ORIGINAL ARTICLE

Can neck circumference predict cardiometabolic risk factors?

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Summary. *Background and aim:* This study aims to evaluate the association between neck circumference (NC) and several cardio-metabolic risk parameters, to compare it with some anthropometric variables. *Methods:* A total of 331 women, aged 20-49 years were recruited. Anthropometric measurements (body weight, height, waist and neck circumferences) and biochemical parameters [serum fasting blood glucose (FBG), fasting blood insulin (FBI), triglycerides, high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), and fibrinogen] were collected. Homeostasis model assessment-estimated IR (HOMA-IR) was calculated. *Results:* According to World Health Organization criteria, percentages of women with normal weight, overweight, obese and morbidly obese were 14.2%, 31.7%, 44.7%, 7.9%, respectively. Seventy-one percent of women had NC less than 37 cm, while that of twenty-nine percent of the women had higher. NC was moderately correlated with BMI, WC, FBI, HOMA-IR, and fibrinogen. A positive weak correlation was found between NC and FBG (p=0.031), TG (p=0.000), and LDL cholesterol (p=0.016). Moreover, a negative weak correlation was found between NC and HDL cholesterol (p= 0.000). A positive relationship between plasma fibrinogen and body weight (r=0.222), BMI (r=0.242), WC (r=0.187), TG (r=0.124), and LDL cholesterol (r=0.118) were detected whereas a negative relationship were found between HDL cholesterol and plasma fibrinogen (r=- 0.119) levels. *Conclusion:* A significant relation is existent between neck circumference and cardio-metabolic risk factors. NC could be used, it is easy to implement, an effective anthropometric measurement to the prediction of cardio-metabolic risks. Its usage together with anthropometric measurements such as waist and hip circumferences, waist-hip ratio and BMI which are widely used to determine cardio-metabolic risks can provide clinical benefits.

Key words: obesity, neck circumference, cardio-metabolic risk factors

Introduction

Cardio-metabolic syndrome is a community of metabolic disorders such as glycolipid metabolism disorder, adiposity, insulin resistance and hypertension (1). One of the components of this syndrome, obesity threats public health because of its prevalence. It poses a risk with regards to cardiovascular diseases as it affects blood lipid level; causes glucose metabolism dis-order, Type 2 diabetes and increase in blood pressure; has negative effects on inflammation and may distort cardiovascular structure and function (2,3). Anthropometric measurements such as body mass index (BMI) and waist circumference (WC) are used to assess obesity. In conducted researches, it has been made clear that both of these measurements have a positive relation with the increase in morbidity associated with obesity (4,5). BMI is used to conjecture body weight

in accordance with height; however, it does not give information about fat distribution in the body. WC is more widely used than BMI since it is the indicator of abdominal visceral fat tissue which has an important role in cardiovascular risk (6). Upper body subcutaneous adipose tissue is related with cardio-metabolic risks at least as much as abdominal visceral fat tissue is (7). In conducted researches, it has been detected that the upper body fat tissue is positively related to free fatty acid (FFA) concentration (8-10). Furthermore, FFA increase is associated with insulin resistance, endothelial dysfunction, very low-density lipoprotein increase and high-density lipoprotein decrease (10). Neck circumference (NC) measurement is used as a risk indicator for cardio-metabolic diseases since it is an anthropometric method which evaluates the distribution of subcutaneous adipose fat tissue (7). Another factor role of which is identified in cardiovascular disease pathophysiology is plasma fibrinogen. Fibrinogen is a coagulation factor and an acute phase indicator of inflammation. In an epidemiological study which analyzes the changes in fibrinogen level and plasma viscosity or size and hardness of thrombus, a positive relation between high plasma fibrinogen and cardiovascular diseases has been detected (11).

The aim of this research is to determine the link between neck circumference and cardio-metabolic risk parameters.

Materials and methods

Study population

The cross-sectional study was conducted between March 2012 and May 2013. A total of 331 women, aged 20-49 years, who attended to the İzmir Bozyaka Training and Research Hospital Internal Medicine, Endocrinology and Diet Outpatients Clinics were recruited.

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, chronic diseases such as diabetes mellitus, renal, liver and heart failure, rheumatoid arthritis and thyroid problems. 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 Celebi University, İzmir, Turkey (Approval number 03/07/2014-135).

Anthropometric measurements

Anthropometric measurements were conducted by a researcher dietitian according to criteria suggested by WHO (12). Bioelectrical impedance analyser (TANITA TBF 300, Tanita Corp., Tokyo, Japan) was used to measure body weight. Subjects were instructed to avoid food or beverage intake and 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 stadiometer while women standing barefoot, keeping their shoulders in a relaxed position, arms hanging freely and head in Frankfort horizontal plane. All the anthropometric measurements of the subjects were measured three times and the mean values were obtained. Based on participants' calculated BMI values, women were classified as normal weight (BMI=18.5-24.9 kg/m²), overweight (BMI=25.0-29.9 kg/m²), obese (BMI=30-39.9 kg/m²) and morbidly obese (BMI≥40 kg/m²) according to WHO criteria (13).

WC was measured while the individuals were standing, arms were open on both sides and feet were together. WC was measured with a tape measure between the iliac crest and the lowest rib (mid-point crossing circumference) when the individual exhaled. The tape measure was positioned horizontally, parallel to the floor, and measurement was carried out with attention paid to applying no pressure to the skin (14). WHO waist circumference ≥88 cm for women, was evaluated of abdominal obese (15).

NC was measured below the cricoid cartilage, at the level of the mid cervical spine. Women with NC ≥34 cm require evaluation of overweight status (16).

Assessment of biochemical parameters
Biochemical analysis

Following a 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), and fibrinogen were analysed in the Izmir Bozyaka Training and Research Hospital Laboratory. Serum FPG, TG, HDL-C, and LDL-C were determined with kits using Architect c16000 autoanalyzer (Abbott Diagnostics, USA). Serum fibrinogen was detected with kits using enzyme-linked Immuno Sorbent Assay (ELİSA) methods (17).

Homeostasis model assessment-estimated IR (HOMA-IR) was also calculated with the following formula: fasting serum glucose (mg/dL) × fasting plasma insulin level (μU/mL) / 405 (18).

Statistical Analysis

SPSS version 21.0 (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Normality of the data distribution was determined with the Kolmogorov-Smirnov test. Descriptive analysis [mean±standard deviation, frequencies (%)] were performed. Pearson correlation test was used to determine relationship between NC, WC and cardio-metabolic risk factors/ biochemical parameters. Results were evaluated with 95% confidence intervals. Two-sided p values were calculated and p<0.05 was set as statistically significant.

Results

The mean age, WC and NC of women were 32.9±7.87 years, 96.0±12.82 cm and 35.1±2.91 cm, respectively. In addition, the mean FBG, TG, HDL and LDL cholesterol levels were 89.5±11.78 mg/dL, 110.4±63.59 mg/dL, 53.0±12.54 mg/dL and 117.1 ± 36.67 mg/dL, respectively (Table 1). According to WHO criteria (14), percentages of women with normal weight, overweight, obese and morbidly obese were 14.2%, 31.7%, 44.7%, 7.9%, respectively. Seventy-one percent of women participating in this study, had NC less than 37 cm, while that of twenty-nine percent of the women had higher NC. It had been detected that WC of 11.5% of the women was ≤80 cm whereas 72.2% of them had 88 cm or more (Table 2).

According to Table 3, a positive strong correlation was found between body weight and NC whereas a moderate correlations were found between BMI, WC, FBI, HOMA-IR, and fibrinogen levels (p=0.000). A

Table 1. Anthropometric Measurements and Biochemical Parameters

Variables	X	SD
Age (year)	32.9	7.87
Height (cm)	161.4	9.53
Body weight (kg)	80.9	16.16
Body mass index (kg/m²)	30.9	6.14
Waist circumference (cm)	96.0	12.82
Neck circumference (cm)	35.1	2.91
Fasting blood glucose (g/dL)	89.5	11.78
Fasting plasma insulin (m/UL)	9.8	6.26
HOMA-IR	2.21	1.63
Triglycerides (mg/dL)	110.4	63.59
LDL (mg/dL)	117.1	36.67
HDL (mg/dL)	53.0	12.54
Fibrinogen (mg/dL)	346.6	86.24

Table 2. Body Mass Index, Waist and Neck Circumference Classification

	n	%
BMI (kg/m²)		
<18.5	5	1.5
18.5 – 24.9	47	14.2
25.0 – 29.9	105	31.7
30.0 – 39.9	148	44.7
≥ 40.0	26	7.9
Waist circumference (cm)		
< 80	38	11.5
≥ 80 - < 88	54	16.3
≥ 88	239	72.2
Neck circumference (cm)		
< 34	235	71.0
≥ 34	96	29.0

positive weak correlation were found between NC and FBG (p=0.031), TG (p=0.000), and LDL cholesterol (p=0.016). Moreover, a negative weak correlation was found between NC and HDL cholesterol (p= 0.000) (Table 3).

A positive strong correlations were found between WC and body weight (r=0.784), BMI (r=0.782), FBI (r=0.525), and HOMA-IR index (r= 0.498). While a positive weak correlation was found between WC and plasma fibrinogen (r=0.187), a negative moderate correlation was determined between HDL cholesterol (r= - 0.309) and WC (Table 4).

A positive relationship between plasma fibrinogen and body weight (r=0.222), BMI (r=0.242),

Table 3. Correlations Between Neck Circumference, Waist Circumference, Plasma Fibrinogen and Cardio-metabolic Risk Parameters

Cardio-metabolic Risk Parameters	Neck Circumference		Waist Circumference		Plasma Fibrinogen	
	r	p	r	p	r	p
Body weight (kg)	0.714	0.000*	0.784	0.000*	0.222	0.000*
Body mass index (kg/m²)	0.688	0.000*	0.782	0.000*	0.242	0.000*
Waist circumference (cm)	0.655	0.000*	-	-	0.187	0.001*
Fasting blood glucose (mg/dL)	0.119	0.031*	0.171	0.002*	0.016	0.767
Fasting blood insulin (U/mL)	0.417	0.000*	0.525	0.000*	0.107	0.058
HOMA-IR	0.385	0.000*	0.498	0.000*	0.105	0.063
Triglycerides (mg/dL)	0.216	0.000*	0.355	0.000*	0.124	0.024*
LDL (mg/dL)	0.132	0.016*	0.105	0.056	0.118	0.032*
HDL (mg/dL)	- 0.240	0.000*	- 0.309	0.000*	- 0.119	0.031*
Fibrinogen (mg/dL)	0.320	0.000*	0.187	0.001*	-	-

*Pearson Correlation test *p<0.05*

Table 4. Correlation Between Cardiometabolic Risk Parameters and Waist Circumference

Cardiometabolic Risk Parameters	Waist Circumference	
	r	p
Weight (kg)	0.784	0.000*
Body mass index (kg/m²)	0.782	0.000*
Fasting blood glucose (mg/dL)	0.171	0.002*
Fasting plasma insulin (U/mL)	0.525	0.000*
HOMA-IR	0.498	0.000*
Triglycerides (mg/dL)	0.355	0.000*
LDL (mg/dL)	0.105	0.056
HDL (mg/dL)	- 0.309	0.000*
Fibrinogen (mg/dL)	0.187	0.001*

*Pearson Correlation test *p<0.05*

Table 5. Correlation Between Cardiometabolic Risk Parameters and Plasma Fibrinogen

Cardiometabolic Risk Parameters	Plasma Fibrinogen	
	r	p
Weight (kg)	0.222	0.000*
Body mass index (kg/m²)	0.242	0.000*
Waist circumference (cm)	0.187	0.001*
Fasting blood glucose (mg/dL)	0.016	0.767
Fasting plasma insulin (U/mL)	0.107	0.058
HOMA-IR	0.105	0.063
Triglycerides (mg/dL)	0.124	0.024*
LDL (mg/dL)	0.118	0.032*
HDL (mg/dL)	- 0.119	0.031*

*Pearson Correlation test *p<0.05*

WC (r=0.187), TG (r=0.124), and LDL cholesterol (r=0.118) were detected whereas a negative relationship were found between HDL cholesterol and plasma fibrinogen (r=- 0.119).

Discussion

Since it was known that upper body fat tissue is related to cardio-metabolic risk at least as much as abdominal lipoidosis is, neck circumference measurement can be used as effectively as waist circumference in determining the cardio-metabolic risks (7).

Starting from this point, this cross-sectional research which analyzes the relation between neck circumference and cardio-metabolic risk indicators had confirmed that a correlation exists among individuals' anthropometric measurements (weight, BMI, and waist circumference) biochemical indicators (fasting blood glucose, insulin, HOMA-IR, triglycerides, HDL, LDL, fibrinogen) and neck circumference.

BMI, which is frequently used in evaluating obesity, does not indicate the regional fat distribution of a body (2). However, distribution of a fat tissue is important for metabolic and cardiovascular diseases and waist circumference is widely used for determining it

(5,6). Studies show that upper body subcutaneous fat tissue evaluated by neck circumference measurement in that it indicates cardio-metabolic risks is as important as abdominal visceral fat tissue (7,19).

The average neck circumference obtained from this research (35.1±2.91 cm), was higher than that of Framingham heart study (7) (34.2±2.8 cm) and Saka et al. study (33.43±3.17 cm); and lower than (36.6±2.9 cm) that of Liu et al. (21) which is obtained from women under the age of 65. Moreover, a correlation had been determined between BMI and waist circumference in this research similar to Framingham's heart study and Saka et al. study (7, 21). On the other hand, Liu et al. did not detect a correlation between BMI and waist and neck circumferences in their study conducted on the women under the age of 65 (20).

Atherogenic dyslipidemia, which is a common form of dyslipidemia, is characterized by high triglyceride and LDL levels and low HDL cholesterol level (22). In this study, after the lipid profiles of the individuals had been analyzed, a positive correlation between neck circumference and LDL cholesterol and TG levels has been detected, whereas a negative one had been found between neck circumference and HDL cholesterol level. While the waist circumference was positively correlated to TG level and negatively to HDL level, no significant relation between waist circumference and LDL cholesterol had been detected. Similar to this study, a correlation had been noticed between neck circumference and TG and HDL in Vallianou et al. research (23). In Framingham heart study, a correlation between neck circumference of men and their LDL cholesterol levels had not been confirmed (7). Furthermore, in Zhou et al. research it had been found that both neck and waist circumference was positively linked to TG and LDL and negatively to HDL cholesterol (24).

Free fatty acid concentration was directly related to insulin resistance (25, 26). For this reason, upper body fat tissue is essential in that it affects the free fat acid level in circulatory system and it has a higher lipolytic activity than the lower body (25, 26). Framingham Heart Study had detected a positive link between neck circumference and type 2 diabetes and insulin resistance (7). Therefore, in addition to waist circumference, neck circumference could also be used as a fast and easy method to determine obesity and insulin resistance. In this research similar to Wang et al. study (27), a positive correlation had been detected between neck and waist circumferences and HOMA-IR. Different from this research, Turan et al (28) had not noticed any correlation between neck and waist circumferences and fasting glucose in patients with Type 2 DM.

The researches which analyze the relation between fibrinogen and adiposity show that individuals with obesity and mild adiposity have high levels of fibrinogen (29). Although no data exists about fibrinogen being synthesized in adipose tissue, it was shown that adipokines which rises with adipose tissue increase cause fibrinogen and other coagulation factors to increase in the liver (30). What's more, the studies indicate that an evaluation in fibrinogen levels was an important factor with regards to cardiovascular diseases (30-32). Similar to Hafez et al. research (31), this study had revealed a positive correlation between neck and waist circumferences and fibrinogen levels. In Kunutsor et al. (33) meta-analysis, a positive correlation had been detected between fibrinogen level and total cholesterol, TG and fasting blood glucose whereas a negative correlation exists between fibrinogen and HDL. This research had yielded similar results. In conclusion, a significant relation was existent between neck circumference and cardio-metabolic risk factors. Neck circumference is an easy and effective anthropometric measurement. For this reason, its combination with anthropometric measurements such as waist and hip circumferences, waist-hip ratio and BMI which are widely used to determine cardio-metabolic risks can provide clinical benefits.

Limitation

There are some constraints of this study. The fact that the individuals' vital symptoms such as pulsation and blood pressure were not evaluated in the scope of the research and that only women were analyzed by the researchers are the main constraints of this research. However, the number of individuals included in the research was among the strengths of it.

Acknowledgements

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