ORIGINAL ARTICLE

Eur. J. Anat. 19 (3): 269-275 (2015)

The best anthropometric index to access the risk of hypertension in the population of Kavre district, Nepal

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SUMMARY

The relation of anthropometric factors with blood pressure is important for determining cardiovascular risk, as previous studies have shown positive association between these variables. But there is no common opinion about the effectiveness of which of the anthropometric tools indicating obesity are the most important to follow up. The present study was carried out to examine this relationship, and to find the most correlated anthropometric index in a Nepalese population. A cross-sectional descriptive study including 238 subjects (75.63% male and 24.37% female, aged 18-87 years old) was conducted among subjects from Kathmandu University, Dhulikhel Municipality, Banepa Municipality and Panauti Municipality of Kavre District, Nepal. Age, weight, height, waist circumference, hip circumference and blood pressure of the subjects were measured. Body mass index and waist hip ratio was calculated. Pearson correlation and linear regression analysis were used to analyze the data. The mean systolic and diastolic blood pressures were 120.2±16.1 and 81.9±11.3 mmHg respectively. In terms of body mass index, 4.2% of the subjects were obese (>29.9 kg/m^2). As for waist hip ratio and waist circumference cut-off points, 57.57% and 21.84% subjects had cardiovascular risk. Significant positive correlation of obesity indicators with both systolic and diastolic blood pressure was observed. For systolic blood pressure, the correlation coefficient was 0.42 with body mass index, 0.44 with waist circumference, and 0.48 with waist hip ratio. For diastolic blood pressure, it was 0.41 with body mass index, 0.45 with waist circumference, and 0.53 with waist hip ratio. Using the Pearson correlation test, waist hip ratio was found to be the most correlated factor for blood pressure among the total population. Specifically, waist hip ratio for male population and waist circumference for female population were the most correlated indices. Therefore, these indices can be considered and utilized to assess risk for elevated blood pressure condition and cardiovascular disease in our study population.

Key words: Anthropometry – Body mass index – Waist hip ratio – Waist circumference – Blood pressure – Hypertension – Obesity – Cardiovascular disease – Nepal

INTRODUCTION

Several epidemiological studies from different populations have reported a significant association between different anthropometric indicators and blood pressure levels (Adedoyin et al., 2008). Studies have found a progressive increase in the prevalence of elevated blood pressure with increasing adipose tissue (Mark et al., 1999) i.e. linear relationships have been found in between anthropometric measures and the risk of cardiovascular disease (Adedoyin et al., 2008).

The prevalence of hypertension is increasing throughout the world. It is a potent risk factor for cardiovascular complication, cerebro-vascular accidents and renal failure (Whelton, 1994). The World Health Organization (WHO) report identified hypertension as one of the most important causes of the disease burden of developed and develop-

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Submitted: 30 December, 2014. *Accepted:* 4 May, 2015.

ing nations (Ezzati et al., 2002). High blood pressure is often referred as “The Silent Killer”, because there are usually no symptoms in its early stages and people may not find out until they have hypertension associated complications with heart, brain or kidneys (Whelton, 1994). A major step needed to be taken to avoid preventable damage caused by elevated blood pressure is *Early intervention through detection* (American Heart Association Council on High Blood Pressure Research, 1999).

In the recent decade, many prospective and cross-sectional studies have been done in order to evaluate the anthropometric measurement methods to assess patients with elevated blood pressure (Seidell et al., 2001; Zhu et al., 2002). Different anthropometric measurements like weight, Body Mass Index (BMI), Waist Circumference (WC), Hip Circumference (HC), Waist-to-Hip Ratio (WHR), Thigh Circumference (TC) measurement (Cox and Whichelow, 1996; Lahti-Koski et al., 2000) and other measures of body fatness have been used in most of these studies to analyze the association between adiposity and cardiovascular risk factors (Adedoyin et al., 2008).

BMI (kg/m^2) has become the measurement of choice to measure overweight and obesity in adults, which describes relative weight for height, is not gender specific and is significantly correlated with total body fat content (American Heart Association Council on High Blood Pressure Research, 1999). BMI is positively and independently associated with morbidity and mortality from hypertension, cardiovascular disease, type II diabetes mellitus and other chronic diseases (Pi-Sunyer, 1993). In the Caucasian population, a strong association has been depicted between BMI and mortality (Hoffmans et al., 1988). A similar association has also been demonstrated among Asian populations (Ni Mhurchu et al., 2004). Some studies have documented a consistent, but modest association between BMI and blood pressure (BP), whereas others suggested a BMI threshold, at which level the relationship with BP begins (Tesfaye et al., 2007). The WHO has agreed on an international standard for identifying overweight and obesity in adult populations using the BMI. However, increased risk of cardiovascular diseases (CVD) has been found in individuals presenting with distribution of excess fat in the abdominal region (Dobbelsteyn et al., 2001). Therefore, there is currently overwhelming evidence that android obesity is a greater risk factor for CVD than general obesity (Bender et al., 2002). BMI does not account for the wide variation of the fat distributions. Obesity is associated with 5 of the 10 leading causes of death in industrialized countries including heart disease, some types of cancer, stroke, diabetes and atherosclerosis (Dobbelsteyn et al., 2001).

Compared to BMI, anthropometric measures of abdominal obesity (e.g. WC, WHR) appear to be more strongly associated with metabolic risk factors, CVD events, and death (de Koning et al., 2007). The cardio-metabolic risk associated with abdominal obesity is attributed to the presence of visceral adipose tissue (VAT), which promotes insulin resistance, dyslipidaemia, and hypertension (Despres, 2006). WC and WHR are the most common proxy measures, and both are correlated with VAT; however, WC is more strongly associated (Pouliot et al., 1994). Other studies also have reported that WC is probably a better indicator of abdominal fatness and CVD than either BMI or WHR (Dobbelsteyn et al., 2001). Despite this, WHR may be a better predictor of CVD risk as hip circumference is inversely associated with the development of CVD (de Koning et al., 2007). The evaluation of central adiposity by way of the WHR has been recognized as a substantial component in the assessment of CVD risk factors due to an association between WHR and hypertension (McKeigue et al., 1991).

Developed countries to some extent have been successful to monitor and estimate patterns of distribution blood pressure in their population. But in the context of a developing country like Nepal, due to lack of proper health care mechanisms, communities are being devoid of primary health care, which is leading to the occurrence of many preventable cases of elevated BP associated complications. Based on the statistics of the USA (Chobanian et al., 2003), it has been also noticed that those who are aware of their hypertension are those who are being treated, and whose disease is under control. But, on the contrary, in our situation most of the cases of hypertension remain undiagnosed, which leads to complications that could be prevented. Primary care physicians are confronted by a remarkable heterogeneity among their patients. Many times a simple question emerges: which anthropometric measurements may be effective to screen/ indicate the CVS risk factor such as hypertension? It has been recommended that each population should determine its best anthropometric measurement tool(s) in order to screen general and visceral adiposity to assess possible risk factor (Kannel et al., 2002). In the context of Nepal, there is dearth of the relevant information regarding the selection of the best anthropometric tool to screen the elevated blood pressure. Due to this lack, the medical practitioners have no choice but to refer to data obtained with reference to foreign subjects, and extrapolate these cases to those of Nepali subjects. Since the physical structure, life styles, dietary habits and genetic makeup of the Nepalese are quite different from foreigners, taking such data for reference for local use can compel us to a huge range of error. This research aims to find the most correlated anthropometric indices with blood pressure which could be a reference value to researchers and medical practitioners.

MATERIALS AND METHODS

Study design and setting: Before conducting the study, ethical issues were taken into consideration. All the participants were informed about the objective and design of the study, and their verbal consent was obtained before measurements were taken. Guarantee of absolute confidentiality and anonymity was explained to the subjects, and data were used for study purposes only. A total of 238 adults [180 (75.63%) were male and 58 (24.37%) were female. Those who met the inclusion criteria (healthy subjects, above 18 years of age, willing to volunteer for the research) were enrolled in the study. The age of the subjects ranged between 18 to 87 years. The subjects were divided into two categories: male and female, and each of which were further categorized into different age groups (less than 20 years, 20-30 years, 30-40 years, 40-50 years, 50-60 years and 60 above). Persons under medication of anti-hypertensive agent, persons who were suffering from any major illness in the past or present, pregnant women, those who were unable to stand erect and the subjects unwilling to participate were excluded in the study.

Sampling design: The simple random cross sectional study design was adopted in this study. The study was conducted among students and staffs of Kathmandu University, people from Dhulikhel, Banepa and Panauti Municipality of Kavre District, Nepal. Data were collected by door to door visit in the morning when the participants could be met at home. The tool used was a set of prepared questionnaire, sphygmomanometer, measuring tape and bathroom weighing scale.

Measurement of blood pressure: During the measurement of blood pressure, after about 15 min of quiet sitting, three readings of BP were taken at intervals of 3-5 minutes using mercurial sphygmomanometer in the sitting position. The concurrent BP value was used for analysis. The same sphygmomanometer was used for all the subjects and BP was measured using auscultatory method. Tight fitting clothes were removed. The cuff was applied firmly on the left arm, which was supported at the level of the heart. The subjects were kept free from smoking and caffeine during the measurement of BP. Based on the definition of hypertension published by the Seventh Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure guidelines (Chobanian et al., 2003) and WHO-International Society of Hypertension guidelines (WHO-ISH, 1999), a cutoff point of 140/90 mmHg for hypertension was adopted. Those with the BP of less than 140/90 mmHg were considered non hypertensive, while those with equal to 140/90 mmHg or higher values were classified as hypertensive. Patients under antihypertensive treatment were excluded.

Anthropometrical measurement: Height was measured with a standiometer. After removing the shoes, the participants were asked to stand upright on the flat floor keeping the heels, the back, and the occiput in touch to the scale with the subjects looking straight ahead during measurement so that the lower boarder of the orbit was in the same plane as the external auditory meatus. The height of each participant was measured to the nearest 0.1 cm. Weight was measured with a bathroom weighing scale calibrated from 0-130 kg with the participant standing with shoes removed and lightly clothed. The weighing machine was standardized each day by the weight of 10 Kg. Body weight was measured in kilograms to the nearest 0.5 kg. The participants' age was also recorded. BMI was calculated by dividing weight in kilograms by height in meters squared (kg/m^2). Using the WHO classification, four categories of BMI were identified as in the Table 1:

Waist circumference was measured in centimeters at the navel, while the person was breathing quietly and hip circumference was measured at the inter-trochanteric line in the standing position with both feet together using a non-stretchable plastic tape without compression of the skin. The ratio of the above two physical parameters was calculated and rounded off to the nearest two decimals. The cutoff used for waist circumference and waist hip ratio is as given in Table 2:

Data analysis: Data gathered were checked for completeness and accuracy. The data analysis as carried out using SPSS version 15.0 software (SPSS Inc., Chicago, IL, USA). The descriptive statistics of means with 95% and 99% Confidence Interval were used to summarize the data collected. Pearson's correlation coefficients were used

Table 1. The BMI groups defined by the criteria of WHO.

BMI groups	BMI cut-off value
Underweight	<18.5
Normal	18.50–24.9
Overweight	25–29.9
Obesity Stage I	30–34.9
Obesity Stage II	35–39.9
Obesity Stage III	>40

http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

Table 2. The WHR and WC risk groups according to the cut-off points for relative risk of CVD in both genders defined by WHO.

	Male	Female
WHR		
No Risk	<0.90	<0.80
Medium Risk	0.90–1.0	0.81–0.85
High Risk	>1.0	>0.85
WC		
No Risk	<94 cm	<80 cm
Medium Risk	94–101 cm	80–87cm
High Risk	>101 cm	>88 cm

WC = waist circumference; WHR = waist to hip ratio.

for continuous variables to find the association between the anthropometric variables and blood pressure. Linear regression analysis was used to assess the influence of different anthropometric indicators on the systolic blood pressure (SBP), diastolic blood pressure (DBP). The level of significance of all tests was taken at $P<0.05$ and $P<0.01$. The correlation coefficient was classified as given the Table3 (Chan, 2003) to measure the strength of relationship.

RESULTS

A total of 238 subjects participated in the study, whose detailed distribution according to sex and age groups is shown in the Table 4. The general characteristics of the participants by gender are presented in Table 5.

BMI, WHR, WC are the different anthropometric indicators for overweight and obesity. According to the criteria defined by WHO based on BMI; 27.3% of total subjects were overweight and 10 4.2% had stage-I obesity. Among males, 30.6% were overweight and 3.9% had stage-I obesity, whereas among females, 17.2% were overweight and 5.2% had stage-I obesity.

Similarly, according to the WHO criteria based on WHR to define the relative risk for CVD, 37.39% of total subjects were in medium risk and 20.17% were in high risk. Among male subjects, 42.2% were in medium risk and 12.8% were in high risk, whereas among female subjects, 22.4% were in medium risk and 43.1% were in high risk. Thus, the percentage of high risk subjects for CVD was more among female than the male.

Similarly, according to the WHO criteria based on WC to define the relative risk for CVD, 14.29% of total subjects were in medium risk and 7.56% were in high risk. Among male subjects, 9.4% were in medium risk and 6.1% were in high risk, whereas among female subjects 29.3% were in medium risk and 12.1% were in high risk for CVD. Thus, the percentage of both medium risk and high risk subjects for CVD was found to be more among female than male.

Pearson correlation test showed that SBP, DBP, and MAP (mean arterial pressure) all were found to be positively and significantly correlated with age, weight, BMI, WC, WHR which is illustrated in table-6. On analyzing the strength of correlation, age was found to be moderately correlated in female, fairly correlated in male and total population with SBP, DBP and MAP. Similarly, weight was found to be fairly correlated in female and total population, whereas poorly correlated among male with SBP, DBP and MAP. Similarly, BMI was found to be fairly correlated with SBP, DBP and MAP among all categories: total population, male population and female population. Although it was fairly correlated, the correlation coefficient was higher in female population than male population. Similarly, correlation of waist circumference with SBP, DBP and MAP was found to be moderately correlated in female population whereas; it was fairly correlated among male population and total population. Similarly, correlation of Waist Hip Ratio with SBP, DBP and MAP was found to be fairly correlated in male population and in total population whereas among female population SBP was correlated fairly, DBP and MAP were found to be moderately correlated with WHR. However, the

Table 3. Strength of linear relationship.

Correlation coefficient value	Strength of liner relationship
At least 0.8	Very strong
0.6 up to 0.8	Moderately strong
0.3 to 0.5	Fair
Less than 0.3	Poor

Table 4. Distribution of the respondent according to sex and age group.

Age group	Sex of the respondents				Total	
	Male		Female			
	No.	%	No.	%	No.	%
18-20	8	4.4	12	20.7	20	8.4
21-30	58	32.2	18	31.0	76	31.9
31-40	48	26.7	7	12.1	55	23.1
41-50	32	17.8	8	13.8	40	16.8
51-60	18	10.0	6	10.3	24	10.1
Above 60	16	8.9	7	12.1	23	9.7
Total	**180**	**100.0**	**58**	**100.0**	**238**	**100.0**

Table 5. General characteristics of the participants by gender.

General characteristics	Male (n=180)	Female (n=58)	Total (n=238)
	Mean ±SD	Mean ±SD	Mean ±SD
AGE (years)	37.6± 14.1	36.7± 19.1	37.4±-15.5
HEIGHT (cm)	166.2± 7.8	154.6± 7.9	163.4± 9.2
WEIGHT (Kg)	65.6± 10.6	53.7± 9.9	62.7± 11.6
WC (cm)	85.2± 9.8	76.8± 11.7	83.2± 10.9
HC (cm)	93.1± 7.2	91.8± 9.8	92.8± 7.9
WHR	0.92± 0.08	0.84±0.10	0.90±0.09
BMI (kg/m^2)	23.7± 3.3	22.4± 3.9	23.4± 3.5
SBP (mmHg)	122.0± 15.4	114.6± 17.1	120.2±16.1
DBP (mmHg)	83.6± 10.6	76.6±- 11.7	81.9± 11.3
MAP (mmHg)	96.43±11.42	89.24±13.15	94.68±12.23

correlation coefficient was higher in females than in males.

Thus, the correlation coefficient was found higher in female than in male populations in all the correlation of anthropometric indexes (age, weight, BMI, WC, and WHR) with blood pressure (SBP, DBP and MAP), which illustrates that blood pressure change occurs more sharply in females than males with respect to change in anthropometric index.

Linear regression models were fitted for SBP, DBP as dependent variables and anthropometric index (age, weight, BMI, WC, and WHR), as independent variables controlled for sex to determine their influence on the variance of these dependent variables, which showed a significant linear relationship between dependent variables and the independent variables. Moreover, the data suggested that in the population under study BP changed more sharply in females than in males with respect to age, BMI, WC, and WHR.

Furthermore, Pearson correlation test was also used to find out the correlation of different anthropometric index with BP among the various age groups. In the subjects of age group of less than 20 years, no anthropometric index showed significant positive correlation with SBP; WC was observed to be the most correlated index with DBP [r=0.618, P<0.01] and MAP [r=0. 598, P<0.01]. Similarly in the subjects of age group of 20-30 years, weight was observed to be the most correlated index with SBP [r=0.431, P<0.01], whereas WC was observed to be the most correlated index with DBP [r=0.388, P<0.01] and MAP [r=0.433, P<0.01]. In the subjects of age group of 30-40 years, BMI was observed to be the most correlated index with SBP [r=0.451, P<0.01], whereas weight was observed to be most the correlated index with DBP [r=0.416, P<0.01] and WC was found to be the most correlated with MAP [r=0.431, P<0.01]. In the subjects of age group of 40-50 years, BMI was observed to be the most correlated index with SBP [r=0.379, P<0.01], whereas no index showed the significant positive correlation with DBP and MAP. In the subjects of age group of 50-60 years, WHR was observed to be most correlated index with SBP [r=0.571, P<0.01], DBP [r=0.627, P<0.01] and MAP [r=0.627, P<0.01]. In the subjects of age group of above 60 years, BMI was observed to be the most correlated index with SBP [r=0.563, P<0.01] and MAP [r = 0.491, P<0.05] whereas no other indices showed significant correlation with DBP.

DISCUSSION

The well-known correlates of anthropometric indicators and BP have again been confirmed in this

Table 6. Correlation of different anthropometric variables with SBP, DBP and MAP in male, female, and total population.

		Systolic	Diastolic	Mean Arterial Pressure
Age	Male	Fair [r=0.388, P<0.01]	Fair [r=0.312, P<0.01]	Fair [r=0.367, P<0.01]
	Female	Moderate [r=0.639, P<0.01]	Moderate [r=0.617, P<0.01]	Moderate [r=0.644, P<0.01]
	Total population	Fair [r= 0.463, P<0.01]	Fair [r=0.401, P<0.01]	Fair [r=0.449, P<0.01]
Weight	Male	Poor [r=0.243, P<0.01]	Poor [r=0.224, P<0.01]	Poor [r=0.247, P<0.01]
	Female	Fair [r=0.423, P<0.01]	Fair [r=0.375, P<0.01]	Fair [r=0.406, P<0.01]
	Total population	Fair [r=0.339, P<0.01]	Fair [r=0.344, P<0.01]	Fair [r=0.360, P<0.01]
Body Mass Index	Male	Fair [r=0.319, P<0.01]	Fair [r=0.326, P<0.01]	Fair [r=0.344, P<0.01]
	Female	Fair [r=0. 583, P<0.01]	Fair [r=0.550, P<0.01]	Fair [r=0.580, P<0.01]
	Total population	Fair [r=0.414, P<0.01]	Fair [r=0.414, P<0.01]	Fair [r=0.436, P<0.01]
	Correlation coefficient was higher in female than male			
Waist circumference	Male	Fair r=0.326, P<0.01]	Fair [r=0.312, P<0.01]	Fair [r=0.339, P<0.01]
	Female	Moderate [r=0.612, P<0.01]	Moderate [r=0.612, P<0.01]	Moderate [r=0.630, P<0.01]
	Total population	Fair [r= 0.445, P<0.01]	Fair [r=0.454, P<0.01]	Fair [r=0. 474, P<0.01]
Waist Hip Ratio	Male	Fair [r=0.380, P<0.01]	Fair [r=0.417, P<0.01]	Fair [r=0.428, P<0.01]
	Female	Fair [r=0. 586, P<0.01]	Moderate [r=0.623, P<0.01]	Moderate [r=0.624, P<0.01]
	Total population	Fair r=0. 476, P<0.01]	Fair [r=0.529, P<0.01]	Fair [r=0.533, P<0.01]
	Correlation coefficient was found to be higher in female than male			

study. In our study population, the age was found to be moderately correlated with SBP, DBP and MAP in females, and fairly correlated in males and the total population, which means that the correlation was stronger in females than in male. This explains that the blood pressure in females increases more sharply than in males with respect to age. Moreover, the significant positive correlation between age and BP indicates the increase in BP with increase in age .The pathophysiology behind this is yet to be fully determined, but it is described that it is collectively due to the gradual depletion of renin levels, the increase in sensitivity to sodium depletion or repletion, structural changes like decrease in connective tissue elasticity and an increase in prevalence of atherosclerosis in the large vessels, which may play a prominent role in increasing in peripheral vascular resistance and aortic impedance and in the rise of SBP level with age (American Heart Association Council on High Blood Pressure Research, 1999). The age was found to be significantly correlated with blood pressure in a similar study (Badaruddoza et al., 2009).

Similarly, BMI was found to be fairly correlated with SBP, DBP and MAP in male, female and total population. However, the correlation coefficient was higher in the case of females than of males. This means that the changes in blood pressure in female occur more sharply than male with respect to BMI. Moreover, the significant positive correlation between BMI and BP indicates the increase in BP with increase in BMI. The finding of this study corroborates the earlier investigations that reported significant positive correlation BMI with SBP and DBP (Gus et al., 2004; Hsieh et al., 2000). BMI was found as the significant predictors of both systolic and diastolic blood pressure (Seidell et al., 2001).

Similarly, WC was found to be moderately correlated with SBP, DBP and MAP in females, and fairly correlated among male and total population. This signifies that the change in BP in females occurs more sharply than in males with respect to WC. Moreover, the significant positive correlation between WC and BP indicates that the increase in BP with increase in WC. WC was found as the significant predictors of both SBP and DBP which is similar to the findings of earlier studies (Seidell et al., 2001).

Similarly, WHR was found to be fairly correlated with SBP, DBP and MAP in male and total population, whereas in females it was correlated fairly with SBP and moderately correlated with DBP and MAP. The higher correlation coefficient in females than in males signifies that the change in blood pressure in females occurs more sharply than in males with respect to WHR. Moreover, the significant positive correlation between BP and WHR indicates the increase in BP with increase in WHR. Significant positive correlations between WHR and SBP and DBP have been reported earlier (Seidell et al., 1991; Shahbazpour, 2003). However, our finding was in contrast with the finding of Seidell et al*.* (2001), where no significant correlation between WHR and DBP was state.

The significance of different anthropometric indices in predicting obesity-related outcomes has been mentioned in several reports. Cox and Whichelow (1996) have examined the predictive ability of simple anthropometric indices for the development of cardiovascular disease over 7 years.

Our study may have some limitations in data gathering like all cross-sectional studies, although the standardized protocol of BP measurements was used and all of the estimations are made in one occasion. Other limitations: (a) Small sample of subjects, drawn from just from three villages around Kathmandu University and may not be generalized for overall Nepali; (b) Measurements at single visit may not coincide to exact values for the BP; (c) asymmetry of the sample size regarding men and women may constitute a bias.

Conclusion

From this study, we found age, BMI, WC, WHR as significant predictors of SBP, DBP. WHR was found to be the most correlated factor for blood pressure for the total population. Specifically, WHR for the male population and WC for the female population were the most correlated indices. According to age group, for the population below 40 years, for the population of 50-60 years of age group and for the population of above 60 years of age, WC, WHR and BMI were the most correlated index with mean arterial pressure (MAP) respectively. This has a beneficial outcome clinically, because patients can be suggested to reduce the particular anthropometric index (most correlated one) through exercise or diet modification in order to have control over their elevated blood pressure. In this way, the finding can be used for the reduction of android obesity in order to reduce the risk of developing hypertension.

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