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Title: Relationship between neck circumference, standard anthropometric measures and blood pressure values in Bosnian young adults

Authors: Asija Zaciragic[1], Mehmed Elezovic[2], Nesina Avdagic[1], Nermina Babic[1], Amela Dervisevic[1], Orhan Lepara[1], Jasminko Huskic[1]

Institutions: [1]Department of Human Physiology, University of Sarajevo School of Medicine, Sarajevo, Bosnia and Herzegovina

[2]Clinic of Family Medicine, Bosanska Krupa Health Centre, Bosanska Krupa, Bosnia and Herzegovina

Correspondence to: Asija Zaciragic, zarias@lol.ba

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Abstract

Objective: Association between neck circumference (NC) and components of metabolic syndrome in different countries and ethnic groups is still insufficiently investigated. The aim of the present study was to assess an impact of gender on NC values and to determine whether NC correlates with standard anthropometric measures and blood pressure values in Bosnian young adults.

Material and Methods: Study participants were recruited by the snowball method. NC, Body Mass Index (BMI), Waist circumference (WC), systolic blood pressure (SBP), and diastolic blood pressure (DBP) were measured by trained personnel. Differences between the means were assessed by a Student t-test. Coefficients of correlation were determined by Pearson's test.

Results: In young men (n =49) value of NC was 37.71±1.79 cm, while in young women (n=62) value of NC was 32.23±1.83 cm (P<0.001). Significant positive correlation in both gender between NC and BMI (r= 0.70; P<0.001 in men and r= 0.53; P<0.001 in women), and between NC and WC (r= 0.48; P<0.001 in men and r= 0.38; P=0.01 in women) was found. Significant correlation of NC with SBP (r=0.08; P=0.57), and with DBP (r=0.20; P=0.17) in young men was not determined. Likewise, in young women significant correlation of NC with SBP (r=0.08; P=0.54), and with DBP (r=0.09; P=0.49) was not observed.

Conclusions: Results of the present study suggest possible use of NC measurement as a valid method of obesity assessment in young adults. Lack of an association between NC and blood pressure values requires additional investigation.

Keywords: anthropometry, blood pressure, young adults, metabolic syndrome

Introduction

Neck circumference (NC) is a novel anthropometric indicator of upper body subcutaneous fat distribution [1]. Studies have shown that adipose tissue in the upper part of the body is more responsible for the production of free fatty acids then visceral adipose tissue, especially in obese individuals [2]. An association of NC with the increased risk for the development of hypertension, diabetes mellitus type 2, lower values of HDL cholesterol, as well as with the increased levels of triglycerides in patients of both gender has been demonstrated [3]. Finally, measurement of NC has become integral part of physical examination in patients with sleep apnea [4].

Limited number of studies evaluated possible use of NC as an indicator of overweight and obesity in a healthy young population. Recently conducted study in Pakistani students reported that values of NC ≥35.5 cm in males and ≥32 cm in females are associated with overweight and obesity [5]. Furthermore, an impact of gender on NC values in young adults has been reported [6].

Investigations conducted thus far point to promising potential of NC as an indicator of metabolic syndrome that significantly depends on age, gender, as well as on ethnical background of individuals [7-9]. As stated in literature, there is a need for the conduct of additional studies that will evaluate an association of NC with components of metabolic syndrome in different countries and ethnic groups [10].

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Studies that investigated association of NC with blood pressure (BP) values have yield conflicting results. Ben-Noon et al. [11] have determined significant positive correlation between systolic blood pressure (SBP), diastolic blood pressure (DBP) and NC in general population. Vallianou et al. [12] have reported significant association of NC with SBP and DBP in women, but not in men included in their study. Conversely, results of Preis et al. [13] have determined significant positive correlation of NC with values of SBP and DBP only in middle-aged men, but not in middle-aged women. These inconsistent findings point to the conclusion that mechanisms that are linking NC with values of BP are yet not completely understood, especially in young healthy individuals since investigations to date included mainly middle-aged and elderly individuals.

Therefore, the aim of the present study was to assess an impact of gender on NC values and to determine whether NC correlates with standard anthropometric measures and BP values in apparently healthy Bosnian young adults.

Materials and Methods

Present cross-sectional study included second-year dentistry students. The study participants were recruited using the snowball method [14]. The research was undertaken during Human Physiology course practical exercises between the months of April and June 2016. Inclusion criteria were that the study participants should be apparently healthy persons between 19 and 24 years of age of both gender. We excluded the individuals with neck deformity and goiter. Furthermore, subjects with a history of thyroid disease, diabetes, dyslipidemia, hypertension or other diseases were excluded from the study.

The study was approved by the local Ethics Committee. All participants signed informed written consent after the explanation of the study procedure.

Individual questionnaires were especially designed for the study and data such as general characteristics, lifestyle characteristics (smoking, alcohol consumption, and physical activity), anthropometric characteristics, values of BP, data on family history of cardiovascular diseases and diabetes mellitus were recorded.

Measurements were taken with the participants standing erect, in light clothes, and without shoes. NC was measured with a standard plastic tape to the nearest 0.5 mm. During NC

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measurement the head was positioned in the Frankfort horizontal plane. The top edge of a plastic tape was placed just below the laryngeal prominence and perpendicular to the longitudinal axis of the neck [15]. Weight was determined using a digital scale (BS-03; Shenzhen J and E Electronic Co., Ltd)) to the nearest 0.1 kg, and height was measured by a portable stadiometer (seca 213; seca®) to the nearest 1 mm barefoot. Following World Health Organization (WHO) guidelines, waist circumference (WC) was taken to the nearest 1 mm using a plastic tape measure [16]. Body Mass Index (BMI) was calculated as weight (kilogram) divided by the square of height (meter).

BP was measured by trained personnel in the morning hours (8:30 to 11:30 am). Standard mercury-column sphygmomanometer (SCH 11B; Smart Care) was used for BP measurement. During BP measurement participants were in sitting position. BP was measured 3-times and the average of three BP measurements was calculated. Essential hypertension was defined as average SBP ≥ 140 mmHg and/or average DBP ≥ 90 mmHg, and/or currently receiving treatment for hypertension with antihypertensive medicine. Based on The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC-7) prehypertension was defined as SBP between 120 and 139 mmHg or DBP between 80 and 89 mmHg [17].

Statistical analysis

Data were analyzed with the Statistical Package for the Social Sciences (SPSS) software version 20.0 (IBM, Chicago, Illinois, USA). In order to test the normality of distribution of the variables the Kolmogorov–Smirnov test was used. Values were expressed as mean ± SD. Differences between the means were assessed by a Student *t*-test. Coefficients of correlation were determined by Pearson's test. Statistical significance was considered for $P < 0.05$.

Results

The total sample comprised 111 participants (49 students of male gender and 62 students of female gender). In the total sample of participants, mean age was 21.83±1.43 years.

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Significant gender difference was observed in values of BMI and WC. Significant difference between the genders was not determined in values of SBP. However, significant gender difference in values of DBP was established. (Table 1)

In healthy young participants of male gender NC value was 37.71±1.79 cm, and in healthy young participants of female gender NC value was 32.23±1.83 cm. Observed gender difference in NC values was statistically significant ($P<0.001$). (Figure 1)

In healthy young participants of both gender significant positive correlation of NC with values of BMI and WC was determined. Significant correlation of NC with values of SBP and DBP in both gender of healthy young participants was not found. (Table 2)

Discussion

To the best of our knowledge, we are the first to report an impact of gender on values of NC in apparently healthy Bosnian young adults. In healthy young adults of male gender determined value of NC was 37.71±1.79 cm, while in healthy young adults of female gender determined value of NC was 32.23±1.83 cm ($P<0.001$). Although studies that evaluated NC values in young adults are scarce, our results are in a compliance with a study conducted among Turkish students of Medical Faculty in which significant gender difference of NC values was established [6]. Gender difference in NC values was also reported in Pakistani first year dental students [5].

NC is a new anthropometric index for estimating obesity [18]. Measurement of NC does not cause discomfort for subjects, which is, as stated in literature, common problem in a use of standard anthropometric methods [19]. Important advantage of the NC measurement in an assessment of overweight and obesity represents the fact that NC is measured on a more stable body area compared to WC, which is decreasing possibility of false positive or false negative results caused by examiners or examinees [20]. Significant positive correlation between NC values and values of standard anthropometric parameters of obesity has been determined in adult individuals of general population [19,21]. However, only few studies conducted thus far have evaluated correlation of NC with standard anthropometric parameters of obesity in a healthy young population. Results of the present study have determined significant positive correlation of NC with BMI and WC values in healthy young adults of male gender. Likewise, in healthy young adults of female gender significant positive correlation of NC with BMI and WC values was determined. Obtained results are in an

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accordance with study by Hingorjo et al. [5] that reported significant positive correlation of NC with values of BMI and WC in the student population. Strong and positive correlation between NC and WC values observed in our research suggests possible use of NC as an indicator of central obesity in healthy young adults. However, confounding factors such as cigarette smoking, alcohol intake and physical activity were collected but not assessed within the present study, and this may represent a potential source of bias for obtained findings. The similar future study should take into consideration these factors.

Limited number of studies conducted thus far investigated association between NC and BP values. Results of these studies, which mainly included middle-aged and elderly individuals, are conflicting [11-13]. In a recent study, Fan et al. [22] reported that NC is significantly associated with SBP and DBP after adjustments for BMI, WC and Waist-to-Hip ratio in Chinese adults. Results of the study by Liang et al. [23], also in Chinese adults, showed in a univariate analysis strong association of NC with SBP and DBP. However, when the results were adjusted for BMI or WC no association between NC and SBP and attenuated association with DBP was observed. Results of our investigation did not determine significant correlation of NC with SBP and DBP values in healthy young adults of male gender. In healthy young adults of female gender significant correlation of NC with SBP and DBP values was also not established.

Although mechanisms linking NC and BP remain to be fully elucidated, data from literature propose several potential mechanisms explaining this association. It has been shown that an elevated concentration of free fatty acids increases oxidative stress markers and leads to vascular endothelial injury, which may result in the development of hypertension [24]. BP regulation is an extremely complex physiological function that depends on a numerous actions of cardiovascular, nervous, renal and endocrine systems [25]. Results of novel research suggest that adipose tissue *via* the hormones it produces has important role in the BP regulation. Studies have shown that regulation of vascular tonus by adipokines is disturbed in obese individuals [26]. Result of current, although still limited, studies are suggesting that decreased concentration of adiponectin and perivascular relaxing factors deriving from adipocytes, as well as increased concentration of leptin, resistin, and angiotensin II leads to hypertension in obesity [27]. Since mean values of anthropometric parameters in both gender of participants included in our study were within optimal values it is possible that adipokines concentrations were also within normal range, so their effect on vascular tonus might not have manifested itself. However, we did not measure serum adipokines concentration in our study sample. Therefore, additional research still needed that will elucidate the role of factors deriving from adipocytes in the BP regulation in non-obese, and especially in obese individuals.

Main limitation of the present study is a small study sample consisting of healthy young adults from a select population. Thus, obtained findings cannot be generalized for entire population. Furthermore, our study had cross-sectional design that does not allow us to draw any cause-effect relations between our results. Finally, we did not directly measure by radiographic means subcutaneous fat depot in the upper-body area. Hence, further large prospective population-based studies and mechanistic studies are still required to corroborate our findings.

Results of the present study suggest possible use of NC measurement as a valid method in an evaluation of obesity in young adults instead of standard but sometimes unreliable and unpractical anthropometric measures such as BMI and WC. Lack of an association between NC and blood pressure values calls for additional investigation.

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Table 1. Gender difference of standard anthropometric measures and blood pressure values in the study participants

Variables	**Men** *n*=49	**Women** *n*=62	**P**
BMI (kg/m^2)	24.68±1.58	21.75±1.31	<0.001
WC (cm)	86.78±6.38	71.65±6.06	<0.001
SBP (mmHg)	122.86±6.02	119.11±5.13	0.17
DBP (mmHg)	76.43±5.25	71.77±4.69	0.03

Data are shown as mean ± SD. BMI: Body Mass Index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure

Figure 1. Gender difference of neck circumference values in the study participants

Results are shown as mean ± SD.

Table 2. Correlation of neck circumference with standard anthropometric measures and blood pressure values by gender in the study participants

Variables	Men **NC** (cm)	Women **NC** (cm)
BMI (kg/m^2)	r=0.70 P<0.001	r=0.53 P<0.001
WC (cm)	r=0.48 P<0.001	r=0.38 P=0.01
SBP (mm Hg)	r=0.08 P=0.57	r=0.08 P=0.54
DBP (mm Hg)	r=0.20 P=0.17	r=0.09 P=0.49

NC: neck circumference; BMI: Body Mass Index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; r: Pearson's correlation coefficient

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