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Association between Obesity and Blood pressure incidence among Minia University Students, Upper Egypt

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Abstract

Obesity is a well-established independent risk factor for hypertension and other cardiometabolic disorders. The target of the study is to evaluate the anthropometric differences and prevalence of hypertension between students at Minia University, Upper Egypt and to know the correlation between anthropometric measurements with blood pressure. A cross sectional study was done with a sample of 5572 college students (3276 Boys and 2296 girls) studying at Minia University, El-minia governorate, Arab Republic of Egypt, of age between 17-19 years old. Anthropometric data was collected, including weight, stature, midarm, midchest, waist, hip circumferences, and skinfold thickness of biceps, triceps, subscapular, abdominal and suprailiac regions. Body mass index (BMI), waist-hip ratio (WHR) and waist-stature ratio (WSR) were calculated. Results; all anthropometric parameters indicating body adiposity were higher in female than male students, except for the mean BMI (males: 23.4±3.9 kg/m2 and females: 23±3.8 kg/m2) and 15.98% of male subjects and 10.5% of females were overweight or obese, with significant level (p<0.05). The means of both systolic and diastolic blood pressure were higher in male students (mean of SBP= 118.1±10 mmHg, DBP= 76.1±7.9 mmHg), than female students (SBP= 110.9±10.3 mmHg, DBP= 71.1±8 mmHg). The present study concluded that; in Minia university Students, overweight, general obesity and central obesity were all positively correlated with hypertension in both genders and the relationship between hypertension and general obesity was stronger than the relationship between hypertension and central obesity in both genders

Keywords: obesity, blood pressure, adolescents, anthropometric measurements

INTRODUCTION

It is well known that obesity is one of the most critical public health problems worldwide. It is a significant independent risk factor for chronic diseases such as cardiovascular disease (CVD) and diabetes mellitus; obesity is also associated with high morbidity and mortality. Over the past 20 years, the prevalence of obesity has increased greatly worldwide, however; the best anthropometric index of obesity that predicts or associates strongly with hypertension and related conditions remains controversial and inconclusive (Sunder et al., 2013).

The rising prevalence of obesity worldwide was associated with an increased incidence of pre-hypertension and hypertension among younger population. Recent studies concerned to determine the prevalence of hypertension among university students. In addition, many studies attempted to know the association between excess body weight and its relation to hypertension (Sunder et al., 2013).

Hypertension is a common health problem affecting the cardiovascular system and indirectly impacts human health. The prevalence of hypertension in 2003–2004 in US was 29.3%, and 7.3±0.9%, 32.6±2.0%, and 66.3±1.8% in the 18 to 39, 40 to 59, and ≥60 age groups, respectively (WHO, 2011). Age is an essential factor for prevalence of hypertension. Thus, analysis of age-related hypertension is necessary (Moussa et al., 2016).

There are 2 main causes of hypertension; secondary hypertension, resulting from another medical condition, and essential hypertension, which has no identifiable cause. Essential hypertension is the most common form of hypertension. The specific causes for essential hypertension have not yet been identified, but there are risk factors that increase the incidence of hypertension, for example, alcohol consumption, stress, poor diet, lack of physical activity, smoking, etc. A combination of these factors may cause hypertension (Brennan et al., 2009).

Adolescents have an increased incidence of elevated blood pressure and cardiovascular diseases. Several studies have shown that hypertension and pre-hypertension can start in adolescence, perhaps in the early stages of life, and continue into adulthood (Ejike et al., 2010).

Simple anthropometric measures were easy methods for the assessment of obesity. Two of the most commonly used anthropometric indices in clinical practice and population surveys are the body mass index (BMI) and the waist circumference (WC), indicating general obesity and central obesity, respectively. Others as waist circumference (WC), skin folds, waist to hip ratio (WHR), and fat percentage (FP) were significantly associated with cardiovascular diseases and prediction of elevated blood pressure, (Kang, 2013).

SUBJECTS AND METHODS

We performed a cross-sectional study involving a sample of 5572 college students (3276 boys and 2296 girls) studying at Minia University, El-Minia governorate, Arab Republic of Egypt. Male and female students who were apparently healthy and aged 17-19 years were recruited. All participants provided written informed consent before data collection. Blood pressure was measured using an Accoson mercury sphygmomanometer of appropriate cuff size and a Littman's stethoscope.

Measurements were done in a quiet room after a ten minutes rest by a single observer and Hypertension is defined and classified according to the WHO guidelines, pre-hypertensive (SBP: 120-139 mmHg and DBP: 80-89 mmHg), stage-1 hypertension (SBP: 140-159 mmHg and DBP: 90- 99 mmHg), stage-2 hypertension (SBP: >160 mmHg and DBP: >100 mmHg), (Aounallah-skhiri et al., 2012). The mean of three readings was taken five minutes apart.

All participants were asked for wearing light clothes and no shoes. Weight was measured by a weighting scale (Momert, China) and recorded to the nearest 0.1 kilograms. Stature was measured using a stadiometer in barefoot subjects and averaged to the nearest 0.1 centimetre. Body mass index (BMI) was calculated as weight in kilograms divided by height in meter squared (BMI = Weight [Kg] / Height [meter]^2).

Skinfold thickness was obtained using a skinfold caliper (Harpenden skinfold caliper) at biceps, triceps, abdominal, subscapular and suprailiac regions. All skin fold measurements were taken by the same observer. Measurements were taken on the right side of the body and the tester pinched the skin to raise a double layer of skin and adipose tissue. The calliper was then applied one cm below and at right angle to the pinch and recorded in millimeters one second later. The mean of three readings was taken, (Dwyer and Gibbons, 1994).

A stretch-resistant tape was used to measure to the nearest 0.1 cm, the circumference of the right upper arm measured at the point of midway between the tip of the shoulder and the tip of the elbow (olecranon process and the acromion), (Yallamraju et al., 2014). Chest circumference is defined as the horizontal circular length taken just above the level of nipples during the period of quiet expiration, (Olweus et al., 1980). The waist circumference was measured at the midpoint between the lower margin of the last palpable rib and the top of the iliac crest, just above the level of umbilicus. Hip circumference was measured at the point yielding the maximum circumference over the buttocks. Waist-hip ratio (WHR) is then calculated as the ratio of the circumference of the waist to that of the hips. The WHO states that central obesity is defined as a waist-hip ratio above 0.90 for males and above 0.85 for females, or a body mass index (BMI) above 30.0, (WHO, 2011).

Waist-stature ratio (WSR) is identified as the waist circumference divided by the height. The WSR is another measure of the distribution of central body fat. Higher values of WSR indicate a higher risk of obesity-related cardiovascular diseases; it is correlated with abdominal obesity (Lee et al., 2008). In people under age of 40 years, the critical value of WSR should be less than 0.5 (Browning et al., 2010). Percent of body fat is calculated by using BMI; = (1.20 × BMI) + (0.23 × age) – (10.8 × gender) – 5.4, using for gender male = 1 and female= 0 (Wang et al., 2007).

Data entry and analysis were done by using statistical package for social sciences SPSS, version 25. Descriptive statistics are presented as a range (minimal & maximal values) and mean ± standard deviation (SD) for continuous variables. Groups compared using (student's t- test) for comparing between two groups. Association between two mutually dependent variables was done by using (Pearson's correlation coefficient), correlation (r) was graded between +1 to be a positive correlation, -1 to be a negative correlation and if (r = 0), indicates no association.

RESULTS

The mean of BMI in males (23.4 Kg/m^2) was higher than in females (22.9 Kg/m^2), (total of 23.2 Kg/m^2). Subjects shared in the study were classified according to body mass index (BMI) into 13.24% were overweight and obese (15.98% of male subjects and 10.5% of females). According to systolic blood pressure, subjects were classified into pre-hypertensive 14% (21% of male subjects and 6.97% of female cases) and hypertensive 2.5% (3.91% of male subjects and 0.45% of females) and according to diastolic blood pressure into pre-hypertensive 6.6% (8.85% of male subjects and 3.31% of female cases) and hypertensive 7% (9.77% of male subjects and 2.87% of females). The number of pre-hypertensive and hypertensive cases was higher in male subjects than females.

In the histogram (Figure-1), the subjects were classified again according to the level of obesity depending on BMI and the means of systolic and diastolic levels of blood pressure to show the relationship between the mean of blood pressure and BMI. For the normal-weight subjects, the mean of (SBP: 113.52 mmHg and DBP: 72.69 mmHg), overweight (SBP: 119.55 mmHg and DBP; 77.83 mmHg) and obese cases (SBP: 128.62 mmHg and DBP: 84.75 mmHg). Despite gradual increase of means of blood pressure with increased BMI, the maximum recorded value of systolic blood pressure (180 mmHg) and diastolic blood pressure (110 mmHg) were found in the non-obese subjects with normal BMI<25 kg/m^2.

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The means of both systolic and diastolic pressures were higher in males (SBP: 118.1±10 and DBP: 76.1±7.9) than females (SBP: 110.9±10.3 and DBP: 71.1±8.6) as described in table- 1, and also the means of weight and stature were higher in males than females. Body mass index (BMI) was slightly higher in males, with a significant difference (P value <0.01).

Measurements by skinfold caliper were higher in females than males; biceps, triceps, abdominal, subscapular, and suprailiac skinfolds. All measured circumferences were higher in male except for hip that was higher in females. Fat mass and fat percentage obtained by BMI- dependent equation were higher in females than males. Lean mass (non- fat mass) was obviously higher in males (59.4±7.1 to 43.7±5). Waist hip ratio (WHR) was higher in males, while waist stature ratio was higher in females. All previously mentioned data indicated higher body fat in female, wider means of hip circumference and lesser WHR (feminine fat distribution).

For the association of systolic blood pressure in females, the BMI (r = 0.447), lean mass (r =0.421), fat mass, (r =0.453) and fat percentage, (r = 0.446) were of the highest fair correlation as shown in table-2. Other variables had fair to weak correlation with systolic blood pressure. All measures were strongly significant (P- value is less than 0.01). Simple linear regression for female cases was done to obtain the constant and beta coefficient for predictive equation of mean of diastolic blood pressure. The correlation of diastolic blood pressure in females with BMI (r = 0.469), mid-chest (r = 0.436), waist (r = 0.412), hip circumferences (r = 0.441), fat mass (r = 0.453), fat percentage (r = 0.469) and lean mass (r = 0.451) were of high levels of fair correlation in female subjects, as shown in table-3. In males, –table 4- all variables had a fair positive correlation with the systolic blood pressure with the most striking parameters were BMI (r = 0.425), mid-arm (r = 0.436), mid-chest (r = 0.440), waist (r = 0.438), hip (r = 0.455) circumferences, fat mass, fat percentage and lean mass (r = 0.410, 0.429 and 0.470, respectively).

All skin-fold thickness measurements of higher correlation with systolic blood pressure in males than females by comparing of figures with table-2. Waist-hip ratio (WHR) of higher correlation with systolic blood pressure in male (r = 0.263), than females (r = 0.117). Diastolic blood pressure in males had higher figures of correlation of measurements of skin fold thickness in table-5 when compared with those of female subjects in table-3. Increase fatness in males had a stronger positive association with diastolic blood pressure than in females.

Figure-1: Values of blood pressure according to BMI

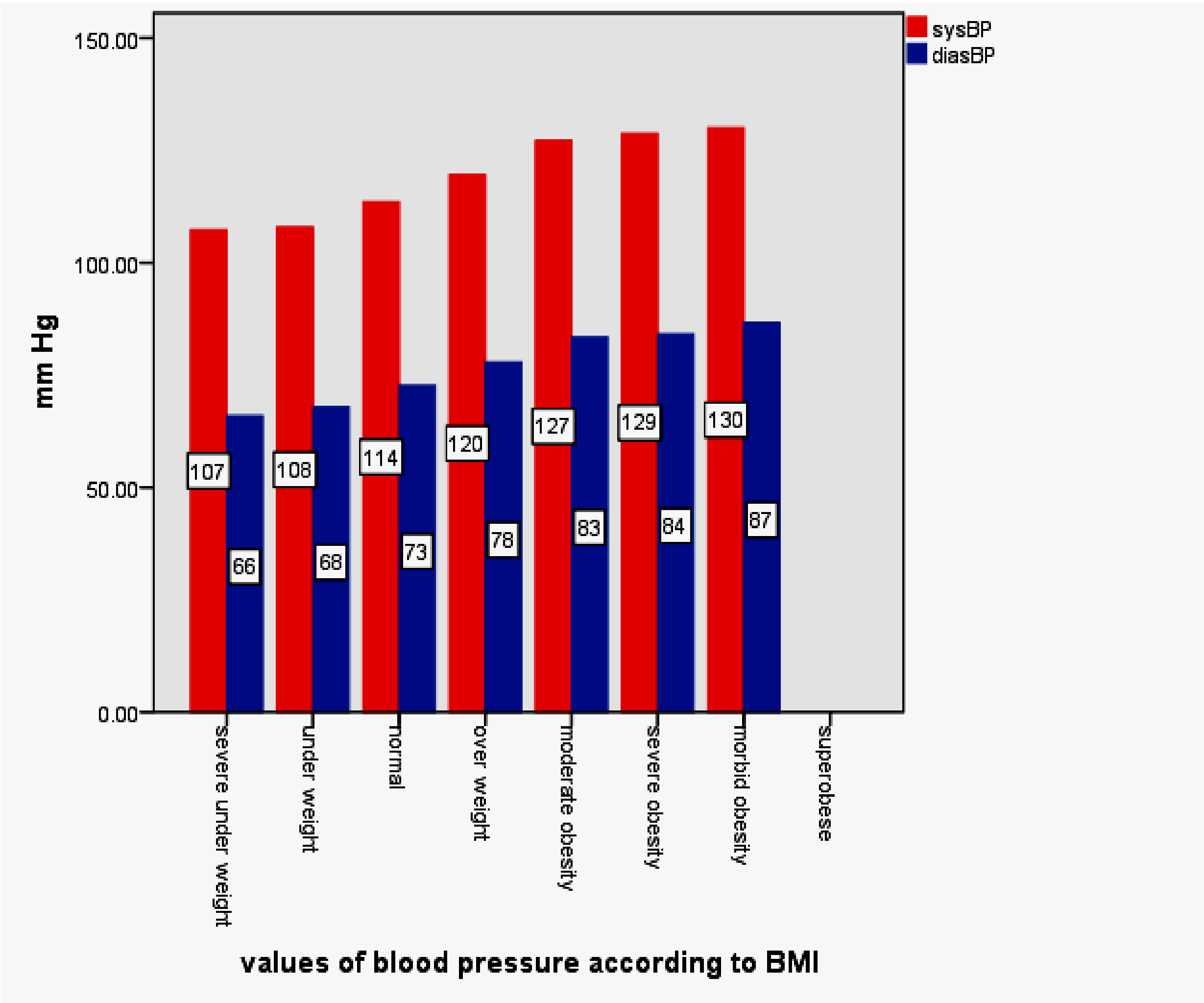

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Table 1: Independent samples T-test for quantitative data between the two sex groups

		Sex		P-value
		Female	**Male**	
		N=2296	N=3276	
SBP	*Range* *Mean ± SD*	(85-145) 110.9±10.3	(90-180) 118.1±10	*<0.001***
DBP	*Range* *Mean ± SD*	(50-100) 71.1±8.6	(55-110) 76.1±7.9	*<0.001***
Weight	*Range* *Mean ± SD*	(35-105) 59.8±10.4	(44-145) 71.4±12.8	*<0.001***
Stature	*Range* *Mean ± SD*	(140-182) 161.3±5.4	(154-193) 174.6±6	*<0.001***
BMI	*Range* *Mean ± SD*	(14-40.5) 23±3.8	(14.7-41) 23.4±3.9	*<0.001***
Biceps	*Range* *Mean ± SD*	(2-36) 10.4±6.1	(2-42) 7.2±4.2	*<0.001***
Triceps	*Range* *Mean ± SD*	(6-46) 19±7.1	(3-48) 12.7±6.4	*<0.001***
Abdomen	*Range* *Mean ± SD*	(7-62) 27.3±8.3	(4-64) 24.8±10.5	*<0.001***
Subscapular	*Range* *Mean ± SD*	(5-52) 19.8±9.9	(5-65) 18.7±8.7	*<0.001***
Suprailiac	*Range* *Mean ± SD*	(5-58) 28.6±8.3	(5-69) 24±11.6	*<0.001***
Midarm	*Range* *Mean ± SD*	(19-41) 27.1±4.3	(19-42) 28.6±3.2	*<0.001***
Midchest	*Range* *Mean ± SD*	(70-121) 89.3±7.3	(73-126) 94.3±7.8	*<0.001***
Waist	*Range* *Mean ± SD*	(74-107) 77.6±8.5	(75.5-130) 80.6±10.3	*<0.001***
Hip	*Range* *Mean ± SD*	(74-122) 95.3±8.2	(69.5-133) 94.7±8.7	*0.018**
WHR	*Range* *Mean ± SD*	(0.63-1) 0.81±0.06	(0.7-1) 0.85±0.04	*<0.001***
WSR	*Range* *Mean ± SD*	(0.35-0.66) 0.48±0.05	(0.31-0.71) 0.46±0.06	*<0.001***
FM.BMI	*Range* *Mean ± SD*	(5.4-49.5) 16.1±5.7	(2.5-53.5) 12±6.5	*<0.001***
FP.BMI	*Range* *Mean ± SD*	(15.3-47.1) 26.2±4.6	(5.3-66.3) 16±4.7	*<0.001***
LM.BMI	*Range* *Mean ± SD*	(29.6-62.7) 43.7±5	(41.1-91.4) 59.4±7.1	*<0.001***

*: Significant level taken at P value < 0.05. - **: highly significant level at P value < 0.01

Table 2: Correlation between systolic blood pressure and different body measures with simple linear regression analysis predicting systolic blood pressure in females

	Constant	B coefficient	P-value	R	R2
BMI	82.9	1.22	*<0.001***	0.447	0.200
Biceps	104.96	0.57	*<0.001***	0.340	0.116
Triceps	100.41	0.55	*<0.001***	0.380	0.145
Abdomen	98.46	0.46	*<0.001***	0.366	0.134
Subscapular	105.12	0.29	*<0.001***	0.281	0.079
Suprailiac	97.66	0.46	*<0.001***	0.371	0.138
Midarm	90.06	0.77	*<0.001***	0.322	0.104
Midchest	58.47	0.59	*<0.001***	0.414	0.172
Waist	74.4	0.47	*<0.001***	0.385	0.148
Hip	63.24	0.5	*<0.001***	0.395	0.156
WHR	93.19	21.73	*<0.001***	0.117	0.014
WSR	76.9	70.6	*<0.001***	0.362	0.131
FM.BMI	97.65	0.82	*<0.001***	0.453	0.205
FP.BMI	84.39	1.01	*<0.001***	0.446	0.199
LM.BMI	72.8	0.87	*<0.001***	0.421	0.177

SBP is the dependent variable
r: Pearson's correlation coefficient (0-0.24 weak), (0.25-0.49 fair), (0.5-0.74 moderate), (0.75-1 strong)
*: Significant level taken at P value < 0.05. - **: highly significant level at P value < 0.01.
Predictive equation: SBP = constant + (B coefficient x variable)

Table 3: Correlation between diastolic blood pressure and different body measures with Simple linear regression analysis predicting diastolic blood pressure in females

	Constant	**B coefficient**	**P-value**	**R**	**R2**
BMI	46.71	1.06	*<0.001***	0.469	0.220
Biceps	66.76	0.42	*<0.001***	0.297	0.088
Triceps	62.98	0.43	*<0.001***	0.353	0.125
Abdomen	60.71	0.38	*<0.001***	0.367	0.135
Subscapular	66.87	0.21	*<0.001***	0.246	0.060
Suprailiac	60.13	0.38	*<0.001***	0.369	0.136
Midarm	53.01	0.67	*<0.001***	0.337	0.113
Midchest	25.29	0.51	*<0.001***	0.436	0.190
Waist	38.07	0.42	*<0.001***	0.412	0.170
Hip	26.92	0.46	*<0.001***	0.441	0.194
WHR	58.01	16.02	*<0.001***	0.104	0.011
WSR	41.21	62.08	*<0.001***	0.383	0.147
FM.BMI	59.51	0.72	*<0.001***	0.476	0.227
FP.BMI	47.93	0.88	*<0.001***	0.469	0.220
LM.BMI	37.23	0.77	*<0.001***	0.451	0.203

DBP is the dependent variable

Table 4: Correlation between systolic blood pressure and different body measures with simple linear regression analysis predicting systolic blood pressure in males

	Constant	**B coefficient**	**P-value**	**R**	**R2**
BMI	92.72	1.09	*<0.001***	0.425	0.181
Biceps	111.62	0.91	*<0.001***	0.378	0.143
Triceps	110.25	0.62	*<0.001***	0.399	0.159
Abdomen	109.55	0.38	*<0.001***	0.396	0.157
Subscapular	109.88	0.44	*<0.001***	0.383	0.147
Suprailiac	110.1	0.34	*<0.001***	0.388	0.151
Midarm	79.76	1.34	*<0.001***	0.436	0.190
Midchest	65.02	0.56	*<0.001***	0.440	0.194
Waist	83.8	0.43	*<0.001***	0.438	0.192
Hip	68.45	0.53	*<0.001***	0.455	0.207
WHR	65.41	62.14	*<0.001***	0.263	0.069
WSR	87.21	66.96	*<0.001***	0.391	0.152
FM.BMI	110.54	0.63	*<0.001***	0.410	0.168
FP.BMI	103.62	0.91	*<0.001***	0.429	0.184
LM.BMI	78.63	1.31	*<0.001***	0.470	0.221

SBP is the dependent variable

Table 5: Correlation between diastolic blood pressure and different body measures with simple linear regression analysis predicting diastolic blood pressure in males

	Constant	**B coefficient**	**P-value**	**R**	**R2**
BMI	55.88	0.86	*<0.001***	0.430	0.185
Biceps	70.82	0.74	*<0.001***	0.388	0.150
Triceps	69.68	0.5	*<0.001***	0.411	0.169
Abdomen	69.03	0.31	*<0.001***	0.413	0.171
Subscapular	69.41	0.36	*<0.001***	0.394	0.155
Suprailiac	69.47	0.28	*<0.001***	0.406	0.165
Midarm	45.7	1.06	*<0.001***	0.439	0.192
Midchest	33.95	0.45	*<0.001***	0.444	0.197
Waist	48.79	0.34	*<0.001***	0.442	0.196
Hip	36.53	0.42	*<0.001***	0.460	0.212

WHR	34.42	49.11	*<0.001***	0.264	0.070
WSR	51.21	53.88	*<0.001***	0.399	0.159
FM.BMI	70.14	0.5	*<0.001***	0.408	0.167
FP.BMI	64.57	0.72	*<0.001***	0.432	0.187
LM.BMI	45.17	0.52	*<0.001***	0.468	0.219

DBP is the dependent variable

ABBREVIATIONS

SBP: Systolic blood pressure (mmHg), DBP: Diastolic blood pressure (mmHg), weight (Kg), stature (cm), Biceps: biceps skinfold (mm), Triceps: triceps skinfold (mm), Abdomen: abdominal skinfold (mm), Subscapular: subscapular skinfold (mm), Suprailiac: suprailiac skinfold (mm), Midarm: midarm circumference (cm), Midchest: midchest circumference (cm), Waist: waist circumference (cm), Hip: hip circumference (cm), WHR: waist-hip ratio, WSR: waist-stature ratio, BMI: body mass index (Kg/m^2), FM.BMI: Fat mass by BMI derived equation (Kg), FP.BMI: Fat percentage by BMI derived equation (%),LM.BMI: Lean mass by BMI derived equation (Kg).

DISCUSSION

The prevalence of obesity has increased worldwide and has nearly doubled between 1980 and 2008. A large number of studies have shown that obesity increases the hypertension incidence; and the relationship between obesity and hypertension differs according to age, gender, geographical area and race (Song et al., 2014). Increase in the body fat was associated with increased blood pressure and both are risk factors for increased cardiovascular morbidity and mortality. Hypertension and obesity may have their start of occurrence during adolescence (Mushengezi and Chillo, 2014).

In the present work, the mean of BMI in males (23.4 Kg/m^2) was higher than in females (22.9 Kg/m^2), total of 23.2 Kg/m^2 for both sexes. These results were reversed in Bahraini adolescents, the mean of BMI in males was 21.65 Kg/m^2 and in females was 23.38 Kg/m^2 (total of 22.55 Kg/m^2) (Al-Sendi et al., 2003). The mean of BMI was higher in female than male students of Port-Said University (25.9 Kg/m^2 males to 27.1 Kg/m^2 females) and among Damietta students (26.6 Kg/m^2 males to 27.7 Kg/m^2 females) (Moussa et al., 2016).

In Brazil, the mean of BMI for the same age group in males was 23.2 Kg/m^2 and in females was 20.8 Kg/m^2 (total of 21.9 Kg/m^2) (Martins et al., 2010), in Korean adolescents, the mean of BMI was (21.6 Kg/m^2 males to 20.3 Kg/m^2 females)(Song et al., 2014), and in Malaysian adolescents the mean of BMI was 23.3 Kg/m^2 (23.5 Kg/m^2 males to 23.1 Kg/m^2 females) (Cheah et al., 2018).

In the current study, about 13.24% of the respondents were overweight or obese according to BMI (15.98% of male subjects and 10.5% of females). In other studies on college students in Louisiana, United States of America 57.7% of adolescents were obese(Deshmukh-Taskar et al., 2006), in Alexandria governorate, Egypt; overall obesity prevalence based on BMI was 10.3% (11.8% males and 8.7% females)(Abolfotouh et al., 2011), in Damietta governorate, obesity prevalence was 52% (47.9% of male subjects and 56.4% of females), in Port-Said, obesity prevalence was 46.9 % (44.2% of male subjects and 49.6% of females) (Moussa et al., 2016). In Spain, Madrid, (25.75% of male subjects and 24.4% of females) (Serrano et al., 2013), in Brazil, the obesity level was 18.2% for 18 years old of age (Martins et al 2010), in Nigeria, 17.3% were obese (Akindele et al., 2016), in Malaysia, the level of overweight and obesity derived from BMI was 40.7% (Cheah et al. 2018).

Hypertension is a public health problem and it is important to be a step towards early intervention, the present study described the proportion of adolescents with systolic and diastolic hypertension as 2.5% and 7% respectively, the findings are different from those found in secondary school adolescents in Dar Essalam, Tanzania, where the prevalence was higher in systolic hypertension to be 17.5%, but the diastolic hypertension was nearly similar per cent, 5.5% (Mushengezi and Chillo, 2014). Both systolic and diastolic hypertension found in urban school in Chennai, India where the prevalence was higher at the level of 21.5% for both systolic and diastolic hypertension (Sundar et al., 2013).

In this study, we found that the mean of systolic and diastolic blood pressure was greater in males (SBP: 118.14 mmHg to DBP: 76.09 mmHg) than females (SBP: 110.89 mmHg to DBP: 71.06 mmHg). In other studies, similar results were found in Bahrain, as the mean values blood pressure in males (SBP: 122.9 mmHg to DBP: 72.1 mmHg) were higher than females (SBP: 118.6 mmHg to DBP: 70.1 mmHg) (Al-Sendi et al., 2003), in Brazil, the mean values blood pressure in males (SBP: 124.1 mmHg to DBP: 80.2 mmHg) were higher than females (SBP: 113.5 mmHg to DBP: 72.8 mmHg)(Martins et al., 2010), and also in Indonesia, the mean blood pressure in males (SBP: 113 mmHg to DBP: 77.17 mmHg) and in females (SBP: 102.58 mmHg to DBP: 70.67 mmHg) (Hastuti et al., 2018), while the diastolic blood pressure was greater in adolescent girls (DBP in girls: 71 mmHg) than boys (DBP: 68 mmHg) in Tanzania (Mushengezi and Chillo, 2014).

The percent of subjects with elevated blood pressure collectively, Pre-hypertensive and hypertensive cases was of higher prevalence in males (systolic: 14.64% and diastolic: 10.95%) than females (systolic: 3% and diastolic hypertension: 2.55%). According to the national survey studies in Egypt, the hypertension prevalence had increased with age from 7.8% in 25- to 34-year-olds to 56.6% in those 75 years or older and according to sex, (Ibrahim et al., 1995). Hypertension in Egypt was slightly more common in adult women than in men (26.9% versus 25.7%, respectively), (Hasan et al., 2014), According to the survey studies in Saudi Arabia, the hypertension prevalence had increased with age from 8.8% in 15- to 25-year-olds, 12.9% in 26- to 35-year-olds to 57.5% in those 60- 75 years or older and according to sex.

Body mass index (BMI); which reflects general body fatness, was a risk factor for elevated blood pressure, which was consistent with other studies reflecting the link between high body fat and high blood pressure (Gus et al., 2004). BMI can be easily measured and it is a simple tool for screening of obesity and hypertension. Although BMI is the most frequently used method to assess the level of obesity, BMI doesn't differentiate between body lean mass and body fat mass; that is a person can have high BMI, but still have low-fat mass, like athletes and vice versa (Fox et al., 2007).

In the present study, rising of the mean of both systolic and diastolic blood pressure was associated with overweight and obesity according to BMI, in normal subjects (the mean of SBP: 109.5 mmHg and mean of DBP: 68.8 mmHg) and in overweight and obese (the mean of SBP: 126.33 mmHg and mean of DBP: 83.02 mmHg), these findings was in agreement with what reported by (Song et al., 2014), in normal Korean adolescent subjects (the mean of SBP: 110.9 mmHg and mean of DBP: 60.45 mmHg) and in overweight and obese (the mean of SBP: 119.8 mmHg and mean of DBP: 64.45 mmHg), Spanish adolescents (the mean of SBP: 111.86 mmHg and mean of DBP: 63.43 mmHg) and in overweight and obese (the mean of SBP: 117.1 mmHg and mean of DBP: 68.77 mmHg)(Serrano et al., 2013).

The correlation of BMI and blood pressure was described as fair correlation in our students, BMI (r= 0.426 for SBP with beta coefficient 1.1 and for DBP, r= 0.441 with beta coefficient 0.97). With similar findings in another study, on Indonesian adolescents, the correlation of BMI and blood pressure, also was fair (r= 0.32 for SBP with beta coefficient 0.82 and for DBP, r= 0.27 with beta coefficient 0.54) (Hastuti et al., 2018), and in Bahrain, the correlation was (r= 0.431 for SBP with beta coefficient 0.98 and for DBP, r= 0.446 with beta coefficient 0.97) (Al-Sendi et al., 2003).

Weight is a simple measure of obesity (Stamler, 1997). Increasing weight has been related to increased salt retention and insulin resistance which may be the cause of hypertension (Rocchini et al., 1989); adipose tissue has the ability to produce angiotensinogen that involved in pathogenesis of elevated blood pressure. The correlation between BMI and angiotensinogen production had been documented in Nigerian and Jamaican population samples (Rotimi et al., 1996). Another explanation of the link between hypertension and adiposity is the deposition of lipids into non adipose organs, such as kidney, which lead to accumulation of toxic metabolites derived from metabolism of fats and resulted in obesity-related glomerulopathy (Unger et al., 2010).

However, the changes in body fat distribution pattern is not linear with BMI and vary by sex and age, so the recent studies using accurate methods of determination of fat percentage as DXA and bioelectrical impedance analysis weakened the association between BMI and body fatness (Nagaraj et al., 2018).

CONCLUSION

13.24% of the students were overweight and obese, the mean of BMI in males was higher than in females, there was a gradual increase of means of blood pressure with increased BMI. The number of pre-hypertensive and hypertensive cases was higher in male subjects than in females, increase fatness in males had a stronger positive association with diastolic blood pressure than in females.

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