Research Article

Association between central body circumferences and derived values with blood pressure among university students in El Minia University

Samah M. Abozaid
Anatomy Department, Faculty of Medicine, Minia University, Minia, Egypt

Abstract
Elevated blood pressure carries risk for both circulatory and central nervous systems. The aim of the present study is determination of the correlation of central body circumferences and derived values with blood pressure of the studied population. The sample consisted of undergraduate students aged 18 years and older of El Minia University. Data on age, gender, smoking, and family history of hypertension were collected. For each participant, central body circumferences (Neck circumference, Waist circumference and Hip circumference) measurements were done using flexible non-stretchable tape. Derived values (BMI, Waist/hip ratio, Waist/height ratio and a body shape index (ABSI)) were calculated by their equations. Blood pressure of the subjects was recorded using auscultatory method. Statistical analyses were done using SPSS version 20. The participants in the study were 144. About 22% of them were overweight and 14% were obese. Three male subjects with elevated both systolic and diastolic blood pressure were recognized in the present study. Statistical analysis of the central body circumference and derived values for both sexes revealed that all variables were greater in male subjects than those of female subjects significantly except DBP whose difference was insignificant. For SBP it is obvious that the highest correlation in males is between SBP and NC, Hip C and WC and in females is between SBP and WHtR, NC and Hip C. For DBP it is obvious that the highest correlation in males is between DBP and Hip C, NC and WC and in females is between DBP and Height, NC, and Hip C. This study concluded that central body circumferences display increased predictive capabilities for detecting blood pressure in male students.
Keywords: Anthropometry**,** Students, Blood pressure, Body indices, Derived values

Introduction
Hypertension is well known to affect cardiovascular and central nervous systems as hypertensive subjects are liable for heart attack and stroke (Almgren et al., 2005).
The prevalence of hypertensive adults worldwide was approximately 22%. Affected male subjects were (21%) and affected female subjects were (16%) (WHO, 2014).

This health problem not only affects older adults, but also younger ones. Hypertensive people with early affection are usually asymptomatic (Kulkarni, 1998).
Anthropometric measurements are applicable, easy to perform, costless and non-invasive methods for assessing human body composition. It is an index of health and nutritional condition (WHO, 1995).

Using anthropometric indices may be of value for early identification of risk factors of hypertension and hence preventing or reducing its complications (WHO, 2014).
In the recent years, it was reported that body mass index (BMI) is not an accurate index of body fatness (Heo et al., 2012), as it doesn't differentiate adipose tissue from lean body mass (Wunderlich and Bai, 2012). Waist circumference (WC) is used as an index to predict abdominal fatness (Janssen et al., 2002). However, the relay of WC on body size is vague (Hsieh and Yoshinaga, 1999). A new body index takes body shape into consideration was appeared (a body shape index (ABSI)) (Browning et al., 2010). This index combines classic anthropometric indices, e.g., height, BMI and WC (Thomas et al., 2013).

It has been proposed that high ABSI correlates to a greater part with abdominal adipose tissue and carries a significant risk for premature death (Krakauer and Krakauer, 2012). It has also been reported that ABSI can evaluate physical health condition of adolescents (Duncan et al., 2013).

Neck circumference (NC) is a newly known anthropometric index. It reflects subcutaneous fat of the upper part of the body (Ben-Noun et al., 2001). Many studies showed that upper body fatness may have an important role in metabolic diseases (Preis et al., 2010) and may lead to cardiovascular affections (Yang et al., 2010).
The correlation of Hip Circumference (Hip C) to blood pressure is inconsistent with most of the previous researches (Snijder et al., 2004). However, there are other studies supporting that high Hip C is risky for metabolic syndrome. This is may be due to Hip C reflects total body obesity and abdominal obesity (Wang and Hoy, 2004).

To have simple and reliable techniques to assess the association between anthropometric indices and blood pressure in primary care clinics is important. Classical anthropometric indices (weight, height, waist circumference and hip circumference) and their derived values (Body mass index, waist-hip ratio and waist-height ratio) are used as indicators for the presence or absence of risk factors for diseases and their clinical management (Khanna et al., 2011)

The aim of the present study is to determine the association between central body circumferences and derived values with blood pressure among students in El Minia University in Egypt

Subjects and Methods

Sample

This cross-sectional study involved undergraduate male and female students of El Minia University. This study involved a population of one hundred and forty four students (84 females and 60 males) with age range between 18-24 years. The aim of the study and the study procedures were explained for all participants. A written consent was taken before data collection. All participants were apparently healthy. Cases with history of diseases (e.g. hypertensive, cardiovascular affection, diabetes mellitus or chronic diseases) or on chronic medication were excluded.
Age of each participant was recorded. Family history of elevated blood pressure, cardiovascular affections and smoking history were taken.

Anthropometric Measurements

All the measurements were taken while participants were without shoes for height measurements and without sweater and jackets for weighing.
The definitions for being obese or overweight were derived from the anthropometric measurement based on the calculation of body mass index (Lucile et al., 1990).
Derived values were calculated according to standardized formulas (Table 1).

Table 1: Central body circumferences and derived values in the present study: technique of measurements, or equation for calculation and references.

Measurements	Equipment, Technique or Equation	references (year)
Measurement of nutritional state		
Weight	Using standard weighing scale (to the nearest Kg).	
Height	Using stadiometer (to the nearest cm).	
Central body circumferences		
Neck Circumference (NC)	Neck circumference was measured while participant was erect and looking forwards, a horizontal measurement was done in the midway of the neck, using non-stretchable tape (to the nearest 0.1 cm).	**Hassan et al., 2015**
Waist Circumference (WC)	By applying the non-stretchable tape at the midway level between the highest point of iliac crest and costal margin at quiet respiration.	**WHO (2008)**
Hip Circumference (Hip C)	By applying the non-stretchable tape at the level of the highest protrusion of the buttocks.	**Mxhosa et al., 2015**
Anthropometric indicators of Adiposity related to Body weight		
Body Mass Index (BMI)	BMI = body weight (in Kg) divided by (height)^2 (in M^2)	
Anthropometric indicators of Adiposity related to Body shape		
Waist to Hip Ratio (WHR)	WHR = waist circumference (in cm) divided by hip circumference (in cm).	**WHO (2008)**
Waist to Height Ratio (WHtR)	WHtR = waist circumference (in cm) divided by height (in cm)	**Ashwell (1995)**
A Body Shape Index (ABSI)	ABSI = WC (in cm) divided by $BMI^{2/3}$ multiply by $height^{1/2}$	**Krakauer & Krakauer (2012)**

Blood Pressure

Auscultatory method was used to determine blood pressure. It was taken while the students were sitting and their feet beside each other on the floor. Measurements were taken using mercury sphygmomanometer. A Cuff was applied to the right brachium with its lower limit about one inch above center of the elbow joint**.** The first korotkoff sound was recorded as systolic pressure and fifth korotkoff sound was recorded as diastolic pressure. Two consecutive measurements were taken at 5-minute in between. The average of these two measurements was obtained. Hypertensive subjects are diagnosed if measured blood pressure above or equal to 140 mmHg or 90 mmHg for systolic blood pressure and/or diastolic blood pressure respectively.

Statistical analysis

Data analysis was done using SPSS statistical package version 20. Mean and standard deviations were obtained for anthropometric indices and derived values of both sexes. Student-t test was done to establish the presence of significant sexual differences. *P* value less than 0.05 considered significant statistically. Pearson's correlation coefficient was done to test the association between central body circumference, derived values and blood pressure.

Results

The total participants in this study were 144. Male subjects were 64 and female subjects were 80. As shown in table 2, the underweight persons were 8 (5.5%), Normal weight persons were 84 (58.5%), Overweight were 32 (22%) and obese were 20 (14%). Cases with elevated systolic blood pressure (equal or more than 140 mmHg) and diastolic blood pressure (equal or more than 90 mmHg) were 3 and they were males. Family history of hypertension was found in 43 (29.9%)

Of participants and history of smoking was found in 28 (19.4%).

Table 2. Characteristics of the study population

	Number (%) (n=144)
Classification based on BMI (kg/m2)	
Underweight (BMI is <18.5)	8 (5.5%)
Average weight (BMI is 18.5 to <25)	84 (58.5%)
Overweight (BMI is 25.0 to <30)	32 (22%)
Obese (BMI is 30.0 or higher)	20 (14%)
Cases with hypertension	
SBP, mm Hg equal or above 140 mmHg	3 (0.02%)
DBP, mmHg equal or above 90 mmHg	3(0.02%)
With family history of hypertension	
Yes No	43(29.9%) 101(70.1%)
Smoking (%)	
Yes No	28 (19.4%) 116 (80.6%)

Statistical analysis of the central body circumference and derived values for both sexes revealed that all variables are greater in male subjects than those of female subjects significantly (p value less than 0.05) except DBP whose difference was insignificant (Table 3).

Table 3: gender differences in studied central body circumferences and derived values

Parameters	**Male students (n=60) Mean±SD**	**Female students (n=84) Mean±SD**	***P*- value**
Age	19.93±1.49	20.38 ± 0.59	<0.0000001
Weight	79.86±23.34	63.7±11.57	<0.0000001
Height	175.53±8.96	162.28±6.95	0.03321
Central circumferences (CC)			
NC	37.9±3.6557196	32.62 ± 2.16	0.00001014
WC	87.9±17.42	76.5 ± 7.91	<0.0000001
Hip C	106.87±11.88	102.73 ± 8.76	0.01051
Derived values			
BMI	25.76±6.44	24.26 ± 3.56	0.000000751
WHR	0.818±0.07	0.74 ± 0.04	0.000000294
WHtR	4.18±0.78	3.9 ± 0.37	<0.0000001
ABSI	0.08±0.004	0.07±0.003	0.002260
BP			
SBP	121 ± 18.92	110.25 ± 25.69	0.01395
DBP	79.67 ± 8.12	66.75 ± 7.30	0.3708

Correlation coefficient between various measured and derived values were recorded and presented for male students (Table 4) and female students (Table 5).

Correlation coefficient between various measured and derived values of male students showed that most of the variables show positive significant correlation with each other except for height which showed negative correlation with both WHR and WHtR. (Table 4)

Correlation coefficient between various measured and derived values of female students showed that most of the variables show positive significant correlation with each other except for WC, WHR, and WHtR which showed negative correlation with ABSI. Also Height showed negative correlation with WHtR (Table 5)

Table 4: The correlation coefficient between various measurements and derived values of male students

r	Male students								
	Wt	**Ht**	**NC**	**WC**	**Hip C**	**BMI**	**WHR**	**WHtR**	**ABSI**
Age	0.07	-0.10	-0.05	0.17	0.09	0.15	0.26	0.22	0.39
Wt	–	0.49	0.87	0.92	0.93	0.93	0.76	0.82	0.43
Ht	–	–	0.25	0.27	0.44	0.15	-0.02	-0.01	0.05
NC	–	–	–	0.09	0.86	0.44	0.8	0.86	0.44
WC	–	–	–	–	0.94	0.92	0.92	0.96	0.67
Hip C	–	–	–	–	–	0.89	0.74	0.86	0.47
BMI	–	–	–	–	–	–	0.83	0.92	0.41
WHR	–	–	–	–	–	–	–	0.95	0.80
WHtR	–	–	–	–	–	–	–	–	0.65

Table 5: The correlation coefficient between various measurements and derived values of female students

r	Female students								
	Wt	**Ht**	**NC**	**WC**	**Hip C**	**BMI**	**WHR**	**WHtR**	**ABSI**
Age	0.14	-0.09	-0.1	0.06	0.15	0.18	0.10	0.07	0.37
Wt	–	0.62	0.78	0.88	0.89	0.88	0.32	0.72	0.15
Ht	–	–	0.34	0.38	0.53	0.24	0.06	-0.002	0.20
NC	–	–	–	0.8	0.65	0.77	0.53	0.74	0.16
WC	–	–	–	–	0.86	0.81	0.60	0.91	-0.01
Hip C	–	–	–	–	–	0.80	0.10	0.70	0.18
BMI	–	–	–	–	–	–	0.31	0.84	0.04
WHR	–	–	–	–	–	–	–	0.64	-0.16
WHtR	–	–	–	–	–	–	–	–	-0.14

Correlation coefficient was carried out to investigate the degree of correlation between anthropometric indices and derived values with SBP and DBP (Table 6).

For SBP it is obvious that the highest correlation in male subjects is between SBP and NC (r=0.6367), Hip C (r=0.6331) and WC (r=0.5887) and in female subjects is between SBP and WHtR (r=0.4169), NC (r=0.4167) and Hip C (r=0.4092).

For DBP it is obvious that the highest correlation in male subjects is between DBP and Hip C (r=0.6806), NC (r=0.6724) and WC (r=0.6308) and in female subjects is between DBP and Height (r=0.4407), NC (r=0.2873) and Hip C (r=0.2454).

Table 6: The correlation coefficient between various measured and derived values with SBP and DBP

	Male students		Female students	
r	**SBP**	**DPB**	**SBP**	**DPB**
Weight	0.4887	0.5347	0.2826	0.2349
Height	0.0872	0.1155	-0.0205	0.4407
NC	0.6367	0.6724	0.4167	0.2873
WC	0.5887	0.6308	0.3768	0.1949
Hip C	0.6331	0.6806	0.4092	0.2454
BMI	0.5338	0.5748	0.3743	0.0918
WHR	0.4691	0.495	0.0903	0.0150
WHtR	0.5956	0.6308	0.4169	0.0179
ABSI	0.0336	0.0801	0.1946	0.2068

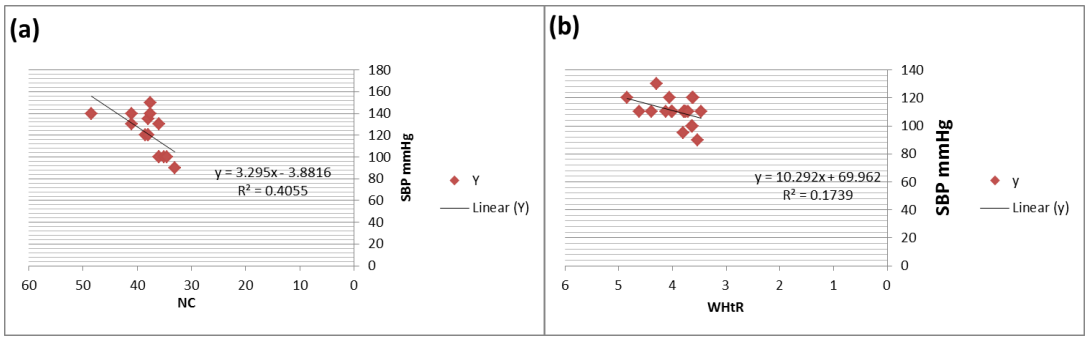

Figure 1. The relationship between (a) SBP and NC in male students and (b) SBP and WHtR in female students

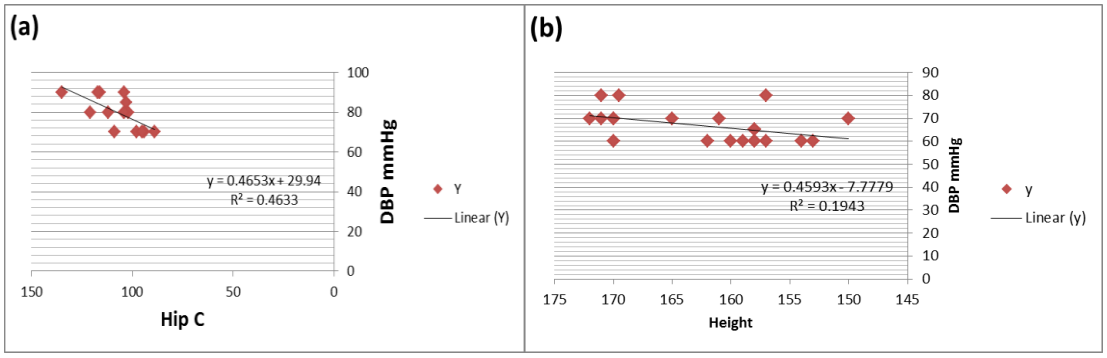

Figure 2. The relationship between (a) DBP and Hip C in male students and (b) DBP and Height in female students

Discussion

Anthropometric indices are important as it is an index of nutritional and health conditions and it can evaluate the community health (Telatar et al., 2009)
High blood pressure is well known risk factors of cardiovascular diseases (Stamler et al., 1978).

The selection of one anthropometric index over one another for prediction of the most reliable determinant of risk factors of CVD in adult populations isn't clear (WHO, 2008).
Pattern of body fat distribution affect the susceptibility to develop cardiovascular diseases. As central accumulation of body fat correlates with blood pressure (Johnson et al., 1992).

The objective of the presented study was to examine the correlation between central body circumferences and derived values within themselves and with SBP and DBP in both male and female students of El Minia University.

The ratio of overweight and obesity ratio among El Minia University students in the present study was (36%) however, In Egyptian tertiary institutions overweight and obesity ratio was found to be 21%, South Africa 19.4%, Namibia 12.3% (Peltzer et al., 2014).The ratio reported in the present study is close to that reported at the University of Botswana by (Tapera et al., 2017) who reported a ratio of 36.8%. However, many African countries showed lower prevalence of overweight and obesity as Ivory Coast and Madagascar with 2.9% and 1.3% respectively (Peltzer et al., 2014).

In the present study significant sex differences was reported only for SBP (p=0.01395) being higher in males however, (Al-Shelleh et al., 2018) found significant sex differences in both SBP (p= 0.003) with mean difference = 18.08 mmHg

and DBP (= 0.011) with mean difference = 3.6 mmHg higher in males than in females. Three male cases out of 144 in the present study were having elevated both SBP and DBP. This is in accordance with (Khanna et al., 2011) who reported sex difference in blood pressure as there were a greater proportion of males who were hypertensive compared to females. This sex difference may be in part due to sex hormones (Al-Shelleh et al., 2018).

In the present study there were correlation between height and DBP in female students (r=0.44).The association between height and blood pressure have been described by many studies. A cohort study reported an association between short stature and SBP but not DBP in middle-aged males and females (Langenberg et al., 2005). On the other hand (Olatunbosun and Bella, 2000) reported no association between height and blood pressure.

Central body circumferences and blood pressure

The present study evaluate the possible role of fat that accumulate in the axial skeleton determined by measuring the central body circumferences (NC, WC and Hip C) and its correlation with blood pressure in a sample of adult male and female students.

In The present study, the NC showed a moderate correlation with SBP (r=0.6367) and DBP (r=0.6724) in male students however, it's the highest correlation among other variables. This is in accordance with Zhou *et al*. 2013 who found a significant correlation between NC and both circulatory and metabolic risk factors including blood pressure in adults of China. However, in females NC showed lower correlation with both SBP (r=0.4167) and DBP (r=0.2873).

In The present study, WC showed moderate correlation in both SBP ((r=0.5887) and DBP (r= 0.6308) in male students however, lower correlation in female students for both SBP ((r=0.3768) and DBP ((r= 0.1949). However the overall association of WC with blood pressure in both sexes was better than BMI. This is in accordance with (WHO, 2011) who reported the better use of WC over BMI when examining the impact of weight on health status as WC is sensitive to body size as well as fat percentage and fat distribution. Also Lemieux et al., 2000 reported that WC is costless, easy technique and may be of practical importance in the assessment of diseases risk factors.

In the present study Hip C correlate moderately with both SBP (r=0.6331) and DBP (r=0.6806) in males. However, (Mxhosa et al., 2015) reported that Hip C correlate positively with SBP only. In females a lower correlation with SBP in females (r=0.4092) and with DBP (r=0.2454). Although several studies have shown that increased Hip C is preventive against hypertension and metabolic diseases (Severinsen et al., 2009; Azizi et al., 2013).However, in a recent study done by (Wang et al., 2018) a positive correlation between Hip C and the occurrence of hypertension in females had been reported.

In the present study all central body circumferences showed relative positive association with blood pressure in both male and females indicating that fat deposited in axial skeleton is more hazardous than all body fat tissue. This is in accordance with (Mazicioglu et al. 2010; Maximova et al. 2011) who stated that sites of fat accumulation is more significant than total fat mass in determining health status.

In the present study central body circumference (NC, WC and Hip C) was taken as an indicator of axial fat deposition and they showed positive correlation with blood pressure indicating the impact of axial fat accumulation on level of blood pressure.

The correlation between axial adipose tissue and BP may be explained by neuroendocrine abnormalities recognized in obese subjects with high waist circumference (Rosmond and Bjorntorp, 1998) and or increased sympathetic nervous system activity (Grassi et al., 1995). As sympathetic over stimulation induces blood vessels constriction and increases ejection fraction of heart. This may lead to increase sodium reabsorption at the proximal convoluted tubules resulting in elevation of

blood pressure in human subjects (Strazzullo et al., 2001).

Derived values and blood pressure

The present study showed a moderate correlation between BMI and SBP (r=0.5338) and DBP (r=0.5748) in males and lower correlation reported for females. However, (Mxhosa et al., 2015) reported a strong correlation between BMI and with both systolic and diastolic blood pressures in females.

The WHR ratio in the present study showed week correlation with blood pressure in both males and females. This is in accordance with (National Institutes of Health, 1998) who recommended the use of WC over WHR as an indicator fat deposited in abdomen.

In female students the highest correlation was between SBP and WHtR (r=0. 0.4169) among other variables. This is similar to many other researches which had reported that WHtR is reliable index of visceral fat associated with circulatory system affections (Kim et al., 2015). Its screening ability was superior to BMI and WC in some studies; however, it was not significantly better than that of the other two anthropometric indices. The use of WHtR rather than BMI and WC may allow proper recognition of children and adolescents liable for cardiovascular risk affection (Lo et al., 2016). Add to this ease of use, simplicity and clarity of the public health messages based on the WHtR (i.e. keep your waist size less than half of your height) (Ashwell, 2012). A cutoff value of 0.5 of WHtR whatever the age or sex is a significant predictor of circulatory system affections however, the mechanism of this association isn't fully understood physiologically (Browning et al., 2010).

As height is constant to some extend during adult age. This lead to any alteration in WHtR is secondary to WC alteration in adults. However, WHR is changeable with time secondary to changes in body size (Ashwell et al., 2012).

Recently a new indices was described ABSI. It was reported to be a predictor of mortality in adult age superior to both BMI and WC and a more reliable index of diseases risks (Krakauer and Krakauer 2012). However, in the present study ABSI showed week correlation with SBP and DBP in both sexes. This is in accordance with recent study which showed that the reliability of ABSI as an indicator of diseases risk factors, including abnormal lipid profile is vague (Janssen et al., 2005).

Conclusion

Central body circumferences are superior to other indices as a predictor of blood pressure in male students. The reliability of BRI to predict blood pressure was not superior to the central body circumferences or other classical derived values. NC correlation with blood pressure both in males and females is interesting.

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