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Original Article

Relationship of Anthropometric Indices of Obesity with Arterial Stiffness and Blood Pressure

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Abstract

Background: To determine the comparison and relationship of anthropometric indices with blood pressure and arterial stiffness index (ASI) in normotensive, prehypertensive and hypertensive male adults.

Methods: In this randomized case control study ninety male subjects between 35-55 years of age were selected with each group comprising of thirty normotensive, pre-hypertensive and hypertensive subjects. According to the World Health Organization (WHO) guidelines their height, weight, hip (HC) and waist circumferences (WC) were measured. Waist hip ratio (WHR), body mass index (BMI), conicity index (CI) and waist stature ratio (WSR) were calculated. Blood pressure (BP) was measured by mercury sphygmomanometer with auscultatory method. Photoplethysmography was done by placing velcro scrap on volar surface of middle finger and digital volume pulse (DVP) was recorded with iWorx-214 physiological interface system and ASI was calculated. Statistically, difference amongst the three groups was determined by applying one way ANOVA. Difference between the groups was analyzed by Post Hoc Tukey's test. Pearson's correlation coefficient was calculated to study the relationship. p-value<0.05 was considered significant.

Results: There was statistically significant difference in WC (0.003), WHR (0.0001) and ASI (0.0001) between the three groups but not BMI (0.223). Amongst the anthropometric measurements, WC and WHR were positively correlated to the systolic and diastolic blood pressure.

Conclusions: Central obesity is better predictor of arterial stiffening and hypertension than BMI.

Key Words: Prehypertension, Hypertension, Arterial stiffness index, Central obesity,Waist circumference,Body mass index

Introduction

There is progressive increase in blood pressure (BP) with upsurge in obesity which is result of industrialization, urbanization, sedentary life styles and behavioral adaptations. The prevalence of obesity is rising not only in affluent societies but also in developing countries irrespective of age, race and ethnicity. [1] Childhood obesity is associated as risk factor for cardiovascular diseases.[2] The anthropometric indices like waist circumference (WC), body mass index (BMI), waist-hip ratio (WHR), conicity index (CI) and waist-stature ratio (WSR) have been proposed as markers of obesity in various studies. Yet, it is not clear which of these markers has the strongest link with BP in our population. Body mass index is the major determinant of overall obesity while central or visceral obesity is more closely linked with BP and cardiovascular diseases (CVD) as evident from literature survey.[3, 4] BMI is usually near similar among the groups while waist to hip ratio (WHR) and waist circumference (WC) were significantly different among normotensive, prehypertensive and hypertensive groups. The measures of central obesity i.e. WHR and WC are distinctly correlated with blood pressure and ASI than BMI which represents the index of overall obesity. According to Gus et al.(2009) waist to hip ratio and waist-stature ratio are better predictors of incidence of hypertension when compared with BMI especially in male gender.Men's hypertension is primarily dependent onvisceral obesity in contrast to women's hypertension which correlates predominantly with overall adiposity.[5] It has been proposed that physical compression of the kidneys by visceral fat deposits and the activation of renin-angiotensin system might be important factors in elevation of blood pressure with increasing body weight.[6]

It is proposed that the visceral fat cell volume has positive correlation with arterial stiffness, central fat mass and cardiovascular risk.[7] The visceral fat and abdominal obesity are closely associated with large artery stiffness. These findings highlight the importance of anthropometric indices of obesity as risk factors for arterial stiffening in middle-aged adults.[8] Arterial stiffness is a cause rather than a consequence of hypertension and precedes the development of hypertension in animal model. [9]

It is argued that arterial stiffness index (ASI) is a useful non-invasive tool for the CVD risk stratification because of its capability to detect early target organ injury. [10] Different techniques have been employed to measure the ASI in various studies ranging from simple to intricate ones. The stiffness index score determined by photoplethesmography is comparable to the arterial stiffness calculated by pulse-wave velocity which is unanimously agreed gold standard marker. [11,12] ASI has been documented to be more sensitive non-invasive tool for assessing the patients at risk of CVD in comparison to total cholesterol,plasma glucose and waist to hip ratio in deceptively healthy population.[13] Obese individuals are at higher risk of arterial stiffness irrespective of their metabolic conditions. [14] Arterial stiffness is considered to be one of the earliest detectable measures of vascular damage.[15] It is increased in obese/overweight subjects without obvious cardiovascular diseases. [16,17]

Obesity is a major modifiable risk factor for coronary artery disease (CAD). [15] The role that systemic arterial stiffness plays in pathogenesis of hypertension and cardiovascular disease has generated great interest in defining basic mechanisms that stiffen the vascular wall, increase blood pressure and contribute to target organ damage with a hope that clarification of these mechanisms will allow for development of more effective treatments.[18]

Subjects and Methods

This case control study was carried out in Dept. of Physiology Army Medical College, from Jan 2014 to Dec 2014. Total ninety male subjects between 35-55 years of age were selected by non-probability, convenience sampling with each group comprising thirty subjects. Normotensive subjects were defined as those with a diastolic blood pressure < 80 mmHg and systolic blood pressure <120 mmHg. Prehypertensive subjects were defined as those with a diastolic blood pressure between 80-89 mmHg and systolic blood pressure between 120-139 mmHg. Hypertensive subjects were those with diastolic blood pressure >90 mmHg and systolic blood pressure >140 mmHg.The subjects were placed into various groups according to JNC-VII report.[19] More than one thousand subjects were interviewed and those having fever, any allergic disease, or taking any kind of medications for at least last two weeks were excluded. Those who had chronic inflammatory disease, diabetes or any prolonged illness were also excluded. The study was started after approval from post graduate board of studies Army Medical College and Ethical Review Committee, Centre for Research in Experimental and Applied Medicine (CREAM). After written informed consent BP was measured by mercury sphygmomanometer. Blood sugar was checked (in order to exclude diabetes mellitus). Weight nearest to 0.1 kgwas measured using pointer spring balance without shoes and single light clothing. Height nearest to 0.5 cm was recorded. WC was measured horizontally halfway between iliac crest and lower border of rib cage using plastic measuring tape. Hip circumference (HC) was measured at the broadest part of buttocks. Both HC and WC were quantified nearest to 0.1 cm. Waist to hip ratio was calculated.BMI was calculated by dividing weight in kilograms by height in meters square. Waist-Stature ratio was calculated by dividing WC by height. Conicity index was calculated by the formulae [CI=WC (m)/$0.109\sqrt{\text{weight (kg)/height (m)}}$].

Photoplethysmography was done by placing velcro scrap on volar surface of middle finger and digital volume pulse (DVP) was recorded via iWorx-214 physiological interface system and ASI was calculated. LabScribe® software was used to analyze recorded data. By placing cursor on two peaks of DVP, reflection time was calculated. ASI was calculated by the formulae [ASI = Height (meters)/ Reflection time (seconds)].One way ANOVA was applied followed by Post-Hoc Tukey's test to compare the means of anthropometric indices of obesity, BP variables and ASI in normotensive, prehypertensive and hypertensive subjects. Pearson's correlation coefficient was determined to study the correlation between various variables. P-value<0.05 was considered statistically significant.

Results

The mean arterial pressure was 37 SD 5; systolic BP 110 SD 6 and diastolic blood pressure was 73 SD 6 in group I, 44 SD 4; 130 SD4 in group II and 59 SD 8; 164 SD 12 in group III (p-value 0.0001). WHR was 0.95 SD 6 meters; waist circumference 0.90 SD 0.08 in normotensive group. In pre-hypertensive group the values were 0.95 SD 0.09 meters and 0.98 SD 0.08 in hypertensive group (p-value 0.0001). Waist hip ratio 0.94 SD 0.56 in group I, 0.99 SD 0.08 in group II and 1.03 SD 0.09 in group III (p-value 0.0001); waist-stature ratio 0.54 SD 0.05 in normotensive group.

Table-1: Comparison of anthropometric indices and arterial stiffness index amongst the groups

Variables	Group 1 Normotensive Mean ± SD (n=30)	Group 2 Prehypertensive Mean ± SD (n=30)	Group 3 Hypertensive Mean ± SD (n=30)	p-value (sig.)
Age	40 ± 4	43 ± 5	47 ± 5	0.0001
MAP	37 ± 5	44 ± 4	59 ± 8	0.0001
SBP	110 ± 6	130 ± 4	164 ± 12	0.0001
DBP	73 ± 6	86 ± 2	105 ± 11	0.0001
WHR	0.94 ± 0.56	0.999 ± 0.08	1.03 ±.09	0.0001
WC	0.90 ± 0.08	0.95 ± 0.09	0.98 ± 0.08	0.003
WSR	0.54 ± 0.05	0.54 ± 0.11	0.57 ± 0.05	0.102
CI	1.28 ± 0.07	1.32 ± 0.08	1.32 ± 0.08	0.051
BMI	25 ± 3	26 ± 3	27 ± 3	0.223
ASI	6.7 ± 0.5	7.8 ± 0.6	12.2 ± 2.6	0.0001

All values are expressed as mean plus/minus standard deviation;[MAP: mean arterial pressure; SBP: systolic blood pressure; DBP: diastolic blood pressure; WHR: waist to hip ratio; WC: waist circumference; WSR: waist stature ratio; CI: conicity index; BMI: body mass index; ASI: arterial stiffness index]

Table-2: Comparison of anthropometric indices and arterial stiffness index between the groups

Variables	Normotensive vs Prehypertensive	Normotensive vs Hypertensive	Prehypertensive vs Hypertensive
Age	0.048	0.0001	0.001
MAP	0.0001	0.0001	0.0001
SBP	0.0001	0.0001	0.0001
DBP	0.0001	0.0001	0.0001
WHR	0.011	0.0001	0.371
WC	0.057	0.003	0.523
ASI	0.014	0.0001	0.0001

MAP: mean arterial; SBP: systolic blood pressure; DBP: diastolic blood pressure; pressure; WHR: waist to hip ratio; WC: waist circumference; ASI: arterial stiffness index

In pre-hypertensive group the values were same and 0.57 SD 0.05 in hypertensive group (p-value 0.0001). The BMI was 25 SD 3, in group I, 26 SD 3 in group II and 25 SD 3 in group III (p-value 0.223). The ASI was 6.7 SD 0.5 in group I, 7.8 SD 0.6 in group II and 12.2 SD 2.6 in group III (p-value 0.0001) (Table 1).The difference between the groups,evaluated by Post Hoc Tukey's test, showed that waist circumference was significantly different between normotensive and hypertensive group (0.003). ASI was significantly different between group I and II (0.014). It was also significantly different between normotensive and hypertensive group (0.0001). ASI was also significantly different between group II and III (0.0001) (Table 2).Relationship between variables, studied by Pearson's correlation coefficient,revealed statistically significant relationship between BP, waist circumference and waist-hip ratio (Table 3).

Table-3: Relationship of anthropometric indices with arterial stiffness index and blood pressure variables

Variables		BMI	WC	WHR	CI	WSR
ASI	r	0.107	0.218	0.269	0.136	0.098
	p	0.316	0.038	0.010	0.201	0.357
SBP	r	0.177	0.323	0.372	0.192	0.167
	p	0.095	0.002	0.0001	0.070	0.116
DBP	r	0.181	0.346	0.362	0.250	0.186
	p	0.088	0.001	0.0001	0.017	0.080
MAP	r	0.182	0.341	0.372	0.228	0.180
	p	0.086	0.001	0.0001	0.031	0.089
PP	r	0.135	0.323	0.209	0.070	0.167
	p	0.204	0.002	0.003	0.051	0.116

ASI: arterial stiffness index; SBP:systolic blood pressure; DBP:diastolic blood pressure; MAP: mean arterial pressure; WSR: waist stature ratio; CI: conicity index; WHR: waist to hip ratio; WC: waist circumference; BMI: Body Mass Index

Discussion

In present study it was revealed that the markers of central obesity (WHR>WC>WSR>CI>BMI) are better related with arterial stiffness index and BP than BMI.

These findings were similar to the study by Gus *et al.*(2009), Recio-Rodriguez JI*et al.* (2012) and Lee *et al.* (2015) that the anthropometric measures of central obesity were better predictors of the incidence of hypertension than the measures of generalized obesity like BMI in male gender especially (Table 4).[20-22]

Our results supported the findings of study by Zhou et al.(2003)that in male gender hypertension is associated with central obesity and overall adiposity correlates mainly with women's hypertension. [5] The study by Mark et al. revealed that the frequency of elevated blood pressure was positively associated with visceral adipose tissue .[23] Significant compression of renal mass by visceral adipose tissue and stimulation of renin-angiotensin system have been proposed to be important factors in causing hypertension with growing body weight.[6]

The visceral fat deposits have been proposed to release various factors which may contribute in causing hypertension by increasing sympathetic activity. [24] The BMI was statistically similar in three groups in our research project which was similar to the findings of another study conducted in population of Peshawar, Pakistan. It was detected in that study that large percentage of male gender in the normal BMI category had raised blood pressure than normal. [25] The studies byMufunda et al. (2006) and Sakurai et al. (2006) also support our observation that BMI was not significantly related with blood pressure especially in male subjects. [26, 27] Ononamadu, C. J. et al. (2017)study revealed that BMI and either WC or waist height ratio have same prediction value in determining risk of hypertension. [28]

Table-4: Correlation orders of anthropometric indices with systolic and diastolic blood pressure in various studies

Studies	Diastolic Blood Pressure	Systolic Blood Pressure
Present study (n=90)	WHR> WC > CI > WSR >BMI (0.000)(0.001)(0.01)(0.06)(0.09)	WHR> WC > WSR > CI >BMI (0.000)(0.002)(0.04)(0.07)(0.09)
Yalcin et al.[29] (n=267)	BMI>WC>WSR>WHR>CI	WSR>BMI>WC>WHR>CI
Ghosh & Bandyopadhyay.[30] (n=180)	BM>WC>WSR>WHR>CI	WSR>BMI>WC>WHR>CI
Zhou Z et al.[4] (n=29079)	BMI>WC>WSR>WHR>CI	BMI>WC>WSR>WHR>CI
Ghosh JR, Bandyopadhyay AR. [31] (n=179)	WC > CI > WSR >BMI (0.01) (0.01) (0.05) (0.53)	WC > CI > WSR >BMI (0.01) (0.01) (0.62) (0.70)

BMI:Body Mass Index; WHR: waist to hip ratio; WC: waist circumference; CI: conicity index; WSR: waist stature ratio

Conclusion

Central obesity (determined byWHR and WC) is better predictor of arterial stiffness and raised blood pressure in middle aged Pakistani men.

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