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Research Article

The Relationship Between Body Mass Index, Waist Circumference, Neck Circumference and Cardiovascular Risk Factors

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Abstract

Background: This study aimed to estimate the correlation between body mass index, waist circumference and neck circumference and cardiovascular risk factors in healthy adult men and women with no history of any disease or chronic drug intake from Diyarbakır and Dicle University medical faculties.

Materials and methods: The study included 199 subjects, 113 males (mean age 36.5 ± 11.3 years) and 86 females (mean age 33.8 ± 11.7 years) aged between 20 and 73 years. Age, height, weight, blood pressure, pulse rate, anthropometric methods; waist circumference (WC), body mass index (BMI), neck circumference (NC), blood glucose and insulin levels were determined. Insulin resistance was evaluated with the Homeostasis model assessment (HOMA-IR) formula. Total-cholesterol, triglyceride, LDL-cholesterol, HDL-cholesterol levels were measured. Pearson correlation and independent t-test were applied to the obtained study parameters.

Results: 47.7% of women were obese, 1.2% were morbidly obese and 59.3% of men were obese. Waist circumference correlated with systolic blood pressure (r=0.426, p<0.001), diastolic blood pressure (r=0.414, p<0.001), total cholesterol (r=0.450, p<0.001), triglycerides (r=0.556, p<0.001) and LDL-cholesterol (i=0.486, p<0.001), and a negative correlation was found between waist circumference and HDL-cholesterol (r=0.261, p<0.001). In women, the relationship between BMI and HOMA-IR (r-0.415, p<0.001) was stronger than the relationship between waist circumference and HOMA-IR (r=0.333, p=0.02). In men, we found a positive correlation between waist circumference and HOMA-IR (r=0.271, p=0.04). In men, we found no correlation between BMI and HOMA-IR. Neck circumference was correlated with waist circumference (i=0.732), total cholesterol (r=0.534), triglycerides (r=0.365), LDL cholesterol (i=0.406), BMI (r=0.568), systolic blood pressure (r=0.200), diastolic blood pressure (r=0. 290), and glucose (r=0.280) (p < 0.001).

Conclusions: Waist circumference was more tightly correlated with metabolic parameters. Waist circumference may better reflect the risk of cardiovascular disease than BMI. Neck circumference measurement, a new obesity indicator, can also be used as an obesity assessment method.

Keywords: Cardiovascular risk factors, body mass index, waist circumference, neck circumference

INTRODUCTION

Obesity is recognised as a worldwide epidemic and the rate continues to rise. According to the latest figures from the World Health Organisation (WHO) [1], approximately 13% of the world's adult population is obese and it is estimated that 50% of the US adult population will be obese by 2030 [2]. Obesity is more common in women than men, especially in middle and older age groups [3,4].

WHO defines obesity and overweight as abnormal or excessive fat accumulation at a level that may impair health [5]. Excessive adiposity greatly increases chronic disease morbidity and mortality, including cardiovascular disease (CVD) [6]. Although measures of adiposity such as body mass index (BMI) or waist circumference (WC) are not the best markers for CVD compared with other cardiovascular risk factors, increased adiposity is strongly associated with the development of insulin resistance, diabetes mellitus (DM). BMI is the most widely used measure of obesity due to its simplicity and reproducibility [5,7]. However, it does not take into account fat distribution. Fat accumulation in the trunk is associated with atherogenic dyslipidemia, type 2 DM, hypertension and inflammation, all of which increase CVD risk [8]. BMI is a more precise indicator of visceral fat accumulation and an adverse metabolic profile than BMI7. However, the two indices are strongly correlated and therefore have similar associations with cardiovascular risk [9]. Another recently used anthropometric measurement is neck circumference (NP), which has been found to be positively correlated with metabolic syndrome elements in studies [10,11].

This study was conducted to evaluate the relationship between Body Mass Index (BMI), Waist Circumference (WC) and Neck Circumference (NC) with major cardiometabolic risk factors and to confirm whether BMI, WC and NC are independently associated with these risk factors.

MATERIALS AND METHODS

Between May-2002 and September-2003, 199 male and female adults from Dicle University Faculty of Medicine and Diyarbakır province were included in the study. A total of 199 individuals aged between 20 and 73 years (mean age 35 ± 11 years), 86 females (mean age 33.8 ± 11.7 years) and 113 males (mean age 36.5 ± 11.3 years), with BMI ranging from 16.3 kg/m2 to 41 kg/m2 (mean 25.7 ± 4.5 kg/m2) were included. University staff and healthy relatives of patients with no history of any disease or drug use were included in the study.

Anthropometric measurements

Waist circumference: Waist circumference was measured in centimetres around the midpoint between the spina iliaca anterior superior and the costal arch.

Body mass index (BMI): It was obtained by the ratio of body weight to the square of height.

Neck circumference: Measured in centimetres from the centre of the neck.

Blood pressure: Systolic and diastolic blood pressures were measured twice with a mercury sphygmomanometer with an appropriate cuff size on the right arm after a rest period of 5 min in a sitting position.

Biochemical methods: Blood samples for serum lipids (triglycerides, total cholesterol, HDL-cholesterol, HDL-k, LDL-k, VLDL-k), fasting blood glucose and basal insulin measurements were obtained from each subject between 08-09 hours in the morning after 12 hours of fasting. LDL-cholesterol. Calculated using the Freidwald equation (LDL-cholesterol=Total-cholesterol-(HDL-k+Triglyceride/5)). insulin resistance: Measured by HOMA-IR test.

HOMA (Homeostasis-model assessment) = insulin (µU/ml) x Glucose (mmol/1)/ 22.5

Statistical Analysis

Pearson's correlation (2 tailed) was applied to all individuals included in the study, male and female groups separately without considering waist circumference, BMI and neck circumference. P<0.05 was accepted as significant. As subgroups, two groups were formed for men (waist circumference < 102, waist circumference > 102) and two groups for women (waist circumference < 88, waist circumference > 88). Two subgroups were formed as BMI < 25 kg/m2 and BMI > 25 kg/m2 for men and women. Independent t-test was applied to subgroups. Mean ± standard deviations were used in group comparisons. P<0.05 was accepted as significant. Statistical analyses were performed with SPSS version 8.

RESULTS

General study parameters in men and women: Systolic and diastolic blood pressures, body mass indexes, total cholesterol and LDL cholesterol levels, insulin and glucose levels were similar in men and women. In men, height was taller, weight, waist circumference, neck circumference, triglyceride levels were higher and HDL-cholesterol levels were lower (table I).

Table I: Characteristics of the study group

n	Male	Female
199	113	86
AGE (year)	36,5 ± 11,3	33,8 ± 11,7
SP (mmHg)	117,6 ± 15,1	113 ± 15,6
DP(mmHg)	74,4 ± 9,9	69,8 ± 11,7
HEIGHT (m)	173 ± 5,9	160 ± 6,7
WEIGHT (kg)	77,1 ± 11,4	65,7 ± 13,8
Waist circumference (cm)	94 ± 10,6	83,7 ± 13,4
NECK (cm)	38,6 ± 2,7	34,3 ± 3,1
TRG (mg/dl)	164 ± 71	132 ±118
T.CHOL (mg/dl)	178 ± 37	185 ± 44
HDL-C (mg/dl)	35 ± 6,6	41,5 ± 12,2
LDL-C (mg/dl)	112 ± 35	109 ± 43
INSULIN (iU/ml)	10,1 ± 8,1	9,4 ± 11
BMI (kg/m^2)	25,7 ± 3,4	25,6 ± 5,6
GLUKOZ (mg/dl)	99±32	95±22

LDL-k; LDL-cholesterol, T-CHOL; Total-cholesterol, TRG; TriglycerideHDL-k; HDL-cholesterol, SP; Systolic pressure, DP; Diastolic pressure, BMI; Body mass index

Study parameters showing the correlation between waist circumference, body mass index (BMI), neck circumference and cardiovascular risk factors (table II) Among anthropometric measurements, waist circumference was more strongly correlated with cardiovascular risk factors than BMI and neck circumference ($p < 0.001$). Waist circumference showed the strongest negative correlation with HDL-cholesterol. The strongest correlation between systolic and diastolic blood pressures and anthropometric measurements was with waist circumference.

Table II: Correlations between anthropometric measurements and cardiovascular risk factors

	STA	DTA	VYK	T.KOL	TG	HDL-k	LDL-k
Waist circumference (cm)	r=0,426 p<0,001	r=0,414 p<0,001	r=0,795 p<0,001	r=0,450 p<0,001	r=0,556 p<0,001	r=0,261* p<0,001	r=0,486 p<0,001
BMI (kg/m²)	r=0,339	r=0,314	r=0,849	r=0,431	r=0,386	r=0 151*	r=0,464
	p<0,001	p<0,001	p<0,001	p<0,001	p<0,001	P=0,055	p<0,001
Neck circumference	r=0,260	r=0,290	r=0,318	r=0,534	r=0,365	r=0,131*	r=0,406
	p<0,001	p<0,001	p<0,001	p<0,001	p<0,001	p=0,223	p<0,001

BMI; Body mass index *; Negatively correlated

DISCUSSION

In our study, we investigated the relationship between body anthropometric measurements and lipid parameters. As a result, hyperglycemia, dyslipidemia, hypertension and obesity-related complications were determined. Blood pressure, total cholesterol, triglycerides, glucose, HOMA-IR, body fat mass, and total cholesterol, total cholesterol, triglycerides, glucose, HOMA-IR were found to be increased in the groups with a waist circumference of 102 cm and a BMI above 25 kg/m2 for men and in the groups with a waist circumference of 88 cm and a BMI above 25 kg/m2 for women. Waist circumference better reflected the risk of cardiovascular disease than BMI (table II). Waist circumference was more strongly correlated with systolic and diastolic blood pressure, total cholesterol, triglycerides, LDL-cholesterol. There was a strong correlation between waist circumference and triglycerides in both men and women and this correlation was higher than other anthropometric measurements (r = 0;556). Triglyceride level increases with increasing waist circumference and this condition is called hypertriglyceridemic waist. Studies indicate that hypertriglyceridemic waist can be used as the only criterion to reflect cardiovascular risk factors [12]. As waist circumference and BMI increase, HDL-cholesterol level decreases. The negative correlation between waist circumference and HDL-cholesterol was stronger than BMI (r = - 0.261, p < 0.001). Waist circumference measurements showed a similarly strong correlation with BMI (r = 0.865) and body weight (r = 0.819). In our study, we found that waist circumference and BMI were correlated with cardiovascular risk factors independently of each other. When the measurement parameters were taken into consideration, it was found that waist circumference was more closely correlated with cardiovascular risk factors in men and women than BMI. However, body fat mass was better correlated with BMI.

In reality, an inherent difficulty with the use of BMI as an indicator of adiposity is that BMI consists of two components [13]; fat mass (fat mass, FM) and fat free mass (free fat mass, FFM).

BMI= (fat mass + fat free mass) / m2 = FM /m2 + FFM / m2

FM I m2-+ is used as fat mass index, FFM / m2 -+ as lean mass index.

The use of BMI as a substitute for both FM and adiposity may affect different health problems. Waist circumference, on the other hand, is not affected much by height [14], so it is unnecessary to divide waist by height when waist circumference is used as an index of adiposity. Due to these features, waist circumference is more advantageous than BMI as it is easily applicable and correlates more strongly with body weight and lipid parameters. Waist circumference has been widely used in recent epidemiological studies [15,16,17]. Recent recommendations for the use of waist circumference as a single measure of body fat and fat distribution are now accepted by many major public health agencies and organisations [18,19,20]. Pauliot et al. found increased cardiovascular risk in men with a waist circumference over 87 cm and in women with a waist circumference over 78 cm [21]. The Framingham Heart Study also found that waist circumference was more powerful than other anthropometric measurements in predicting mortality [22]. The World Health Organisation recommends waist circumference as a basic anthropometric measurement along with BMI [23].

In many consecutive large-scale studies, an association between waist circumference and diabetes and cardiovascular risk factors has been found (the US Third National Health and Nutrition Examination Survey [24] and the Italian olivetti heart study [25]. Recent studies have found that waist circumference is closely associated with insulin resistance in women [26]. In our study, the HOMA-IR method was used to evaluate insulin resistance. In women, the relationship between body mass index and insulin resistance (r=0.415, p<0.001) was stronger than the relationship between waist circumference and insulin resistance (r=0.333, p=0.02). In men, we found a positive correlation between waist circumference and HOMA-IR (r=0.271, p=0.04). In our study, we did not find a correlation between BMI and HOMA-IR in men. In recent studies, waist circumference has been found to be closely associated with insulin resistance syndrome in women [26], type 2 diabetes in men [15], breast cancer in women [27] and colon cancer in men [28]. In this respect, waist circumference measurements can be used as a method to assess general health risks. In our study, we evaluated nuchal circumference in addition to

anthropometric measurements. Nuchal circumference was correlated with body weight (r=0.760), waist circumference (r=0.732), total cholesterol (r=0.534), triglycerides (r=0.365), LDL cholesterol (r=0.406), BMI (r=0, 568), systolic blood pressure (r=0.260), diastolic blood pressure (r=0.290), glucose (r=0.280) and p < 0.001 in all correlations. Long neck circumference was positively correlated with metabolic syndrome elements [10,11].

CONCLUSION

Obesity may lead to increased blood pressure, dyslipidemia and insulin resistance.

There is a relationship between BMI, waist circumference, neck circumference and dyslipidemia in determining obesity characteristics.

A tighter relationship was found between waist circumference and metabolic parameters.

Waist circumference may reflect cardiovascular disease risk better than BMI.

Neck circumference measurement, which is a new obesity indicator, can also be used as an obesity assessment method.

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