 35.0–39.9 kg/m^2, and obese class III if the BMI was ≥40 kg/m^2.[16]

Those who were menopausal, who had any comorbidities, or who were using endocrine-related drugs (e.g., antidiabetic and thyroid hormone regulator) were excluded from the study.

The data were analyzed using the SPSS (Statistical Package for Social Sciences Version 20.0) program. The normal distribution of the variables was checked with the Kolmogorov–Smirnov test. Categorical variables were described as frequency distributions and presented as frequency and percentage. Continuous variables were described as mean, standard deviation, median, minimum, and maximum. A correlation of nonparametric variables was detected using Spearman's correlation, and parametric variables were detected by using Pearson's correlation tests. Logarithmic transformation was performed for the data that did not fit the normal distribution. Multiple linear regression analysis was used to calculate the adjusted β coefficients of NC for IR in different models with adjustment for potential confounders. For model 1, no variables were adjusted; for model 2, age was adjusted; and for model 3, age, triglyceride, total cholesterol, HDL-C, and LDL-C were adjusted. For all p-values, 0.05 or less was considered statistically significant.

RESULTS

A total of 105 women with IR were included in the study. The mean age of the participants was 32.4±9.1 years, BMI was 35.1±5.9 kg/m^2, and NC was 37.2±3.1 cm. Of the 105 participants, 79 (75.2%) had a familial history of T2DM. Only 3 (2.9%) of the participants were in the normal class for BMI, 13 (12.4%) were in the overweight class, 40 (38.1%) in obese class I, 28 (26.6%) in obese class II, and 21 (20.0%) in obese class III. Sixty-four (61.0%) of the participants were married. Regarding education, 18 (17.2%) of the participants were primary school, 12 (11.4%) secondary school, 46 (43.8%) high school, and 29 (27.6%) university graduates. The anthropometric and metabolic measurements of the participants are summarized in Table 1.

Table 1. Anthropometric and metabolic measurements of the participants

	Mean±SD
Weight (kg)	93.4±16.0
Height (cm)	163.0±0.1
BMI (kg/m^2)	35.1±5.9
WC (cm)	104.5±11.9
HC (cm)	123.3±11.6
NC (cm)	37.2±3.1
MUAC (cm)	34.3±3.9
WHtR (cm)	0.6±0.1
Body fat percentage (%)	38.1±5.3
Body fat mass (kg)	36.6±10.7
Body muscle mass (kg)	54.2±6.2
HbA1c (%)	5.7±0.4
LDL-c (mg/dL)	101.8±27.2
HDL-c (mg/dL)	51.4±11.6
Total cholesterol (mg/dL)	176.9±31.6
	Median (min–max)
FPG (mg/dL)	94.0 (74.0–120.0)
Fasting insulin (mU/L)	16.5 (10.3–39.9)
C-peptide (ng/mL)	2.9 (1.6–6.0)
HOMA-IR	4.0 (2.5–10.3)
Triglyceride (mg/dL)	104.0 (41.0–608.0)
WHR (cm)	0.8 (0.5–1.0)

BMI: Body mass index; FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; HC: Hip circumference; HDL-C: High-density lipoprotein cholesterol; HOMA: Homeostasis model assessment; IR: Insulin resistance; LDL-C: Low-density lipoprotein cholesterol; MUAC: Middle-upper arm circumference; NC: Neck circumference; WC: Waist circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio.

NC showed a moderately positive correlation with BMI and WC (r=0.568, p<0.001 and r=0.572, p<0.001, respectively). The relationship between NC and other anthropometric measurements is summarized in Table 2.

Statistically significant NC correlated positively with C-peptide and HOMA-IR (r=0.194, p=0.048 and r=0.199, p=0.043, respectively). The relationship between NC and metabolic parameters is summarized in Table 3.

Multiple linear regression models of NC with HOMA-IR in women with IR are summarized in Table 4. In model 1, with no adjustment for any confounding factors, there was a significant association between HOMA-IR and NC (p=0.023); this predicted 4% of the variance (R^2=0.040). When age was included in model 2, there was still a significant association (p=0.008); with this model the prediction was 7.2% of the variance (R^2=0.072). In model 3 where age, triglyceride, total cholesterol, LDL-C, and HDL-C were included, the association of HOMA-IR and NC was found to be statistically significant (p=0.027) and this model predicted 7.4% of the variance (R^2=0.074).

DISCUSSION

In this study, it was aimed to evaluate the correlation of NC with other anthropometric measurements and metabolic parameters in women with IR. It was determined that women aged between 18 and 45 years with IR had a mean NC of 37.2 cm. Considering previous studies, it is possible to say that a value of NC ≥34 cm for women may indicate

Table 2. Relationship between the neck and other anthropometric measurements

	Neck Circumference (cm)	
	r	p
BMI (kg/m²)	0.568	<0.001*
WC (cm)	0.572	<0.001*
HC (cm)	0.441	<0.001*
MUAC (cm)	0.494	<0.001*
WHtR (cm)	0.601	<0.001*
WHR (cm)	0.332	<0.001†
Body fat percentage (%)	0.260	0.007*
Body fat mass (kg)	0.412	<0.001*
Body muscle mass (kg)	0.589	<0.001*

BMI: Body mass index; HC: Hip circumference; MUAC: Middle-upper arm circumference; NC: Neck circumference; WC: Waist circumference; WHR: Waist-to-hip ratio; WHtR: Waist-to-height ratio.

*Pearson correlation test; †Spearman correlation test.

Table 3. Relationship between the neck circumference and metabolic parameters

	Neck Circumference (cm)	
	r	p
LDL-c (mg/dL)	-0.156	0.114*
HDL-c (mg/dL)	-0.134	0.172*
Total cholesterol (mg/dL)	-0.067	0.499*
HbA1c (%)	-0.015	0.878*
FPG (mg/dL)	0.179	0.068†
Fasting insulin (mU/L)	0.147	0.135†
C-peptide (ng/mL)	0.194	0.048†
HOMA-IR	0.199	0.043†
Triglyceride (mg/dL)	0.201	0.040†

FPG: Fasting blood glucose; HbA1c: Hemoglobin A1c; HDL-C: High-density lipoprotein cholesterol; HOMA: Homeostasis model assessment; IR: Insulin resistance; LDL-C: Low-density lipoprotein cholesterol.

*Pearson correlation test; †Spearman correlation test.

an increased risk of IR, T2DM, and metabolic syndromes.[17,18] In a study carried out in 2001, it was determined that a value of NC ≥34 cm in female adults increases the risk of metabolic diseases.[19] According to the Turkey Nutrition and Health Survey 2017, the average NC was found to be 34.9 cm in women aged 19 years and over in Turkish society.[20] As patients diagnosed with IR were included in our study, the mean of NC was determined to be above 34 cm, as expected.

In our study, there was a statistically significant correlation with NC and all other anthropometric measurements. NC showed a moderately positive correlation with BMI, WC, WHtR, and body muscle mass, and showed a weak positive correlation with HC, MUAC, body fat mass, body fat mass, and WHR. A study conducted by Pei et al. in 2018 with 1169 adults also demonstrated a similar result to this study; that is, NC has a moderately positive correlation with WC and BMI.[21] In a study conducted with patients diagnosed with T2DM in 2014, it was found that body weight, BMI, WC, and HC showed strong positive correlations with NC in both genders.[22] Considering the positive correlation between NC and WC, both in the literature and in this study, and the known relationship between WC and IR, it can be concluded that there may be a relationship between NC and IR.

When NC and metabolic parameters were analyzed, it was found that NC correlated positively with C-peptide, HOMA-IR, and triglyceride in adult women with IR. Assyov et al. also demonstrated that NC had a positive correlation with FPG, fasting insulin, and Finnish Diabetes Risk Score, which helps determine the risk for diabetes.[23] Other studies found similar results to our study in that NC has a positive correlation with HOMA-IR.[24,25]

Furthermore, after adjusting for potential confounding factors in the multiple linear regression, a statistically significant association between HOMA-IR and NC was found, and when age, triglyceride, total cholesterol, LDL-C, and HDL-C were adjusted, it was demonstrated that NC predicted 7.4% of the variance. A recent study conducted with patients diagnosed with polycystic ovary syndrome found similar results due to the association between HOMA-IR and NC.[26] Over recent years, it has been demonstrated that NC is an easy tool to use in clinical settings, and while WC can be affected by the time of the day, the state of hunger/satiety of the patient, edema in the body, or menstrual cycle, NC does not fluctuate in the same way. Different studies have determined that NC has a good correlation with other anthro-

Table 4. Multiple linear regression models of the neck circumference with HOMA-IR in women with IR

	Adjusted R²	β	F	p
Model 1	0.040	0.222	5.323	0.023
Model 2	0.072	0.274	5.051	0.008
Model 3	0.074	0.216	2.660	0.027

Model 1: not adjusted; Model 2: adjusted for age; Model 3: adjusted for age, triglyceride, total cholesterol, HDL-C, and LDL-C.

HOMA: Homeostasis model assessment; IR: Insulin resistance.

Multiple linear regression.

pometric measurements and some metabolic parameters that are used to determine IR or T2DM.[25,27] Our study was conducted with female patients with IR and demonstrates that NC is an easy measurement and might be a useful tool for this patient group. NC may probably give an idea of BMI, body fat mass, C-peptide, HOMA-IR, and triglyceride levels.

One of the most important limitations of this study is that it is a single-centered study, and the number of individuals who participated was relatively low. For the diagnosis of IR, we used HOMA-IR instead of hyperinsulinemic-euglycemic clamp, which is accepted as the gold standard. Another limitation is that it is a descriptive study. With further intervention studies, the relationship between changing anthropometric measurements and metabolic parameters of patients with IR and NC should be examined.

CONCLUSION

While evaluating women with IR, NC measurements should be obtained. In this study, we determined that women with IR have an average NC of 37.2 cm. This study has demonstrated that NC has a positive correlation with C-peptide and HOMA-IR, both of which are used to determine IR. For this reason, when tracking changes in other anthropometric measurements, NC should be included.

Disclosures

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