Research Article

Anthropometric measures in association with blood pressure level in physical education and medical male college students, El-minia University

Maher M. Kamel, Mohamed A. Desoky, El-Sayed A. Mahran, Nabil A. Al-sayed and Sayed F. El-Sheikh
Department of Anatomy, Faculty of Medicine, El-Minia University.

Abstract
Lack of physical activity, social stress and sedentary life style are involved as risk factors for cardiovascular diseases. The target of the study is to evaluate the anthropometric and blood pressure differences between physical education students and medical students after one or two years of study at El-minia University. A cross sectional study was performed with a sample of 814 male students (400 medical students), of age between 18-19 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. All anthropometric parameters indicating overweight and obesity were higher in medical than physical education students, including BMI (24.6±4.4 kg/m2 to 23.1±2.3 kg/m2), with significant level ($p<0.05$). Also the means of both systolic and diastolic blood pressure were higher in medical students (mean of SBP= 122.5±13 mmHg, DBP= 78.9±9.5 mmHg), than physical education students (SBP= 118.9±8.5 mmHg, DBP= 76.4±7.3 mmHg). Decreased physical activity and sedentary stressful life considered as risk factors for blood pressure elevation
Keywords: blood pressure, excess weight, physical activity, students.
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), **Subscpular**: 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), **Obesity BMI:** obesity classification according to BMI, **Obesity FP:** obesity classification according to fat percentage.

Introduction
Body composition was described as the percentage of fat, bones, water and muscle in the individual. Individuals with the same sex and body weight should have a different body composition, (Wellens et al., 1992).
The seventh report of the Joint National Committee on the Prevention, Detection, Evaluation and Treatment of high blood pressure introduced a new hypertension category (pre-hypertension), when a systolic pressure of 120 to 139 mmHg or diastolic blood pressure of 80 to 89 mmHg (Aounallah-skhiri et al., 2012). Individuals with Pre-hypertension have a great risk of developing hypertension than those with lower blood pressure levels (Huxley et al., 2014).

Hypertension in adolescents has a rising prevalence, and studies suggesting that hypertension in almost half of adults had elevated blood pressure values during childhood, (McNiece et al., 2007). An excess in body fat was associated with elevated 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). Despite of the prevalence of elevated blood pressure in adolescents is low, new studies have shown increased risk of hypertension to occur among obese children (Oduwole et al., 2012).

In adults, hypertension and obesity are in close association and obese individuals are more likely to be hypertensive, (Stamler et al., 1978). Moreover, blood pressure could be decreased in a dose-related fashion when weight is reduced, (Mokadad et al., 2003).

The use of simple anthropometric measures was an easy method for assessment of overweight; body mass index, hip circumference, and skin folds were associated with hypertension, (Kang, 2013). Evaluation of anthropometric measurements on association with elevated blood pressure can help to understand its pathogenesis and management, (Hastuti et al., 2018).

Physical activity is necessary for one hour per day to decrease the risk of elevated blood pressure and cardiovascular diseases in adolescents, (Andersen et al., 2006). Decreased physical activity was associated with increased body fatness in boys rather than girls (Basterfield et al., 2012).

Subjects and Methods

We performed a cross-sectional study involving 814 male college students (414 physical and 400 medical students of 2nd year of study) at El-minia University, El-minia governorate. Students who were apparently healthy and aged 18-19 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 by a single observer and elevated blood pressure was defined as SBP > 120 mmHg and DBP >80 mmHg, (Aounallah-skhiri et al., 2012). A total of three readings were taken five minutes apart. Weight was measured by a weighting scale (Momert, China) and recorded to the nearest 0.1 kilogram. Stature was measured using a stadiometer and averaged to the nearest 0.1 centimeter. Body mass index (BMI) was calculated as weight in kilograms divided by height in meter squared (BMI = Weight [Kg]/stature [meter]^2).

Skin fold thickness was obtained using a skin fold caliper (Harpenden skin fold 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, but not the muscle. The caliper 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 midpoint between the tip of the shoulder and the tip of the elbow (olecranon process and the acromium), (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 breathing, (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. Hip circumference was measured at the point yielding the maximum circumference over the buttocks. Waist-hip ratio (WHR) is the dimensionless ratio of the circumference of the waist to that of the hips. This is calculated as waist measurement divided by hip measurement. The WHO states that abdominal 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, both measured in the same units. Percent body fat is calculated by using BMI; = (1.20 × BMI) + (0.23 × age) – (10.8 × gender) – 5.4, using for gender male = 1, (Wang et al., 2007).

The collected data were coded, tabulated, and statistically analyzed using **SPSS program (Statistical Package for Social Sciences) software version 25.**

Results

All variables were compared between physical education and medical students, table-1. The means of both systolic and diastolic blood pressure were significantly higher in medical students (SBP= 122.5± 13, DBP= 78.9±9.5), than physical education students (SBP= 118.9±8.5, DBP= 76.4±7.3)

Also, all means of parameters that indicated more body adiposity were significantly higher in medical than physical education students, weight, biceps skinfold, triceps skinfold, abdominal skinfold, subscapular skinfold, suprailiac skinfold, waist circumference, hip circumference, body mass index BMI (24.6±4.4 kg/m^2 to 23.1±2.3 kg/m^2), waist stature ratio and fat percentage derived from BMI equation, with significant statistical difference (P value <0.01).

Table (1): Descriptive statistics for blood pressure, different body measures, classification of obesity and elevated blood pressure in all cases:

	Medical students N=400	Physical education N=414	P value
SBP	122.5±13	118.9±8.5	***<0.001****
DBP	78.9±9.5	76.4±7.3	***<0.001****
Weight	74.7±14.4	70.7±6.9	***<0.001****
Stature	174.2±6.4	175.2±5.2	***0.013****
Biceps	8.3±4.8	5.7±2.7	***<0.001****
Triceps	14.7±7.2	10.5±4.5	***<0.001****
Abdominal	26.3±11.9	19.7±7.5	***<0.001****
Subscapular	21.7±10.1	16.3±5.5	***<0.001****
Suprailiac	27.7±12.9	20.4±8.1	***<0.001****
Midarm	29.2±3.6	29±2.7	*0.273*
Midchest	96.3±8.5	94.9±5.2	***0.005****
Waist	84.2±11.4	80.7±6.3	***<0.001****
Hip	97.8±9.7	94.3±5.5	***<0.001****
WHR	0.86±0.04	0.85±0.03	*0.113*
WSR	0.48±0.07	0.46±0.04	***<0.001****
BMI	24.6±4.4	23.1±2.3	***<0.001****
FM.BMI	13.8±6.9	11.3±3	***<0.001****
FP.BMI	17.5±5.3	15.8±2.7	***<0.001****
LM.BMI	61±8	59.3±4.3	***<0.001****
Obesity BMI			***<0.001****
Under weight	17(4%)	2(0.5%)	
Normal	236(55.5%)	350(82.4%)	
Over weight	125(29.4%)	68(16%)	
Moderate obesity	35(8.2%)	5(1.2%)	
Severe obesity	11(2.6%)	0(0%)	
Morbid obesity	1(0.2%)	0(0%)	
SBP			***<0.001****
Normal	219(51.5%)	311(73.2%)	
Elevated	206(48.5%)	114(26.8%)	
DBP			***<0.001****
Normal	270(63.5%)	347(81.6%)	
Elevated	155(36.5%)	78(18.4%)	

For medical subjects, table (2), variables had a fair positive correlation with the systolic blood pressure with the highest figures were BMI (r= 0.431), mid-arm (r= 0.413), mid-chest (r= 0.489), waist (r= 0.437), circumferences, and lean mass dependent on BMI (r=0.524). All skin-fold thickness measurements were in between weak-to fair correlation with systolic blood pressure.

For diastolic blood pressure, also BMI (r= 0.447), mid-arm (r=0.420), mid-chest (r= 0.492), waist (r= 0.446), hip circumferences (r= 0.423), fat mass (r= 0.311) and lean mass (r= 0.502) depending on BMI equations were of high numbers of fair correlation in non-athletic subjects, as shown in table (3).

Table (2): Correlation between systolic blood pressure and different body measures in medical students & Simple linear regression analysis predicting systolic blood pressure medical students:

	Constant	B coefficient	P value	R	R2
BMI	87.47	1.18	***<0.001***	0.431	0.186
Biceps	110.72	0.48	***<0.001***	0.237	0.056
Triceps	109.92	0.32	***<0.001***	0.216	0.047
Abdomen	106.92	0.32	***<0.001***	0.291	0.085
Subscapular	108.03	0.35	***<0.001***	0.307	0.094
Suprailiac	107.06	0.30	***<0.001***	0.291	0.084
Midarm	82.53	1.16	***<0.001***	0.413	0.171
Midchest	54.87	0.65	***<0.001***	0.489	0.239
Waist	76.86	0.48	***<0.001***	0.437	0.191
Hip	67.58	0.50	***<0.001***	0.397	0.157
WHR	67.06	57.42	***<0.001***	0.275	0.076
WSR	88.51	56.11	***<0.001***	0.299	0.089
FM.BMI	108.38	0.47	***<0.001***	0.287	0.082
FP.BMI	113.39	0.07	***<0.001***	0.046	0.002
LM.BMI	85.36	0.56	***<0.001***	0.524	0.274

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 & Simple linear regression analysis predicting diastolic blood pressure in medical students:

	Constant	B coefficient	P value	R	R2
BMI	51.38	0.97	***<0.001***	0.447	0.199
Biceps	70.60	0.37	***<0.001***	0.234	0.055
Triceps	69.70	0.26	***<0.001***	0.229	0.052
Abdomen	67.15	0.27	***<0.001***	0.310	0.096
Subscapular	68.58	0.27	***<0.001***	0.298	0.089
Suprailiac	67.28	0.25	***<0.001***	0.308	0.095
Midarm	47.81	0.93	***<0.001***	0.420	0.176
Midchest	26.03	0.52	***<0.001***	0.492	0.242
Waist	43.16	0.39	***<0.001***	0.446	0.199
Hip	33.93	0.42	***<0.001***	0.423	0.179
WHR	38.50	42.44	***<0.001***	0.257	0.066
WSR	51.42	47.68	***<0.001***	0.322	0.103
FM.BMI	68.26	0.40	***<0.001***	0.311	0.097
FP.BMI	71.65	0.11	***<0.001***	0.086	0.007
LM.BMI	51.47	0.43	***<0.001***	0.502	0.252

DBP is the dependent variable

Predictive equation: **DBP = constant + (B coefficient x variable)**

Table (4): Correlation between systolic blood pressure and different body measures & Simple linear regression analysis predicting systolic blood pressure in athletics:

	Constant	B coefficient	P value	R	R2
BMI	84.63	1.47	*<0.001***	0.390	0.152
Biceps	113.73	0.87	*<0.001***	0.271	0.073
Triceps	112.81	0.56	*<0.001***	0.285	0.081
Abdomen	111.14	0.38	*<0.001***	0.331	0.110
Subscapular	109.91	0.54	*<0.001***	0.344	0.118
Suprailiac	110.78	0.39	*<0.001***	0.364	0.132
Midarm	90.13	0.98	*<0.001***	0.310	0.096
Midchest	63.38	0.58	*<0.001***	0.361	0.130
Waist	69.24	0.61	*<0.001***	0.448	0.201
Hip	51.52	0.71	*<0.001***	0.467	0.218
WHR	69.30	57.74	*<0.001***	0.193	0.037
WSR	79.45	85.21	*<0.001***	0.387	0.151
FM.BMI	104.54	1.24	*<0.001***	0.426	0.181
FP.BMI	99.25	1.23	*<0.001***	0.389	0.151
LM.BMI	72.32	0.78	*<0.001***	0.384	0.148

SBP is the dependent variable

***Predictive equation:* SBP = constant + (B coefficient x variable).**

Table (5): Correlation between diastolic blood pressure and different body measures & Simple linear regression analysis predicting diastolic blood pressure in athletics:

	Constant	B coefficient	P value	R	R2
BMI	47.04	1.26	*<0.001***	0.385	0.149
Biceps	71.26	0.87	*<0.001***	0.313	0.098
Triceps	70.14	0.58	*<0.001***	0.341	0.116
Abdomen	68.61	0.39	*<0.001***	0.386	0.149
Subscapular	67.33	0.55	*<0.001***	0.402	0.162
Suprailiac	68.64	0.37	*<0.001***	0.403	0.162
Midarm	52.07	0.83	*<0.001***	0.302	0.091
Midchest	26.26	0.53	*<0.001***	0.376	0.142
Waist	29.43	0.58	*<0.001***	0.489	0.240
Hip	14.82	0.65	*<0.001***	0.493	0.243
WHR	22.43	62.90	*<0.001***	0.243	0.059
WSR	39.53	79.66	*<0.001***	0.418	0.174
FM.BMI	64.25	1.05	*<0.001***	0.416	0.173
FP.BMI	59.56	1.05	*<0.001***	0.385	0.148
LM.BMI	35.17	0.69	*<0.001***	0.394	0.155

DBP is the dependent variable

***Predictive equation:* DBP = constant + (B coefficient x variable)**

In athletic group, table 4, all variables had a fair positive correlation, but WHR was of weak correlation (r= 0.193). The systolic blood pressure was correlated with the most striking factors were waist (r= 0.448), hip (r= 0.467) circumferences and fat mass dependent on BMI (r= 0.426), while BMI and lean mass derived from BMI- dependent equation of lower correlation levels with systolic blood pressure in athletes than non athletic group by comparing of figures of table-25. Waist-hip ratio (WHR) of weak correlation (r= 0.193) with systolic blood pressure and higher correlation with waist-stature ratio (WSR) (r= 0.387) in athletes, while the reverse in non athletes (WHR, r= 0.275) and (WSR, r= 0.299).

For diastolic blood pressure, table-5, also all measures had a fair positive correlation, except WHR was of weak correlation (r= 0.243). Sub-scapular (r= 0.402), supra-iliac skin folds (r= 0.403), waist (r= 0.489), hip circumferences (r= 0.493), and fat mass (r= 0.416) from BMI equation of high numbers of fair correlation in athletic subjects comparing with non physical education students.

Discussion

The present work aimed to compare between the effect of physical activity on physical education students and sedentary stressful life of medical students on the body adiposity measures and blood pressure at El-minia University, Egypt. The means of both systolic and diastolic blood pressure were higher in medical students than physical education students, which was in agreement with similar study in University of Guilan, Iran, in non-athletic students (mean of SBP= 126.3±14 mm Hg, DBP= 86.1±6 mm Hg), while in physical education students (SBP= 117.3±7 mm Hg, DBP= 76.1±7.3 mm Hg), (Arazi et al., 2012). Budapest, Hungary, the mean blood pressure for medical students was (SBP= 122.3±13.8 mm Hg, DBP= 80.6±7.8 mm Hg), reported by (LEFFELHOLC and BODZSAR, 1997).

In the current study, the means of all variables of increased body adiposity -BMI, skinfold thickness, circumferences, waist-hip ratio (WHR), and waist-stature ratio (WSR) – were higher in medical group than physical education one. (Arazi et al., 2012) described similar results between athletic and non-athletic students for Stature (175 cm to 169 cm), weight (67 kg to 78 kg) and BMI (21.9kg/m^2 to 27.3kg/m^2), respectively. In medical school student, University Malaysia Sabah, all anthropometric measurements for second year medical students were lower than ours, except the triceps skinfold thickness, (Zin et al. 2014).

It was reported that the effect of regular physical activity with dietary control had a great effect of reduction of body adiposity and subsequently development of hypertension. Sedentary life and stress are known to be strongly correlated with development of elevated blood pressure, (Bouchard, 1996).

(Bacon et al., 2004) documented that the combination of dietary control and regular exercise was effective in reduction of elevated blood pressure in pre-hypertensive individuals, with improvement similar to those who are receiving drug therapy for control of mildly elevated blood pressure.

Researches that studied the effect of physical activity on body composition and blood pressure didn't provide a précised support for this idea, a four-month program of physical activity (three moderate-intensity exercise sessions per week) didn't result in changes in BMI or blood pressure in adults (Vianna et al., 2012), while in adolescents, physical fitness exhibit a minor effect on blood pressure and a high BMI was associated with elevated blood pressure, especially for systolic pressure in ages 14 to 18 years old, (Sousa et al., 2014). However, new scientific evidence relating physical activity to health, physical activity was recommended by various organizations to promote and maintain health, all healthy adults aged 18 to 65 years need moderate-intensity physical activity for a minimum of 30 min on five days each week, (Haskell et al., 2007).

Adiposity in medical students may a result of psychosocial, socioeconomic and study challenges or stress activate the hypothalamic-pituitary-adrenal axis, and when these occur on a chronic basis, they are associated with an increased incidence of visceral obesity, abnormal fat distribution and predisposition to develop the metabolic syndrome, (Kyrou et al., 2006).

Conclusion

According to this study, Decreased physical activity and sedentary life considered as risk factors for blood pressure elevation. Much research work needs to be done to clarify the relationship of body fitness to the risk of development of hypertension.

Acknowledgement

We thank all staff members of anatomy department and all participants in this study. Thanks to Dr. Mostafa M. Asem for statistical revision of the present work.

References

1. Andersen, L. B., Harro, M., Sardinha, L. B., Froberg, K., Ekelund, U., Brage, S., & Anderssen, S. A. (2006). Physical activity and clustered cardio-vascular risk in children: a cross-sectional study (The European Youth Heart Study). The Lancet, 368(9532), 299-304.
2. Aounallah-Skhiri, H., J. El Ati, P. Traissac, H. B. Romdhane, S. Eymard-Duvernay, F. Delpeuch, N. Achour and B. Maire (2012). "Blood pressure and associated factors in a North African adolescent population. A national cross-sectional study in Tunisia." BMC Public Health 12(1): 98.
3. Arazi, H., Hoseini, R., & Behrozi, A. (2012). A comparison of body fat and blood pressure between physical education and non-physical education major male students. *Facta universitatis-series: Physical Education and Sport, 10*(2), 127-134.
4. Bacon, S. L., Sherwood, A., Hinderliter, A., & Blumenthal, J. A. (2004). Effects of exercise, diet and weight loss on high blood pressure. *Sports Medicine, 34*(5), 307-316.
5. Basterfield, L., Pearce, M. S., Adamson, A. J., Frary, J. K., Parkinson, K. N., Wright, C. M., . . . Team, G. M. S. C. (2012). Physical activity, sedentary behavior, and adiposity in English children. American journal of preventive medicine, 42(5), 445-451.
6. Bouchard C. Can obesity be prevented? Nutr Rev. (1996); 54:S125-S130.
7. Brown, S. P., W. C. Miller and J. M. Eason (2006). Exercise physiology: basis of human movement in health and disease, Lippincott Williams & Wilkins.
8. Dwyer, T., & Gibbons, L. (1994). The Australian Schools Health and Fitness Survey. Physical fitness related to blood pressure but not lipoproteins. Circulation, 89(4), 1539-1544.
9. E. LEFFELHOLC and E. B. BODZSAR (1997). BODY COMPOSITION AND BLOOD PRESSURE OF MEDICAL STUDENTS. ACTA BIOL. SZEGED. 42, pp. 241-243.
10. Haskell, W. L., I.-M. Lee, R. R. Pate, K. E. Powell, S. N. Blair, B. A. Franklin, C. A. Macera, G. W. Heath, P. D. Thompson and A. Bauman (2007). "Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association." Circulation 116(9): 1081.
11. Hastuti, J., N. T. Rahmawati and R. A. Suriyanto (2018). "Anthropometric Indicators for Blood Pressure and the Prevalence of Hypertension in Indonesian College Students Aged 18-25 Years." Pakistan Journal of Nutrition 17(4): 163-170.
12. Huxley, R. R., J. R. Misialek, S. K. Agarwal, L. R. Loehr, E. Z. Soliman, L. Y. Chen and A. Alonso (2014). "Physical activity, obesity, weight change, and risk of atrial fibrillation: the Atherosclerosis Risk in Communities study." Circulation: Arrhythmia and Electrophysiology 7(4): 620-625.
13. Kang, Y. S. (2013). Obesity associated hypertension: new insights into mechanism. Electrolytes & Blood Pressure, 11(2), 46-52.
14. Kyrou I, Chrousos GP, Tsigos C. Stress, visceral obesity, and metabolic complications. **Ann NY Acad Sci** 1083: 77–110, 2006.
15. McNiece, K. L., T. S. Poffenbarger, J. L. Turner, K. D. Franco, J. M. Sorof and R. J. Portman (2007). "Prevalence of hypertension and pre-hypertension among adolescents." The Journal of pediatrics 150(6): 640-644. e641.
16. Mokdad, A. H., E. S. Ford, B. A. Bowman, W. H. Dietz, F. Vinicor, V. S. Bales and J. S. Marks (2003). "Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001." Jama 289(1): 76-79.

17. Mushengezi, B. and P. Chillo (2014). "Association between body fat composition and blood pressure level among secondary school adolescents in Dar es Salaam, Tanzania." The Pan African medical journal 19.
18. Oduwole, A. A., T. A. Ladapo, I. B. Fajolu, E. N. Ekure and O. F. Adeniyi (2012). "Obesity and elevated blood pressure among adolescents in Lagos, Nigeria: a cross-sectional study." BMC Public Health 12(1): 616.
19. Olweus, D., Mattsson, Å., Schalling, D., & Loew, H. (1980). Testosterone, aggression, physical, and personality dimensions in normal adolescent males. Psychosomatic medicine.
20. Sousa, N., Silva, S., Abrantes, C., Reis, V. M., & Mendes, R. (2014). RELATIONSHIP OF PHYSICAL FITNESS AND BODY COMPOSITION IN THE INCIDENCE OF HYPERTENSION AMONG SCHOOL-AGED CHILDREN AND YOUTH IN THE NORTH OF PORTUGAL. *Revista Uniandrade, 15*(3), 205-217.
21. Stamler, J. (1997). "The INTERSALT Study: background, methods, findings, and implications." The American journal of clinical nutrition 65(2): 626S-642S.
22. Vianna, M. V. A., Cáder, S. A., Gomes, A. L. M., Guimarães, A. C., Seixas-da-Silva, I. A., do Rêgo, A. R. d. O., . . . Dantas, E. H. M. (2012). Aerobic conditioning, blood pressure (BP) and body mass index (BMI) of older participants of the Brazilian Family Health Program (FHP) after 16 weeks of guided physical activity. Archives of Gerontology and Geriatrics, 54(1), 210-213.
23. Wang, Z., S. Heshka, J. Wang, D. Gallagher, P. Deurenberg, Z. Chen and S. B. Heymsfield (2007). "Metabolically active portion of fat-free mass: a cellular body composition level modeling analysis." American Journal of Physiology-Endocrinology and Metabolism 292(1): E49-E53.
24. Wellens, R., R. Malina, A. Roche, W. Chumlea, S. Guo and R. Siervogel (1992). "Body size and fatness in young adults in relation to age at menarche." American journal of human biology 4(6): 783-787.
25. Organization, W. H. (2011). Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008.
26. Yallamraju, S. R., R. Mehrotra, A. Sinha, S. R. Gattumeedhi, A. Gupta and S. V. Khadse (2014). "Use of mid upper arm circumference for evaluation of nutritional status of OSMF patients." Journal of International Society of Preventive & Community Dentistry 4(Suppl 2): S122.
27. Zin, T., Yusuff, A. S. M., Myint, T., Naing, D. K., Htay, K., & Wynn, A. A. (2014). Body fat percentage, BMI and skinfold thickness among medical students in Sabah, Malaysia. South East Asia Journal of Public Health, 4(1), 35-40.