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EFFECT OF BODY MASS INDEX AND WAIST CIRCUMFERENCE ON BLOOD PRESSURE IN ADULTS

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ABSTRACT

Background: Hypertension in adolescence is increasing with obesity epidemic. Body mass index (BMI) and waist circumference (WC) are used to assess obesity. WC can be suggested to be a better predictor of high blood pressure (BP) than BMI in adults. **Methodology**: A total of 350 medical students aged 18 -21 years were included in the study without blood pressure medication, without diabetes, cardiovascular disease or any daily dysfunction at baseline. Height, weight, BMI, WC, and blood pressure were recorded. **Results:** Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were found to be significantly higher with high BMI groups. Waist circumference also strongly associated with both SBP and DBP ($p < 0.001$). **Conclusions**: An increased BMI and increased WC are good predictors of rise in SBP and DBP. WC is easier to measure than blood pressure so can be

used as screening tool for adolescence hypertension in terms of training and access to equipment.

KEYWORDS: Obesity, Waist circumference, Body mass index, Blood pressure.

OBJECTIVES: To see the association between change in BMI and change in SBP and DBP.

INTRODUCTION

Obesity, globally epidemic and a preventable cause of death, is involving more than 600 million adult and 100 million children worldwide, out of which 39% of adults, aged 18 years and over, were overweight in 2016, and 13% were obese.[1] Obesity is considered to be one of the most serious public health problem of 21st century and is classified as a disease by the American Medical Association in 2013.[2,3]

An excessive food intake and lack of physical activity explain most cases of obesity while genetics, psychiatric illness and medical reasons, are also contributing factors.[4,5]

Obesity and overweight are associated with morbidity and mortality from elevated blood pressure, metabolic syndrome, type 2 diabetes mellitus, high blood cholesterol, and triglyceride levels, types of cancer, osteoarthritis and asthma. The mortality related to BMI is noticed in Caucasian and Asian populations, the Asian populations at a lower BMI develop negative health consequences than Caucasians.[6,7,8,9,10]

Obesity is assessed by BMI, WC and wrist circumference. BMI varies with age, sex and is related to total body fat and its percentage.[10,11] BMI is expressed in weight in kilograms per height in square meter or (Pounds \ inch^2 and equals to 703 x (kg/m^2) / (lb/in^2). The BMI $\geq$ 45 or 50 kg/m^2 is super obesity, $\geq$40–44.9 kg/m^2 is morbid obesity, $\geq$ 35 or 40 kg/m^2 is severe obesity, BMI of 30–35 kg/m^2 reduces life expectancy by two to four years, while severe obesity reduces life expectancy by ten years.[12]

The WC, a visceral fat indicator and reflecting the central adiposity has been identified as a cardiovascular risk factor in children and adolescents. However, still unresolved whether WC measured in childhood correlates with high BP or not than the BMI.[13]

In adults, measurement of blood pressure and WC is not a part of regular health check-up and thus may lead to under diagnosis of hypertension in this age group. Early diagnosis and

prevention of obesity in adults is important to reduce the risk of cardiovascular disease later in life.

This study was done to see the relationship of BMI and WC with blood pressure and pulse rate as the cardiovascular diseases is more strongly associated with adiposity and fat distribution compared to BMI.

MATERIAL AND METHOD

This cross sectional study conducted at Mahi-ud-din Islamic Medical College on 350 undergraduate medical students aged 18 - 21 years. The students already on blood pressure medication, anti-diabetics, or with cardiovascular disease and other systemic illnesses were excluded from the study. An informed consent was taken from the students and the study was approved by the ethical committee of the institution. Anthropometric measurements including height, weight, waist circumferences and the physiological dimensions like pulse and blood pressure were taken on each subject.

Weight and height were measured using Medical Equipment Weight & Height Scale (Zzjkh-01). Weight was measured while the subject wearing light clothes (gown or underwear) nearest to 0.5 kg. The height was measured nearest to 0.1 cm. while the subject stood straight without shoes; keeping the heels, buttocks, shoulder blades and back of head vertical and looking directly forward.

BMI was calculated using standard formula: weight (kilograms)/height (meters^2). BMI was classified according to WHO criteria - (CED III <16, CED II = 16-16.9, CED I = 17-18.49, underweight < 18.5, normal = 18.5-24.5, overweight = 25.0-29.9, and obese ≥30.00.[1]

According to BMI, students were categorized into 4 groups: Group A underweight, Group B normal weight, Group C overweight and Group D obese.

Waist circumference was measured in cm (nearest to 0.1 cm) at the end of quite expiration, midway between the lowest portion of the rib cage and iliac crest, and anteriorly midway between the xiphoid process of the sternum and the pubic symphysis at level of the umbilicus.

Blood pressure was measured by auscultatory method using mercury sphygmomanometer with appropriate cuff size (bladder width 40% of the arm circumference) involving two thirds

of upper arm length. The BP was measured 5-10 minutes after rest with the subject seated, from the right arm positioned at the level of the heart. The blood pressure was measured twice to avoid the effects of white coat hypertension and the mean was taken as blood pressure value.

A standardized protocol was followed while taking measurements. Normal SBP was taken as < 120 mmHg and DBP <80 mmHg. The SBP values of 120-139 mmHg and 80-89 mmHg DBP value were classified as pre-hypertensive. Stage-I hypertension was taken as 140-159 mmHg SBP, and 90-99 mmHg DBP, whereas blood pressure of >160 mmHg SBP and >100 mmHg DBP were classified as stage II hypertension respectively.

Statistical Analysis

Data was analyzed with SPSS 17.0. The non-paired Student t –test was used. Values were expressed as mean ± standard deviation. P values <0.05 indicated statistical significance.

RESULTS

Table 1 shows effect of different BMI group on SBP, and DBP. A total of 350 students were inducted in the study, out of which according to WHO classification 32 (9.1%) were underweight (BMI < 18.5), 185 (52.9%) were normal (BMI 18.5-24.5), 103 (29.4%) were overweight (BMI 25.0-29.9) while 30 (8.6%) were obese (BMI ≥30.00). A 205 (58.6%) participants were having normal systolic blood pressure, while 136 (38.9%) had pre-hypertension, 08 (2.3%) in stage I and 01 (0.3%) participant had stage II hypertension. Considering the diastolic blood pressure, 152 (43.4%) participants were having normal diastolic blood pressure, 124 (35.4%) pre-hypertensive, 63 (18%) in stage I, while 11 (3.1%) had stage II diastolic hypertension.

Out of 103 overweight BMI participants, 31.4% were female and 27.4% were male. The systolic and diastolic pre-hypertension was noticed in 58 (56.3%) and 38 (36.9%) participants respectively, 17 (16.5%) had stage I and 07 (6.8%) had stage II diastolic hypertension.

Out of 30 obese participants, male percentage was double than the female, 19 (63.3%) showed systolic and 09 (30%) showed diastolic pre-hypertension, 08 (26.7%) and 19 (63.3%) showed systolic and diastolic stage I hypertension respectively, while only 01 (3.3%) participant showed stage II diastolic hypertension.

Table 2 shows comparison of various variables between male and female. A statistically significant difference ($p<0.05$) was noticed regarding age, weight, waist, and wrist measurements. Same trend of significant difference ($p<0.05$) was also seen when systolic and diastolic blood pressure, pulse, height and body mass index (BMI) were considered.

Table 3 shows comparison of variables between different BMI groups.

A statistically significant difference ($p<0.05$) was seen between group A (underweight) and group B (normal BMI) participants regarding body weight, systolic blood pressure and BMI, however, the difference was non-significant for waist (p-0.139), wrist (p-0.393), pulse (p-0.071), and height (p-0.246). When the weight, waist, systolic blood pressure, diastolic blood pressure, pulse and BMI were compared between normal (group B) and overweight (group C) participants a statistically significance difference ($p<0.05$) was noticed, however, the difference was found to be non-significant when wrist (p-0.551) and height (p-0.883) measurements were compared. A significant difference ($p<0.05$) was also seen when weight, systolic and diastolic blood pressure, pulse, waist, height and BMI between overweight (group C) and obese participants (group D) were compared, while difference between the height was found to be non-significant (p-0.099).

Table 4 shows correlation between various variables. Age was positively correlated with systolic blood pressure (r 0.212, p-0.000) diastolic blood pressure (r-0.332, p-0.000), waist (0.262, p-0.000) and BMI (r 0.322, p-0.000). The weight showed a significant positive correlation with systolic pressure (r – 0.218, p-0.000), diastolic pressure (r - 0.518, p-0.000), waist (r-0.633, p-0.000) and BMI (r-0.795, p-0.000). A same trend of significant positive correlation of BMI was seen with systolic pressure (r-0.466, p-0.000), diastolic pressure (r - 0.332, p-0.004), and waist (r - 0.032, p-0.000) while it showed a significant negative correlation with height (r -0.152, p-0.000). The systolic blood pressure showed significant positive correlation with diastolic pressure (r- 0.653, p-0.000), height (r – 0.234, p-0.000) and BMI (r –0.466, p-0.000), while diastolic blood pressure had significant positive correlation with waist (r-313, p-0.000), height (r-0.391, p-0.000) and BMI (r-0.332, p-0.000).

Table 1: Effect of BMI on Systolic and Diastolic Blood pressure.

Variables	Underweight BMI <18.5 n-32 (9.1%)	Normal BMI 18.5-24.9 n-185 (52.9%)	Overweight BMI 25.0-29.9 n-103 (29.4%)	Obese BMI >30 n-30 (8.6%)
Male	10 (5.7%)	97 (55.4%)	48 (27.4%)	20 (11.4%)
Female	22 (12.6%)	88 (50.3%)	55 (31.4%)	10 (5.7%)
Systolic Blood pressure (SBP) Normal (<120 mmHg) n-205 Prehypertension (121-139 mmHg),n-136 Stage 1 HTN (140-159 mmHg) n-08 Stage II HTN (>160 mmHg) n-01	29 (14.1%) 03 (2.2%) 0 (0%) 0 (0%)	128 (62.4%) 56 (41.2%) 0 (0%) 0 (0%)	45 (22.0%) 58 (42.6%) 0 (0%) 0 (0%)	03 (1.5%) 19 (14.0%) 08 (100.0%) 01 (100%)
Diastolic blood pressure (DBP) Normal (<80 mmHg) n-152 Prehypertension (81-90 mmHg), n-124 Stage 1 HTN (91-100 mmHg), n-63 Stage II HTN (>100 mmHg), n-11	21 (13.8%) 07 (5.6%) 04 (6.3%) 0 (0%)	89 (58.6%) 70 (56.5%) 23 (36.5%) 03 (27.3%)	41 (27.0%) 38 (30.6%) 17 (27.0%) 07 (63.6%)	01 (.7%) 09 (7.3%) 19 (30.2%) 01 (9.1%)

Table 2: Comparison between male and female in various measurements.

variables	Male	Female	95% CI	P value
Age (yrs)	20.22±1.33	19.69±0.91	0.291 – 0.772	0.000
Weight (kg)	67.93±12.81	60.59±10.81	4.843 – 9.830	0.000
Systolic blood pressure (mmHg)	117.03±11.73	111.31±11.44	3.277 – 8.151	0.000
Diastolic blood pressure (mmHG)	80.65±10.81	74.11±9.23	4.428 – 8.657	0.000
Waist (cm)	33.82±3.28	31.92±5.15	0.994 – 2.811	0.000
Wrist (cm)	7.08±2.35	8.95±2.84	-3.088 - -0.652	0.003
Pulse (bpm)	74.62±9.71	78.65±11.47	-6.263 – 01.794	0.000
Height (cm)	168.58±9.72	163.09±6.92	3.712 – 7.262	0.000
BMI	24.09±4.37	22.99±3.81	0.235 – 1.961	0.000

Table 3: comparison of various variables between underweight, normal, overweight and obese participants.

variables	Underweight n-32 (group A)	Normal n-185 (group B)	P Value A and B	Overweight n-103 (group C)	P value B and C	Obese n-30 (group D)	P value C and D
Weight (Kg)	48.37±6.41	59.29±7.24	0.000	72.58±8.9	0.000	83.26±11.70	0.000
Systolic BP (mmHg)	106.56±8.27	110.65±10.63	0.040	117.82±9.71	0.000	131.50±9.29	0.000
Diastolic BP (mmHg)	72.65±10.47	75.51±10.23	0.148	79.36±9.81	0.002	87.16±7.84	0.000
Waist (cm)	30.15±3.40	31.37±4.43	0.139	34.79±2.68	0.000	38.36±2.41	0.000
Wrist (cm)	7.10±2.64	8.09±6.41	0.393	8.56±6.32	0.551	6.64±0.30	0.099
Pulse (bpm)	78.47±11.46	74.44±11.59	0.071	80.84±8.91	0.000	73.77±5.10	0.000
Height (cm)	167.88±10.17	165.93±8.46	0.246	166.08±7.62	0.883	162.24±12.57	0.041
BMI	17.16±0.87	21.61±1.81	0.000	26.51±1.37	0.000	32.05±1.59	0.000

Table 4: Pearson's Correlation between the variables.

	Age	Weight	Systolic pressure	Diastolic pressure	Waist	Wrist	Pulse	Height	BMI
Age	1	.367 0.000	.218 0.000	.332 0.000	.262 0.000	-.036 0.497	-.147 0.006	.157 0.003	.322 0.000
Weight	.367** 0.000	1	.566** 0.000	.518** 0.000	.633** 0.000	-.034 0.520	.101 0.060	.430** 0.000	.795** 0.000
Systolic pressure	.218** 0.000	.566** 0.000	1	.653** 0.000	.404** 0.000	-.093 0.083	.103 0.055	.234** 0.000	.466** 0.000
Diastolic pressure	.332** 0.000	.518** 0.000	.653** 0.000	1	.313** 0.000	-.093 0.084	.095 0.077	.391** 0.000	.332** 0.000
Waist	.262** 0.000	.633** 0.000	.404** 0.000	.313** 0.000	1	-.072 0.179	.061 0.254	.252** 0.000	.517** 0.000
Wrist	-.036 0.497	-.034 0.520	-.093 0.083	-.093 0.084	-.072 0.179	1	.104 0.052	-.130* 0.015	.032 0.545
Pulse	-.147** 0.006	.101 0.060	.103 0.055	.095 0.077	.061 0.254	.104 0.052	1	.061 0.254	.083 0.122
Height	.157** 0.003	.430** 0.000	.234** 0.000	.391** 0.000	.252** 0.000	-.130* 0.015	.061 0.254	1	-.152** 0.004
BMI	.322** 0.000	.795** 0.000	.466** 0.000	.332** 0.000	.517** 0.000	.032 0.545	.083 0.122	-.152** 0.004	1

DISCUSSION

Our results showed significant positive correlation of age with both systolic and diastolic blood pressure in males as well as in females. The results are in consistent with many studies who showed significant relationship between blood pressure and age (both SBP and DBP) among both males and females.[14,15]

The blood pressure increases with age which is considered to be a risk factor for high blood pressure. The systolic and diastolic pressures among male showed statistically significant compared to females during adulthood. All ethnic groups showed higher prevalence of systolic and diastolic hypertension in male compared to female.[15,16,17]

Before menopause, female have large quantity and increased activity of lipoprotein lipase in the gluteal and femoral subcutaneous regions with larger fat cells compared to males, so the fat deposit is more in the lower body fat depot areas in female, however, these depot disappear after menopause. The higher level of intra-abdominal tissue in male compared to premenopausal female shows greater prevalence of dyslipidaemia and chronic heart disease in males compared to premenopausal female. The hypertension in young male and female may persist later in life.[17,18,19]

Our study is in agreement with a number of studies who showed statistically significant positive correlation between anthropometric measures like BMI, WC and elevated SBP and DBP in adolescents. The increased weight and obesity is associated with increased risk of cardiovascular disease risk factor, morbidity and mortality, however, this has not been proven in children or adolescents so far. BMI, one of the best indicator of nutritional status in adults, is an important predictors of hypertension.[20,21,22]

Fox et al[22] showed a linear significant correlations between systolic and diastolic blood pressure with all anthropometric measurements in adolescence as seen in our results. Qing et al[23] showed increased BMI association with an increase in SBP and DBP in obese and non-obese children after adjustment for age, gender, and height. An increase in 1 BMI unit, was associated with an increase of 0.56 mm Hg and 0.54 mm Hg in SBP and DBP respectively for obese children and 1.22 mm Hg and 1.20 mm Hg increase in SBP and DBP respectively in non-obese children.

Our study showed high prevalence of prehypertension in overweight participants, which is similar to report from industrialized economies and urban residents >18 years by Israeli et al.[24] The participants with prehypertension should be taken serious as these subjects are unaware of their condition and disease prevention must be applied, as a small reduction in mean blood pressure of the population will result in relatively large reduction in overall disease risk.

There is inadequate vasodilatation in the presence of increased blood volume and cardiac output in obesity-associated hypertension, which results an increase in body mass. Overweight and obesity found to be risk factor for increased DBP which depend more on peripheral resistance in males and females. The factors that increase DBP also increase the SBP.[14,25,26]

Ribeiro et al[27] showed similar significant positive correlation between obese children and adolescence with blood pressure. Fox et al[22] showed >50% of the obese patients had elevated BP: out of which 31.5% were pre-hypertensive and 26.1% hypertensive.

Rao et al[28] showed significantly (P<0.001) higher mean SBP, by about 12 mm Hg, among overweight children, and 8 mm Hg in the diastolic blood pressure (P<0.001) compared to age, sex matched non-overweight. Similar results of significantly high systolic and diastolic blood pressure in the obese subjects compared to controls (p< 0.001) were shown by Gupta et al.[14]

Mazicioglu et al[29] showed significant relationship between elevated blood pressure and anthropometric parameters (BMI and WC) in adolescents irrespective of age and sex and WC was the main factor associated with systolic hypertension, while according to Zhang et al,[30] the prevalence of high BP increased from 9.21% (boys) and 11.76% (girls) in the <5th WC percentile group to 58.99% (boys) and 40.34% (girls) in the ≥95th WC percentile group, an increase of 5.4 and 2.4 times. Systolic BP in both sexes and diastolic BP in boys were higher in the high BMI (>85th percentile) and high WC (>90th percentile) groups.

CONCLUSION

Our study demonstrates that in addition to BMI, increased WC is an indicator of high blood pressure in adults. Blood pressure measurement requires a greater operator skill and is liable to be falsely elevated unless measured with care and stress free situations, while WC is much

easier to measure than blood pressure in terms of training and access to equipment, especially in low income settings, so we suggest measurement of WC as a screening tool for adolescence hypertension. Our study also showed elevated BMI being associated with prehypertension which suggest that such individuals may be at increased risk of progressing to frank hypertension, therefore weight management programs should be considered.

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