Relationship between the Neck Circumference, Standard Anthropometric Measures, and Blood Pressure in Bosnian Young Adults

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

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ORCID IDs of the authors:
A.Z.: 0000-0002-3293-4698
M.E.: 0000-0002-0754-4428
N.A.: 0000-0003-4089-3037
N.B.: 0000-0002-3207-0172
A.D.: 0000-0002-4251-1437
O.L.: 0000-0002-3588-3347
J.H.: 0000-0002-3824-847X

[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

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Correspondence to: Asija Zaciragic
E-mail: zarias@lol.ba

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ABSTRACT

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

Materials and Methods: Study participants were recruited by the snowball method. The 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's t-test. Coefficients of correlation were determined by Pearson's test.

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

Conclusion: Our results suggest that the NC measurement can be used as a valid method in obesity assessment in young adults. A lack of association between the NC and blood pressure requires additional investigation.

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

Introduction

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

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

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

Studies that investigated the association between NC and blood pressure (BP) values have yielded conflicting results. Ben-Noon et al. [11] determined that there was a significant positive correlation

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

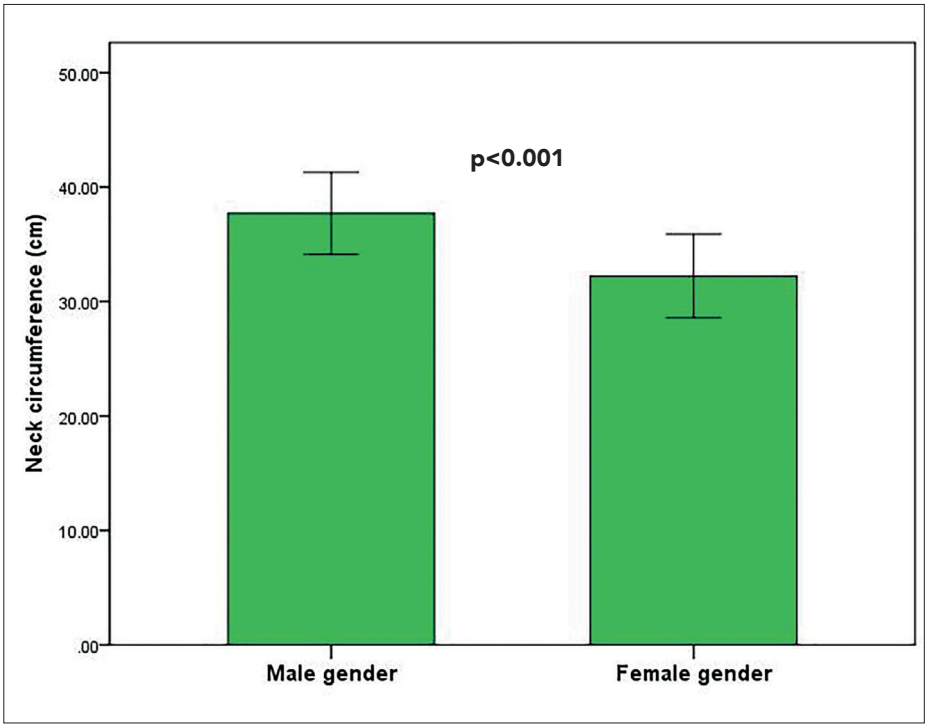

Figure 1. Gender differences in study participants' neck circumference values results are shown as the mean±SD.

Table 1. Gender differences in study participants' standard anthropometric measures and blood pressure values

Variables	Men n=49	Women n=62	p
BMI (kg/m²)	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 the mean±SD.
BMI: body mass index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure.

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

Variables	Men NC (cm)	Women NC (cm)
BMI (kg/m²)	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.

Therefore, the aim of the present study was to assess an impact of gender on NC values and to determine whether the 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. Study participants were recruited using the snowball method [14]. The research was conducted during the Human Physiology course practical exercises between the months of April and June 2016. Inclusion criteria were the following: the study participants had to be healthy individuals between 19 and 24 years of age of both genders. We excluded the individuals with neck deformities 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 Ethics Committee of University of Sarajevo School of Medicine. All participants signed informed written consent after the explanation of the study procedure.

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

Measurements were taken with the participants standing erect, in light clothes, and without shoes. The NC was measured with a standard plastic tape to the nearest 0.5 mm. During the NC 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 perpendicularly to the longitudinal axis of the neck [15]. The weight was measured using a digital scale (BS-03; Shenzhen J and E Electronic Co., Ltd.) to the nearest 0.1 kg, and the height was measured by a portable stadiometer (seca 213; seca®) to the nearest 1 mm barefoot. Following the World Health Organization guidelines, the waist circumference (WC) was rounded to the nearest 1 mm using a plastic tape measure [16]. Body mass index (BMI) was calculated as weight (kilograms) divided by the square of height (meters).

The BP was measured by trained personnel in the morning hours (8:30 to 11:30). A standard mercury-column sphygmomanometer (SCH 11B; Smart Care) was used for the BP measurement. During BP measurement, participants were in the sitting position. The BP was measured three times, and the average of the three BP measurements was calculated. Essential hypertension was defined as an average SBP≥140 and/or average

DBP≥90 mmHg, and/or currently receiving antihypertensive medicine for treatment of hypertension. 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 the SBP between 120 and 139 mmHg, or DBP between 80 and 89 mmHg [17].

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software version 20.0 (IBM, SPSS Corp.; Armonk, NY, USA). To test the normality of distribution of the variables, the Kolmogorov–Smirnov test was used. Values were expressed as the 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 to be $p<0.05$.

Results

The sample comprised a total of 111 participants (49 males and 62 females). In the total sample of participants, the mean age was 21.83±1.43 years.

Significant gender differences were observed in the BMI and WC values. A significant difference between the genders was not found in the SBP values. However, a significant gender difference in the DBP values was established (Table 1).

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

In healthy young participants of both genders, a significant positive correlation between the NC and BMI and WC was determined. A significant correlation between the NC and the SBP and DBP values in healthy young participants of both genders was not found (Table 2).

Discussion

To the best of our knowledge, we are the first to report the impact of gender on NC values in apparently healthy Bosnian young adults. In healthy young adults of male gender, the determined NC value was 37.71±1.79 cm, while in healthy young adults of female gender, the determined NC value 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 from the Medical Faculty in which significant gender differences with regard to NC values were established [6]. Gender differences in NC values were also reported in Pakistani first-year dental students [5]. The NC is a new anthropometric index for obesity estimation [18]. The measurement of NC does not cause discomfort for subjects, which is, as stated in the literature, a common problem in the use of standard anthropometric methods [19]. An important advantage of the NC measurement in an assessment of overweight and obesity is that the NC is measured on a more stable body area compared to WC, which is decreasing the possibility of false-positive or false-negative results caused by examiners or examinees [20]. A significant positive correlation between NC values and values of standard anthropometric obesity parameters has been determined in adult individuals of general population [19, 21]. However, only few studies conducted thus far have evaluated the correlation between NC and standard anthropometric parameters of obesity in a healthy young population. Results of the present study show that there is a significant positive correlation between the NC and BMI and WC values in healthy young adults of male gender. Likewise, in healthy young adults of female gender, there is a significant positive correlation between the NC and BMI and WC values. Obtained results are in accordance with the study by Hingorjo et al. [5], which reported a significant positive correlation between the NC and BMI and WC values in a student population. A 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 in the present study, and this may represent a potential source of bias. A similar future study should take into consideration all these factors.

A limited number of studies conducted thus far investigated the 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 the 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 a strong association between the NC and SBP and DBP. However, when the results were adjusted for BMI or WC, there was no association between the NC and SBP and attenuated association with DBP was observed. Our study results did not determine a significant correlation between the NC and SBP and DBP values in healthy young adults of male gender. In healthy young adults of female gender, a significant correlation between the NC and SBP and DBP values was also not established.

Although mechanisms linking the NC and BP remain to be fully elucidated, data from the 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 hypertension [24]. The BP regulation is an extremely complex physiological function that depends on numerous actions of the cardiovascular, nervous, renal, and endocrine systems [25]. Results of a novel research suggest that the adipose tissue, via the hormones it produces, plays an important role in BP regulation. Studies have shown that the regulation of vascular tonus by adipokines is disturbed in obese individuals [26]. Results of current, although still limited, studies are suggesting that a 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 the mean values of anthropometric parameters in participants of both genders included in our study were within optimal values, it is possible that adipokines concentrations were also within the normal range, so their effect on the vascular tonus might not have manifested itself. However, we did not measure the serum adipokines concentration in our study sample. Therefore, additional research is still needed that would elucidate the role of factors deriving from adipocytes in the BP regulation in non-obese, and especially in obese individuals.

The 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 an entire population. Furthermore, our study had a cross-sectional design that did not allow us to draw any cause–effect relations between our results. Finally, we did not directly measure by radiographic means the 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.

Our results suggest possible use of the NC measurement as a valid method in the evaluation of obesity in young adults instead of standard, but sometimes unreliable and unpractical, anthropometric measures like BMI and WC. A lack of association between NC and BP values calls for additional investigation.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University of Sarajevo School of Medicine, Bosnia and Herzegovina.

Informed Consent: Informed consent was obtained from the patients who participated in this study.

Peer-review: Externally peer-reviewed.

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