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Original Research Article

Study of anthropometric indices and it's co-relation with blood pressure in young healthy individuals

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ABSTRACT

Background: Overweight and obesity are shown to be independent risk factors for hypertension by several epidemiological studies. A practical, inexpensive and easily performed method for evaluation of body fat is anthropometry. Hence the present study was undertaken to explore association between anthropometric indices and blood pressure and determine efficacy of neck circumference to identify overweight subjects and define NC cutoff levels for overweight and obesity.
Methods: Cross sectional, comparative study conducted on apparently healthy medical college students, 150 having parental history of hypertension and 150 without a parental history of hypertension. Height, weight, waist circumference, hip circumference, neck circumference, body mass index, waist-hip ratio, waist- height ratio, and blood pressure were measured. Data was analyzed using SPSS version 20.
Results: Prevalence of pre-hypertension is 42.33%. 54.33% pre-hypertensive subjects had family history of hypertension but there is no statistically significant association between family history of hypertension and pre-hypertension. Neck circumference correlated with BMI, WC, W/H ratio ($p<0.05$) indicating that NC could be a useful screening tool. NC cutoff values determining overweight & obesity in this study is >33.30 cm in females and >37.15 cm in males. 61.76% and 38.98% pre-hypertensive males and females respectively have BMI above 25Kg/m² in comparison to 19.51% normotensive males and 20.88% normotensive females.
Conclusions: Study reveals development of hypertension is attributable to overweight and obesity and no statistically significant relationship has been established between family history of hypertension and risk for developing hypertension. NC>37.15cm for males and >33.30 cm for females was the best cut off levels for determining overweight/obese subjects.

Keywords: Anthropometry, Hypertension, Family history, Neck circumference, Obesity

INTRODUCTION

Obesity is one of today's most blatantly visible yet most neglected public health problems.[1] The epidemic of obesity is becoming a significant health issue in developing nations as well, compared to the popular belief that it is restricted to only industrialized countries.[2]

As per the World Health Organization (WHO) in 2014, 1.9 billion adults aged 18 and older were overweight, and of these, nearly 600 million were obese.[3]

Overweight and obesity has been shown to be an independent risk factor of type 2 diabetes (DM), hypertension (HTN), dyslipidemia and cardiovascular disease (CVD) by several epidemiological studies.[4,5]

High blood pressure if often called as the "Silent Killer".[6] It is known to be one of the major risk factors for cardiovascular morbidity and mortality and is known for its causation of coronary heart disease, strokes and other vascular catastrophes which in turn accounts for 20-50% of all deaths.[7,8] It is the commonest cardiovascular disorder, posing a major public health challenge to population and socio-economic and epidemiological transition. Therefore it is necessary to assess hypertension in the early stages itself so as to reduce complications and aid effective management.[9]

Hypertension accounts for more than 5.4% of total deaths, 1.9% of years of lost life and 1.4% of disability adjusted life years globally and the risk for developing hypertension is four times than average in individuals in industrialized countries.[10]

Hypertension in adults may be preceded by high blood pressure i.e. pre-hypertension in childhood.[11] Prehypertension is a warning sign, early in age which denotes the risk of hypertension later on in life.[12] According to JNC-7, pre-hypertension is labelled when a person has systolic blood pressure of 120-139 mm of Hg or diastolic blood pressure of 80-89 mm of Hg. The aim of the JNC-7 was to increase awareness of near-abnormal levels of blood pressure so that such "pre-hypertensive" persons would initiate lifestyle changes to delay development of frank hypertension.[13]

Parental history has been shown to be an important risk factor for subsequent development of cardiovascular diseases.[14] In fact for several diseases like hypertension, myocardial infarction, diabetes, and obesity a familial aggregation has been shown to occur.[15-18] Also a higher body mass index is noted in children and adolescents with a positive family history of cardiovascular diseases.[19]

Even after availability of extensive treatment options, hypertension remains inadequately managed everywhere. So the importance here is on primary prevention.[2]

Considering the above association of obesity with hypertension it is important to develop a reliable, simple, quick method for its assessment in primary care clinics. A practical method for evaluation of body fat is anthropometric dimensions as they are inexpensive, non-invasive and easily performed. Basic anthropometric measurements (weight, height, waist circumference and hip circumference) and their derived indices (Body mass index, waist-hip ratio and waist-height ratio) are used as indicators for the presence of diseases and their assessment in clinical practice.[21]

BMI is often used to reflect total body fat amounts, whereas the waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHR) are used as surrogates for intra- abdominal adiposity.[22,23]

Results received so far also show neck circumference to be an innovative and additional parameter to determine the distribution of body fat, which is associated with visceral fat and obesity.[24-27]

Hence this study aims to explore the association between anthropometric indices and blood pressure in young healthy individuals for development of a strategy to limit the disease burden due to hypertension.

METHODS

It was a cross sectional, comparative study conducted in MGM Medical College and Research Centre, Aurangabad, India during the period August-September 2016.

300 medical college students in the age group 18-25 of both sexes were included in the study, half of whom (150) had a parental history of hypertension i.e. the study group and the other half did not have a parental history of hypertension i.e. the control group. Parental history was considered positive with either parents or even both of the parents having hypertension. The participants were matched across age and sex.

Students having history of hypertension, taking Cardio active drug, alcoholics and smokers were excluded in order to limit the bias due to confounding factors.

Data collection

The participants were examined for various anthropometric parameters and their blood pressure.

Anthropometric parameters

Body weight

Taken to the nearest 0.1 kg by modern electronic digital LCD weighing machines placed on a flat surface. The scales were calibrated everyday against a standard (20 kg).

Height (cm)

Taken while the participants stood in erect posture, touching the occiput with the back, hip and heels on a straight measuring wall, participants looking straight ahead.

BMI

Weight in kilograms divided by the square of the height in meters.

Waist and hip circumference

Waist circumference (WC) was measured by placing an inelastic tape horizontally midway between the lower

border of the ribs and iliac crest on the mid-axillary line at the end of the respiratory breathing.

A waist circumference more than 102 cm for males and more than 88 cm for females was considered cut-off for obesity.[29]

Hip circumference (HC) was measured to the nearest centimeter at the greatest protrusion of the buttocks just below the iliac crest.

Table 1: WHO classification of adults according to BMI [28]

Classification	BMI (kg/m^2)
Underweight	<18.5
Normal	18.5-24.99
Overweight	25.0-29.99
Obese	>30.0
Obese I	30.0-34.99
Obese II	35.0-39.99
Obese III	>40.0

Waist-hip ratio

WHR was calculated as WC divided by hip circumference. The cut-off used for the waist-hip ratio (WHR) for males will be 1 and for females it will be 0.85.[29]

Waist-height ratio (WHtR) or Waist-stature ratio (WSR)

WHtR=WC (cm)/Height (cm). The cut-off value used was 0.5 for both males and females.[30]

Neck-circumference (cm)

NC was measured in the midway of the neck, between mid- cervical spine and mid anterior neck, to within 1 mm, using non-stretchable plastic tape with the subjects standing upright. In men with a laryngeal prominence (Adam's apple), it was measured just below the prominence. While taking this reading, the subject was asked to look straight ahead, with shoulders down, but not hunched. Care was taken not to involve the shoulder/neck muscles (trapezius) in the measurement.

Blood pressure

Blood pressure was measured twice by using standardized mercury sphygmomanometer in right upper arm in sitting position after ensuring that the subject had relaxed at least for 5 minutes. The second reading was taken after 10 minutes and an average of the two readings was taken to calculate the final value. The seventh report of the Joint National Committee (JNC 7) proposed a new definition of blood pressure values below 140/90 mm Hg. Pre-hypertension was considered to be blood pressure readings with a systolic pressure from 120 to 139 mm Hg or a diastolic pressure from 80 to 89 mm Hg. Readings greater than or equal to 140/90 mm Hg was considered hypertension.[31]

To reduce subjective error all measurements were taken by the same principal investigator only. A female colleague accompanied the investigator while taking anthropometric measurement's for females.

The approval and clearance of the Institutional Ethics Committee for Research on Human Subjects was taken prior to the initiation of the research activity.

Statistical analysis

The collected data was compiled in MS Excel sheet 2013. Data was analyzed using SPSS version 20. The quantitative data is represented in form of mean and standard deviation. To compare the associations between different anthropometric indices and blood pressure the chi square test was applied, the p value applied at 5% level of significance. Pearson's correlation co-efficient was applied to compare the relation of neck circumference with other anthropometric parameters and an receiver operating characteristic (ROC) curve analysis was done to determine the best cut-off for neck circumference to label a subject as obese.

RESULTS

In Table 2, this study, 127 (42.33%) subjects had pre-hypertension. Of the 68 male pre-hypertensive, 37 (54.41%) had a positive family history of hypertension and among the 59 female pre-hypertensive subjects, 32 (54.24%) had a positive family history of hypertension. The higher incidence of prehypertension among males and females with family history of hypertension was not statistically significant.

In Table 3, using the Pearson's correlation co-efficient, neck circumference shows a highly significant correlation with height, weight, waist circumference, hip circumference and BMI in both male and female.

In Table 4, the ROC analysis, the area under the curve for male is C=0.843 with standard error=0.033 and 95% confidence interval from 0.780 to 0.907. The best cut-off that maximizes (sensitivity + specificity) is 37.15 cm. At this value, the sensitivity is 0.759 and specificity is 0.815. The area under the curve for female is C=0.867 with standard error=0.031 and 95% confidence interval from 0.807 to 0.928. The best cut-off that maximizes (sensitivity + specificity) is 33.30 cm. At this value, the sensitivity is 0.762 and specificity is 0.833.

In Table 5, out of the 300 subjects, 100 (33.33%) were overweight and obese. Of the 58 males having BMI above 25 kg/m², 29 (50%) had a family history of hypertension. The chi-square statistic is 0 and p-value is 1. Of the 42 females having BMI above 25 kg/m², 16 (38.10%) had a family history of hypertension and 26

(61.90%) had no family history of hypertension. The chi-square statistic is 3.307 and p value is 0.69.

There is no statistically significant difference in the BMI in male or female with parental history of hypertension and without parental history of hypertension.

In Table 6 and 7, the number of study participants having anthropometric indices above the specified cut-off values is compared between the groups with family history of hypertension and without a family history of hypertension both separately in male subjects and female subjects. There is no statistically significant difference in the anthropometric indices measured in male and female with parental history of hypertension and without parental history of hypertension.

Table 2: Distribution of pre-hypertensive subjects in groups according to gender.

Gender	Without HTN history (%)	With HTN History (%)	Total (%)	Chi Square value	P value
Male (Pre-hypertensive)	31 (45.59)	37 (54.41)	68 (53.54)	0.97	0.33
Female (Pre-hypertensive)	27 (45.76)	32 (54.24)	59 (46.46)	0.6985	0.4033
Total	58 (45.67)	69 (54.33)	127 (42.33)		

Table 3: Relation between neck circumference and various variables, Pearson's correlation co-efficient.

	Male		Female	
Variable	**Corr. Coeff**	**P value**	**Corr. Coeff**	**P value**
Height	0.278	0.001	0.228	0.005
Weight	0.780	0.000	0.791	0.000
Waist	0.755	0.000	0.734	0.000
Hip	0.697	0.000	0.694	0.000
BMI	0.702	0.000	0.726	0.000

Table 4: Neck circumference cut-off levels for determining the subjects with BMI >25kg/m² using ROC analysis.

	Male	Female
NC cut-off	37.15	33.30
Sensitivity	0.759	0.762
Specificity	0.815	0.833
LR+	4.10	4.56
LR-	0.29	0.28
Area under curve	0.843	0.867

Table 5: Distribution of BMI in study subjects in relation to family history of hypertension.

	Male		Female		
BMI classification	**Without HTN history (%)**	**With HTN history (%)**	**Without HTN history (%)**	**With HTN history (%)**	**Total**
Underweight (<18.5 kg/m²)	3 (4)	4 (5.33)	4 (5.33)	9 (12)	20 (6.67)
Normal (18.5-24.9 kg/m²)	43 (57.33)	42 (56)	45 (60)	50 (66.67)	180 (60)
Overweight and obesity (25 kg/m²+)	29 (38.67)	29 (38.67)	26 (34.67)	16 (21.33)	100 (33.33)
Total	75	75	75	75	300

Table 6: Comparison of male study subjects having anthropometric indices above cut-off values in relation to family history of hypertension.

	Anthropometric parameter	Without HTN history (%)	With HTN history (%)	Total (%)	Chi Square	P value
Male	Waist circumference (>102 cm)	2 (2.67)	6 (8.0)	8 (5.33)	2.1127	0.146084
	Waist-hip ratio (>1.0)	0	2 (2.67)	2 (1.33)	2.027	0.154
	Waist-height ratio (>0.5)	24 (32)	31 (41.33)	55 (36.67)	1.4067	0.2356
	Neck circumference (>37.15cm)	28 (37.33)	33 (44)	61 (40.67)	0.6907	0.4059

Table 7: Comparison of female study subjects having anthropometric indices above cut-off values in relation to family history of hypertension.

	Anthropometric parameter	Without HTN history (%)	With HTN history (%)	Total (%)	Chi square	P value
Female	Waist circumference (>88 cm)	20 (26.67)	25 (33.33)	45 (30)	0.7937	0.3729
	Waist-hip ratio (>0.85)	50 (66.67)	53 (70.67	103 (68.67)	0.2789	0.597
	Waist-height ratio (>0.5)	37 (49.33)	46 (61.33)	83 (55.33)	2.1849	0.1393
	Neck circumference (>33.30 cm)	24 (32)	26 34.67)	50 (33.33)	0.12	0.7290

Table 8: Distribution of BMI in study participants based on presence or absence of pre- hypertension.

	Males		Females		
BMI classification	**Pre-hypertensive (%)**	**Normotensive (%)**	**Pre-Hypertensive (%)**	**Normotensive (%)**	**Total (%)**
Underweight (<18.5 kg/m²)	0	7 (8.54)	2 (3.39)	11 (12.09)	20 (6.67)
Normal (18.5-24.9 kg/m²)	26 (38.24)	59 (71.95)	34 (57.63)	61 (67.03)	180 (60)
Overweight and obesity (25+kg/m²)	42 (61.76)	16 (19.51)	23 (38.98)	19 (20.88)	100 (33.33)
Total	68	82	59	91	300

Table 9: Comparison of male study subjects having anthropometric indices above cut-off values in relation to presence or absence of pre-hypertension.

	Anthropometric parameter	Pre-hypertensive (%)	Normotensive (%)	Total (%)	Chi square	P value
Male	Waist circumference (>102 cm)	8 (11.76)	0	8 (5.33)	10.19	0.0014
	Waist-hip ratio (>1.0)	2 (2.94)	0	2 (1.33)	2.44	0.1179
	Waist-height ratio (>0.5)	38 (55.88)	17 (20.73)	55 (36.67)	19.78	0.000009
	Neck circumference (>37.15 cm)	44 (64.71)	17 (20.73)	61 (40.67)	29.79	0.0000

Table 10: Comparison of female study subjects having anthropometric indices above cut-off values in relation to presence or absence of pre-hypertension.

	Anthropometric parameter	Pre-Hypertensive (%)	Normotensive (%)	Total (%)	Chi square	P value
Female	Waist circumference (>88cm)	24 (40.68)	21 (23.08)	45 (30)	5.28	0.021
	Waist-hip ratio (>0.85)	42 (71.19)	61 (67.03)	103 (68.67)	0.287	0.5921
	Waist-height ratio (>0.5)	40 (67.800	43 (47.25)	83 (55.33)	6.11	0.013425
	Neck circumference (>33.30cm)	28 (47.46)	22 (24.18)	50 (33.33)	8.73	0.0031

In Table 8, out of the 68 pre-hypertensive males, 42 had BMI above 25kg/m² in comparison to 16 males from the normotensive group. Overweight and obesity is significantly associated with prehypertension in males ($p<0.01$)

Of the 59 hypertensive females, 23 had BMI above 25 kg/m² in comparison to 19 females from the normotensive group. Overweight and obesity is significantly associated with prehypertension in females ($p=0.015$)

Table 9 and 10 shows the result of comparison of anthropometric indices between the pre-hypertensive and the normotensive group. A higher BMI, waist circumference, waist-height ratio and neck circumference in the group with pre-hypertension was found to be statistically significant in comparison to the group with normal blood pressure. But waist-hip ratio does not show a statistically significant association with pre-hypertension in either males or females.

DISCUSSION

Prevalence of pre-hypertension

The prevalence of pre-hypertension in our study is 42.33%. Various other studies conducted in different parts of the nation have reported prevalence of pre-hypertension ranging from 21%-67%.

In study done by Monika in a medical college in Wardha, prevalence of pre-hypertension was found to be 52%.[9] Rao et al reported prevalence of pre hypertension to be 31.8% and hypertension as 9.8% in 18-35 year old young adults in semi urban district in Telangana.[12] Chitrapu et al reported overall prevalence of prehypertension as 37.45% and prevalence of hypertension as 3.63%.[13] Hazarika et al reported prevalence of pre-hypertension to be 54% in a study conducted in native rural population of Assam.[32] Shobha et al reported prevalence of pre-hypertension to be 55.4% amongst medical students in coastal Karnataka.[33] Das et al conducted a study on 18-25 year old medical college students in West Bengal and reported 21% prevalence of pre-hypertension.[34] Muralidhar et al reported prevalence of 67% for prehypertension and hypertension in medical college students in Davangere, Karnataka.[35]

Prehypertension and family history of hypertension

In our study, 54.33% pre-hypertensive subjects had family history of hypertension but chi- square analysis reveals no statistically significant association between family history of hypertension and pre-hypertension. Study by Das et al, also reports similar result of family history not being a significant risk factor for development of pre-hypertension.[34]

But a positive association between family history of hypertension and pre-hypertension has been observed in several studies which is in contrast to our study findings.[7,9,12,33]

Anthropometric parameters and family history of hypertension

In both males and females, the group with family history of hypertension showed more subjects above the cut-off used for anthropometric parameters of BMI, waist circumference, waist-hip ratio, waist height ratio and neck circumference in comparison to the group without family history of hypertension but this difference observed was not statistically significant for any anthropometric parameter compared in our study. This implies that family history of hypertension is not a significant risk factor for development of subsequent obesity. Development of obesity is instead linked to an individual's dietary habits, physical exercise, sleep pattern, smoking, and alcoholism among the several other personal and environmental risk factors.

But several studies report strong relationship between family history of hypertension and obesity. According to Glowinska et al, children with positive family history of cardiovascular diseases have significantly higher body mass index. (25.4 vs. 23.8 kg/m2).[19]

Also Kalbande et al, Choudhary et al, Khanna et al have all reported a significant association between family history of hypertension and obesity.[14,20,21]

Neck circumference and obesity

In our study neck circumference (NC) moderately correlated with common indices of obesity such as BMI, WC, W/H ratio ($p<0.05$) indicating that NC could be a useful screening tool for high BMI in adults.

NC is related to upper body sub- cutaneous tissue. Upper body fat distribution has been recognized as related to increased cardiovascular disease risk & neck skin fold or neck circumference.[36] Upper-body subcutaneous fat is a novel, easily measured fat depot & may lead to a better understanding of the differential effects of adiposity in males and females. Free fatty acid release from upper-body subcutaneous fat was reported to be larger than that from lower-body subcutaneous fat.[37] Visceral fat may be a marker for excess free fatty acids, it is not the source of circulating levels. Upper-body SC fat is responsible for a much larger proportion of systemic free fatty acid release than visceral fat, particularly in obese individuals. Obesity and elevated levels of plasma free fatty acids are associated with insulin resistance and increased VLDL production. Increased levels of free fatty acids have also been correlated with markers of oxidative stress and vascular injury and are associated with the development of hypertension.[38]

The present study provides gender-derived cutoff values for overweight and obesity screening adults for high BMI that could be used in a busy clinical setup. The ROC analysis for BMI of >25 Kg/m^2, NC cutoff values determining overweight and obesity in this study is >33.30 cm in females and >37.15 cm in males.

Hingorjo et al reported cut-off of 35.5 cm for male and 32 for female, Aswathappa reported cut-off of 36 cm for male and 32 cm for female, Kumar reported a cut-off of 38cm for male and 34.7 cm for female.[25-27] Even the cut-off reported in this study is in a similar range.

Individuals above the cut-off levels require a more comprehensive evaluation of their overweight or obesity status. Prevention of obesity is more cost effective, than is the treatment of risk factors resulting from obesity.

As a first step to achieve obesity control, NC can be used as a quick, reliable, simple screening tool for the assessment of obesity in primary care clinics, and also by health care workers. One potential benefit of NC measurement is that it has cultural advantage, especially in females where it can be measured easily with -out much awkwardness.

Prehypertension and obesity

This study shows that obesity is a significant risk factor for development of pre-hypertension which in turn is the precursor for hypertension.

61.76% pre-hypertensive males and 38.98% pre-hypertensive females have BMI above 25Kg/m² in comparison to 19.51% normotensive males and 20.88% normotensive females. The results obtained are statistically significant.

Obesity could be due to causes like sedentary life-style, diet rich in saturated fat and cholesterol, excess consumption of junk food amongst others. The findings of this study show that obesity is linked significantly with pre-hypertension and being obese predisposes and individual to development of hypertension.

Waist circumference, waist- height ratio, neck circumference shows a statistically significant relation with pre-hypertension in our study. These indices are a measure of central obesity and this significant relationship implies that higher central obesity is an important risk factor for development of pre-hypertension in individuals.

The findings of this study of obesity being a significant risk factor for hypertension is corroborative with findings of many similar studies.[7,9,12,13,33,34.]

But these studies report waist-hip ratio to be a significant anthropometric parameter which is contradictory to our findings. This could be due to higher cut-off value used in our study, which was 1 for male and 0.8 for female which is the standard WHO cut-off.

CONCLUSION

In our study among young healthy medical students, prevalence of pre-hypertension is 42.33% and the various basic and derived anthropometric indices showed significantly higher values in pre-hypertensive subjects as compared to normotensive subjects. Our study reveals there exists no statistically significant relation between family history of hypertension and the risk for developing obesity or hypertension in future. So development of hypertension is attributable to environmental factors and personal habits like diet, sedentary lifestyle, stress among others and not heredity. Therefore individuals should be advised to do regular exercise to control their weight, avoid obesity, to abstain from taking junk and oily food and motivated for regular monitoring of their blood pressure.

Also neck circumference positively co-related with other indices of obesity in males and females. NC> 37.15cm for males and >33.30 cm for females was the best cutoff levels for determining the overweight/obese subjects. Neck Circumference could be a potential, inexpensive, easily measured clinical screening tool for evaluating central obesity.

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