Original Article

Anthropometric indexes for predicting high blood pressure in Turkish adults

Burcu Aksoy Canyolu[1], Nilüfer Şen[2], Beste Özben Sadıç[3]

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, Istanbul Medeniyet University, Istanbul, Turkey, [2]Department of Nutrition and Dietetics, Faculty of Health Sciences, Gazi University, Ankara, Turkey, [3]Department of Cardiology, School of Medicine, Marmara University, Istanbul, Turkey

Abstract

Purpose: It is controversial which anthropometric indexes are the best in predicting the risk of hypertension and how anthropometric measurements are related to blood pressure (BP). This study aimed to evaluate the relationship between BP and anthropometric indexes and to determine the best predictors for hypertension risk. **Methods:** This cross-sectional study was conducted with 415 consecutive participants (161 men, mean age: 33.4 years) aged 18–88 years in Istanbul, Turkey. Weight, height, waist circumference (WC), and neck circumference (NC) and BP were measured by well-trained personnel. Waist-to-height ratio (WHtR) and body mass index (BMI) were calculated. Pearson correlation, linear regression, and multivariate analyses were used to assess the relationship between anthropometric measurements and SBP, DBP, using the Statistical Package for the Social Sciences version 23.0. **Results:** The systolic BP (SBP) and diastolic BP (DBP) were related to weight, WC, NC, BMI, and WHtR ($P < 0.05$). Linear regression analyses showed BMI and WC as independent risk factors for SBP with an increase by 1.11 mmHg in men ($P = 0.036$) and 1.59 mmHg in women ($P = 0.001$) in SBP when BMI increased 1 unit, while SBP increases by 0.2 mmHg when WC increases by 1 unit regardless of gender ($P = 0.013$). **Conclusion:** Our results showed that BMI and WC are related to BP and important predictors of hypertension risk. Therefore, the uses of BMI and WC are recommended as screening tools for the prediction of hypertension risk among Turkish adults.

Keywords: Anthropometric index, blood pressure, hypertension, Turkey, Turkish adults

Introduction

Hypertension is a global public health concern which increases heart, brain, kidney diseases, stroke risk and is a leading cause of premature death of cardiovascular and cerebrovascular diseases.[1] Over the world, almost 1.28 million adults are hypertensive, and prevalence is higher in middle- and low-income countries.[2] Additionally, 14% of total deaths are directly or indirectly due to hypertension (31,5%, 1,04 million people).[2] The prevalence of hypertension in Turkey is also quite high; one out of every three adults are hypertensive.[3] Considering the health expenditure including medical treatment, drug utilization, hospitalization, and complications related to hypertension, it constitutes a substantial amount of all health expenditures.[1] It has been reported that the monthly average cost of treatment of hypertension and cardiovascular diseases for each patient is almost 22$ and 300–1000$, respectively. Therefore, to determine hypertension risk and to combat with the burden of hypertension are still crucial.[4]

Basic anthropometric measurements such as body mass index (BMI), waist circumference (WC) and hip circumference (HC), waist–hip ratio (WHR), and waist-to-height ratio (WHtR) are considered as noninvasive, cost-effective, and laborless feasible methods to determine hypertension risk.[5] In addition, neck circumference (NC) as a novel measurement has gained attention in recent years as a predictor to determine the

Address for correspondence: Dr. Burcu Aksoy Canyolu, İstanbul Medeniyet Üniversitesi Cevizli Yerleşkesi, Atalar Mahallesi, A Blok A-103, Kartal, İstanbul - 34862, Türkiye.
E-mail: burcu.aksoy@medeniyet.edu.tr

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risk of hypertension.[6] Although numerous prospective and cross-sectional trials have been carried out, there is no agreement about which indicator has a stronger relationship with blood pressure (BP) and which is a stand-alone risk factor.[6-11] The Prospective Population-Based Turkish Adult Risk Factor Study determined BMI in women and WHR in men as predictors of systolic BP (SBP) and diastolic BP (DBP)[12] while another study reported that WC was an independent indicator in hypertensive patients.[13] However, up to date, the efficacy of anthropometric indices as a direct predictor of hypertension and the relationship between BP has not been comprehensively investigated in Turkish adults.[12-14]

Accordingly, this study aimed to identify the best traditional or novel anthropometric predictors for hypertension risk and to determine the relationship between BP, and anthropometric measurements in Turkish adults.

Methods

Study design and participants

This cross-sectional study was conducted between December 2020 and April 2021. Non-hypertensive and hypertensive adults who applied to the cardiology outpatient clinic in a training and research hospital in Istanbul, Turkey, were included consecutively. All participants who participated in this research study gave written informed consent.

Ethical clearance and confidentiality

This study was approved by the relevant ethics committee (protocol number 09.2020.262 on 03/06/2020), and the necessary permissions were obtained from the hospital management. This study was conducted in accordance with the World Medical Association and the Helsinki Declaration. All participants who participated in this research study gave written informed consent. Confidentiality of data was assured, and all participants were informed that the data would only be used for the stated purpose of the survey.

Data collection and measurements

Socio-demographic characteristics, anthropometric measurements, and general health information data were collected face-to-face interviews with a questionnaire, and the accuracy of the data was checked from the hospital's medical records.

Blood pressure measurement

Participants were advised not to smoke, drink alcohol, coffee, or tea and exercise for at least 30 minutes before measuring BP. Blood pressures were measured by an experienced nurse via an aneroid sphygmomanometer (215 004 02, Erka Perfect, İstanbul, Turkey) from the non-dominant arm after 15 minutes of rest. Blood pressures have been measured three times with an interval of 5 minutes, and average BP has been used for hypertension classification.

Definition of hypertension

Hypertension definition was based on SBP ≥140 mmHg and/or DBP ≥90 mmHg and/or use of antihypertensive medication.[15] Combined hypertension was based on DBP ≥90 mmHg and SBP ≥140.[9]

Anthropometric measurements

Height and weight were measured without shoes and heavy clothes, using an electronic scale (Tanita RD 953, Tartı, İstanbul, Turkey) and portable stadiometer (Seca 213, Nisan medikal, Ankara, Turkey), and WC was measured midway between the lower rib margin and the iliac crest at the end of gentle expiration in the upright position by an expert dietitian using a standardized protocol.[16] Neck circumference (NC) was measured just above the cricoid cartilage and perpendicular to the long axis of the neck, using folding rule (Baseline Gulick tape, Ramak group, İstanbul, Turkey). Body mass index was calculated as weight measured in kg divided by the height in meters squared (kg/m^2).

Classification of anthropometric measurements

World Health Organization body mass index classification as (<18.5 underweight, 18.5–24.9 normal weight, 25.0–29.9 overweight, and ≥30.0 obese) was used.[17] Waist circumference was classified according to the cut off point (obesity ≥100 cm for men, ≥90 cm for women) for the Turkish population,[14] and the cutoff point of the WHtR was taken as 0.5 which is recommended for use in different ethnic groups.[18] Neck circumference was classified according to the cut off point (≥35.5 cm in men and ≥32 cm in women) for the Pakistan population due to not having a cut off point Turkish population.[19]

Statistical analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences version 23.0 (SPSS Inc., Chicago, Illinois, USA). Data were tested for normality using the Kolmogorov–Smirnov test. The partial correlation coefficient was used to investigate the relationship between anthropometric measurements with SBP and DBP. Evans classification was used to interpret the relation level.[20] Independent risk factors affecting SBP and DBP were analyzed with linear regression. Independent risk factors affecting combined hypertension were analyzed as univariate and multivariate models by using logistic regression. Results are presented as mean ± standard deviation and median (minimum–maximum) for quantitative data and as frequency and percentage for categorical variables. The level of significance was set at <0.05 throughout the study.

Results

The baseline characteristics of the study population are shown in Table 1. Age-adjusted correlations of SBP and DBP with anthropometric measures stratified by gender are displayed in Table 2. In total, SBP and DBP were related with weight, WC, NC, BMI, and WHtR ($P < 0.05$). In females, SBP were found positively and weakly correlated with weight, WC, BMI, and

WHtR (r = 0.198, r = 0.191, r = 0.245, r = 0.204, respectively; $P < 0.05$). DBP was found very weakly correlated with weight and BMI (r = 0.164; r = 0.0170 respectively; $P < 0.05$).

The results of the sex-specific linear regression analyses for SBP and anthropometric variables are presented in Table 3. Regression models created for men and women were found to be significant ($P < 0.05$; $P < 0.001$ respectively), and it is found that SBP increases by 1.11 mmHg when BMI increases 1 unit in men, ($P = 0.036$), and SBP increases by 1.59 mmHg when BMI increases 1 unit in women, ($P = 0.001$) [Figure 1]. Moreover, it is found that SBP increases by 0.2 mmHg when WC increases 1 unit regardless of gender ($P = 0.013$).

In Table 4, anthropometric risk factors for combined hypertension are shown in univariate and multivariate logistic regression models 1 and 2. According to univariate and multivariate analysis model 1, NC was found to be an independent measurement of combined hypertension. The risk of combined hypertension decreased 0.917 ($P = 0.004$) in univariate analysis and 0.933 ($P = 0.043$) in multivariate analysis times when NC increases 1 unit.

Discussion

Considering that both hypertension and obesity are very common and interrelated with each other and public health problems among adults in Turkey, determining the relationship between BP and anthropometric measurement, and predictors are quite critical.[1]

In this study, the age-adjusted partial correlation, linear regression, and univariate and multivariable logistic regression analyses were used to investigate the relationship between BP and BMI, WHtR, WC, and NC, which are feasible and strong indicators.

Correlation of anthropometric measurements and BP: The association between BP and anthropometric measurements showed that SBP and DBP are significantly correlated with BMI, WHtR, WC, and NC and these results were consistent with previous studies.[5,21,22] In the present study, SBP and body weight relationship was found as the strongest among anthropometric indices (r = 0.335; $P < 0.001$). Chen *et al.* (2020)[21] showed that SBP and DBP were significantly correlated with BMI, WC, NC, and WC was more strongly associated with SBP in men than in women in Chinese age-adjusted hypertensive population. Ononamadu *et al.* (2017)[5] showed that BMI was strongly associated with SBP in Nigerian women, whereas these results are in line with our findings, BP and strongly correlated anthropometric indices vary among studies from different countries. These difference may be due to firstly older Chinese (mean age: 63.22 years)[21] and younger Nigerian (mean age: ~23 years) study population compared to our study population[5] secondly, higher hypertension prevalence

Table 1: Characteristics of the study population

	Mean±SD	Median (min–max)
Age (years)	33.4±13.7	28 (18-88)
SBP (mmHg)	118.9±15.1	120 (79-161)
DBP (mmHg)	75.2±11.5	74 (49-104)
Weight (kg)	71.1±15.4	69 (40-120)
WC (cm)	84.6±15.8	82 (29-125)
NC (cm)	34.7±5.5	35 (19-49)
BMI (kg/m^2)	25.2±5.00	24.09 (16.44–43.26)
WHtR	0.50±0.09	0.49 (0.17–0.78)
	n	**%**
Gender		
Men	161	38.8
Female	254	61.2
Non-hypertensive	351	84.6
Hypertensive	64	15.4

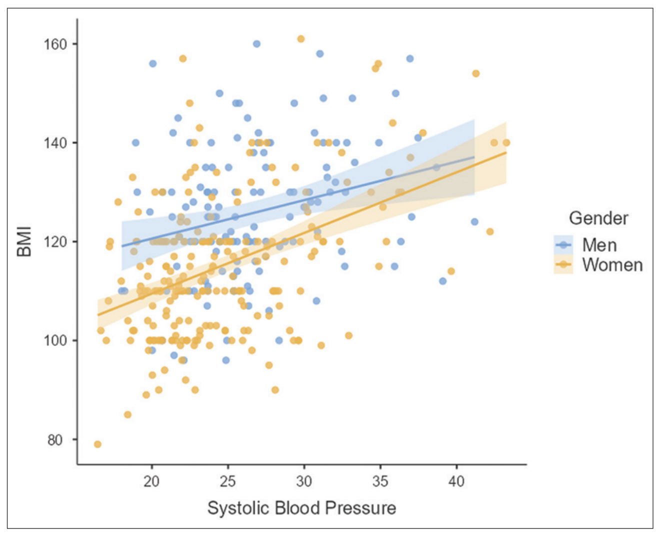

Figure 1: Effect of BMI on SBP in linear regression analysis for both genders

Table 2: Age-adjusted partial correlation between anthropometric variables with SBP and DBP in both genders

	SBP						DBP					
	Men		Women		Total		Men		Women		Total	
	r	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*	*r*	*P*
Weight	0,114	>0.050	0.198	<0.050	0.335	<0.001	0.118	>0.050	0.164	<0.050	0.287	<0.001
WC	0.089	>0.050	0.191	<0.050	0.283	<0.001	0.049	>0.050	0.097	>0.050	0.198	<0.001
NC	-0.037	>0.050	-0.004	>0.050	0.164	<0.050	0.086	>0.050	0.025	>0.050	0.139	<0.050
BMI	0.103	>0.050	0.245	<0.001	0.262	<0.001	0.109	>0.050	0.17	<0.050	0.200	<0.001
WHtR	0.085	>0.050	0.204	<0.050	0.221	<0.001	0.046	>0.050	0.092	>0.050	0.129	<0.050

r: partial correlation coefficient. *Pearson correlation

Table 3: Linear regression analysis for predictors of systolic blood pressure in both genders

	β_0 (%95 CI)	β_1	*t*	*P*	r^1	r^2	VIF
Men[a]							
Constant	110.64 (91.07–130.21)	110.64					
Weight	-0.25 (-0,59–0.09)	-0.248	-1.451	0.149	0.155	-0.13	3.92
WC	0.19 (-0.03–0.41)	0.192	1.736	0.085	0.24	0.155	1.909
NC	-0.31 (-0.82–0.19)	-0.314	-1.227	0.222	0.024	-0.11	1.266
BMI	1.11 (0.08–2.15)	1.112	2.124	0.036	0.243	0.189	4.083
Women[b]							
Constant	-0.27 (-0.62–0.08)	91.874					
Weight	-0.27 (-0.62–0.08)	-0.271	-1.534	0.126	0.365	-0.11	7.093
WC	0.12 (-0.09–0.34)	0.121	1.104	0.271	0.375	0.075	3.376
NC	-0.25 (-0.64–0.15)	-0.246	-1.218	0.225	0.109	-0.08	1.265
BMI	1.59 (0.68–2.5)	1.588	3.444	0.001	0.432	0.23	7.942
Total[c]							
Constant	84.42 (74.52–94.33)	84.425	16.768				
Weight	0.15 (-0.05–0.34)	0.146	1.471	0.142	0.415	0.08	4.599
WC	0.2 (0.04–0.36)	0.2	2.508	0.013	0.416	0.135	3.01
NC	-0.07 (-0.38–0.25)	-0.065	-0.409	0.683	0.229	-0.02	1.502
BMI	0.38 (-0.19–0.95)	0.376	1.295	0.196	0.411	0.07	4.202

β_0: Non-standardized beta coefficient; β_1: Standardized beta coefficient; r^1: Zero-order correlation; r^2: Partial correlation *enter method. SBP: F^a=3.314; P^a=0.013; R^{2a}=%9.8; Adjusted R^{2a}=%6.8; F^b=13.524; P^b<0.001; R^{2b}=%20.3; Adjusted R^{2b}=%18.8; F^c=21.111; P^c<0.001; R^{2c}=%19.9; Adjusted R^{2c}=%19.0. Mark: The adjusted R^2 value represents the level of prediction in the linear regression model

Table 4: Logistic regression analysis for anthropometric predictors of combined hypertension

	Univariate					
	Men		Women		Total	
	OR (95% CI)	*P*	OR (95% CI)	*P*	OR (95% CI)	*P*
Model 1						
Gender						
Men	---	---	---	---	Reference	
Women	---	---	---	---	3.229 (1.397–7.467)	0.006
NC	0.941 (0.826–1.071)	0.356	0.938 (0.87–1.011)	0.092	0.917 (0.865–0.972)	0.004
WC	0.973 (0.929–1.019)	0.238	1.005 (0.981–1.03)	0.698	0.987 (0.967–1.007)	0.212
Model 2						
Gender						
Men	---	---	---	---	Reference	
Women	---	---	---	---	3.229 (1.397–7.467)	0.006
BMI	0.886 (0.721–1.088)	0.248	1.010 (0.944–1.08)	0.774	0.977 (0.914–1.043)	0.484
WHtR	0.005 (0–17.404)	0.205	3.238 (0.082–128.399)	0.531	0.447 (0.015–13.231)	0.641
	Multivariate					
	Men		**Women**		**Total**	
	OR (95% CI)	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Model 1						
Gender						
Men	---	---	---	---	Reference	
Women	---	---	---	---	2.539 (1.019–6.329)	0.046
NC	0.959 (0.833–1.104)	0.556	0.925 (0.856–0.999)	0.047	0.933 (0.872–0.998)	0.043
WC	0.975 (0.927–1.025)	0.316	1.015 (0.988–1.042)	0.280	1.007 (0.983–1.031)	0.585
Model 2						
Gender						
Men	---	---	---	---	Reference	
Women	---	---	---	---	3.295 (1.404–7.733)	0.006
BMI	0.966 (0.832–1.121)	0.645	0.925 (0.856–0.999)	0.048	0.989 (0.883–1.109)	0.854
WHtR	1.034 (0.823–1.298)	0.776	0.950 (0.842–1.071)	0.400	1.791 (0.004–784.627)	0.851

in study populations compared to our study population (52.6% and 22.8%, respectively); and thirdly, racial differences among participants. A previous study among Turkish adults showed that SBP was correlated with BMI, WC, WHtR, and correlation levels were consistent with the present findings;[22] however, this previous study in Turkish population, in which age adjustment was not applied, and NC was not investigated.[22] On the other hand, another study conducted with a relatively small sample in Turkey, in which also age was not adjusted, any significant relationship was found between BP and BMI, WHtR, WC.[14] Difference in findings from Turkey may have arisen from sample characteristics, sampling, methods, and differentiation in researchers applications in anthropometric and blood pressure measurements.

Linear regression of anthropometric predictor for BP: In the present study, according to linear regression the association between BP and anthropometric risk factors has shown that BMI was found to be an independent, important predictor of SBP for both men and women, and WC was found to be an independent predictor for SBP regardless of gender according to linear regression analysis. This is in agreement with other previous studies which were conducted in Nigeria,[5] Saudi Arabia,[9] and Ethiopia.[23] Moreover, two other national studies conducted in Turkey[12,13] also found that BMI was a strong independent predictor for SBP in women while WC was an independent risk factor for SBP in men.[13] In the present study, WC found as an independent predictor of SBP regardless of sex among Turkish adults which can be interpreted due to cutoff points specific to the Turkish population among the anthropometric indices examined in present study was only available for WC.

On the other hand, in the literature, different anthropometric measurements than BMI have been found as strong predictors for hypertension risk.[24,25] A systematic review in including 78 different studies[24] and a meta-analysis including 10 researches have reported that WHtR is a better significant predictor than BMI and WC for SBP.[25] In addition, some studies carried out in Korea,[8] Jordan,[11] and China[21] showed that WC, WHR, and WHtR were stronger predictors than BMI for hypertension risk.[8,11,21]

Evidence suggests that the strongest association or the best predictor of the risk of hypertension can differ according to residence area (rural or urban), gender, cultural group, age, and ethnic group.[5,8,24,25] These results might be explained with whether participants have concomitant diseases, age, gender, race, lifestyle, and environmental factors. Also, it may be arisen due to the differences in the cutoff points for BPs, anthorometric measurements, different study designs, measurement techniques, and statistical methods.[8,26]

Univariate and multivariate models for anthropometric predictor for combined HT: In the present study, logistic regression, between BP and anthropometric measurements, showed that NC was inversely associated with hypertension risk (odds ratio (OR) = 0.917). Examining the literature, the relationship between BP and NC is not clear yet.[6] In recent years, it has been reported that the NC as an important indicator of subcutaneous fat in the upper body and is closely related to the cardiovascular risk factors.[27] While some studies have only reported correlation between NC and BP, some have reported NC and hypertension OR[27] and a few studies have reported both[6] so it has been also reported that NC does not add much incremental information when BMI or WC is known.[28] According to the results of a meta-analysis of 29 studies, NC was associated with the risk of hypertension in Western populations, but not in Eastern populations; in addition, it was not directly associated with the risk of prehypertension.[6] Since several studies in Asia[29] and Latin America[30] have reported that NC has a direct relation with the BP in adults, a study with older adults in Brazil and another cross-sectional study in Caucasian population, multivariate analysis among older women and univariate analysis by adjusted age respectively showed that NC was not related to the BP.[27,31] The results of current studies on the relationship between NC and BP are controversial.[6] Because the best predictor for hypertension and prehypertension differs by gender, age, country, and residential status as rural or urban.[6]

Previous studies on the relationship between NC and BP in Turkey only examined the correlation coefficient, and reported NC had a significant correlation with BP in Turkish adults.[32-34] Another study examining the relationship between anthropometric measurements and prehypertension among university students in Çorum-Turkey (prevalence of prehypertension: 49.0%), also found that NC was the strongest predictor of prehypertension.[35] Present study is the first study to evaluate the relationship between NC and BP in Turkish adults with both correlation coefficient and linear and logistic regression. According to the result of this study, the negative relationship between hypertension risk and NC may have arisen due to firstly the quite young mean age of the study sample (mean age: 33.4). In young adults, due to relatively higher lean body mass compared to older adults, and elderly NC can also be wider because of the upper body muscle mass and higher physical activity level (especially their active lifestyle; weight lifting and training) even though they are normotensive. Secondly, the few numbers of hypertensive and prehypertensive individuals in the group (prevalence of hypertension and prehypertension, respectively: 15.4%, 22.7%) and relatively narrower NC (NC mean: 34.7 cm) compared to the previous studies in Turkey which are half of the study population are hypertensive. Thirdly, body composition analysis was not performed since neck circumference is used to represent upper-body subcutaneous fat, but radiographic measures not used fat distribution were not examined to if it is accumulated in the upper body (apple-shaped) or lower body (pear-shaped) which can affect NC, and lastly non-existence of Turkish population-specific NC cut-off points.

Limitation

One of the limitations of this study is that due to the nature of the cross-sectional study, it is not possible to conclude the cause–effect relationship between BP and anthropometric measurements. Although the median age of the sample is quite similar to the median age of the Turkish population, the mean and median age of the sample were relatively young compared to other studies. Therefore, this may have limited the power of the study to detect better performance in the elderly population. Other limitations of this study are that BP was measured in a single-day visit, and radiographic measurements could not be performed to measure upper-body subcutaneous fat, lean body mass, and fat mass. Cutoff points for obesity diagnosis are international and not specific to Turkish population except WC. This study was conducted in a single center, so these results cannot be generalized to the whole city or country. Moreover, as BP was measured by an experienced nurse, white coat syndrome may have caused the blood pressures of some participants to read higher than it normal.

Conclusions

To our knowledge, the present study is among the first to predict the performance of anthropometric measurement of hypertension risk in Turkish adults by using advanced statistical analysis. The results of our study showed that BMI and WC were independent predictors for SBP, and NC was inversely related to hypertension risk. Consequently, considering the prevalence and health burden of hypertension in Turkey, risk screening and assessment for hypertension are important especially in primary healthcare system and so on for family medicine physicians. Our findings support that BMI and WC can be used to determine the hypertension risk in adults. However, NC does not add much incremental information when BMI or WC is known. Simple, cost-effective, non-invasive anthropometric measurements save time, labor, and health expenditure in the diagnosis and management of hypertension for family medicine physicians. Moreover, this is merely a preliminary study that warrants further research. Future studies comprising large numbers of non-selected samples and long-term follow-ups are warranted to identify the role of anthropometric indexes especially neck circumference in hypertension and prehypertension risk. The use of combined indexes as BMI, WC, and NC measurements can be included into individual's medical history like height, weight and used as tools for cardiovascular health screening.

Declaration of ethical approval for study

The ethics committee approved this study with protocol number 09.2020.262 on 03/06/2020, and the necessary permissions were obtained from the hospital management. This study was conducted in accordance with the World Medical Association and the Helsinki Declaration.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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