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Relationship between body fat percentage determined by bioelectrical impedance analysis and metabolic risk factors in Syrian male adolescents (18–19 years)

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ABSTRACT: The association between increasing obesity and metabolic syndrome among adolescent and the adverse consequences in adulthood including type-2 diabetes and coronary heart disease is well documented. The main objectives of this study were to evaluate the major metabolic risk factors and some clinical important parameters in Syrian male adolescents (18–19 years old), and to assess the correlations between BF% determined by BIA-man prediction equation and metabolic risk factors in the same group. The correlations between body fat percentage (BF%) based on BIA-man predictive equations, blood pressure, fasting blood sugar (FBS), cholesterol (Chol), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), triglycerides (TG), Hematocrit (Ht), and hemoglobin (Hb) in 1596 healthy Syrian adolescents aged 18–19 years and the mean values of these parameters were examined. Data showed that, DBP, Chol, TG, LDL and TG/HDL-C were significantly ($p < 0.05$) higher in overweight and obese subjects in comparison to normal weight cases. Whereas, SBP, FBS and Ht were significantly ($p < 0.05$) higher in obese subjects in comparison to normal weight. However, all measured variable related to metabolic syndrome risk factors increased with increasing the BF% determined by BIA-man. The present study suggests that % BF by BIA-man is a good predictor of metabolic risks factors for Syrian adolescents.

KEY WORDS: bioelectrical impedance analysis, body composition, metabolic syndrome, Syrian adolescents

Introduction

An increase in body size, besides being associated with cardiovascular risk factors such as hypertension, diabetes melli-

tus, and hyper-lipidemia, directly affects cardiac structure and function (Russo et al. 2011). In fact, epidemiologic and clinical studies have suggested that high level of fat mass might be associated with increased metabolic syndrome risk (MetS)

(Liu et al. 2013; Madeira et al. 2013; Ranasinghe et al. 2013). Adipose tissue not only stores excess triglycerides, but function as an endocrine organ by releasing several adipokines, which appear to modulate glucose and lipid metabolism, inflammation, appetite and insulin resistance (Attie and Scherer 2009). Furthermore, percentage body fat (%BF) is more effective in detecting individuals with disturbed glucose tolerance, risk of cardiometabolic disease, early stage cardiovascular disease (Gomez-Ambrosi et al. 2011; Yamashita et al. 2012). It seems that true body fatness may be better evaluated by assessment of body fat and fat-free mass (Lavie et al. 2012). Therefore, much research has recently examined the potential role of body composition measurements (Zeng et al. 2012; Cruz et al. 2011; Bintvibok et al. 2013). Until now, bioelectrical impedance analysis (BIA) methods validity has been tested, taking BF% as the outcome variable; with a range of reference techniques including, total body water, hydrodensitometry and dual energy X-ray absorptiometry and other criterion methods in assessing BF% (Meeuwssen et al. 2010; Ranasinghe et al. 2013; Xu et al. 2011). BIA has also many advantages compared with other methods because it is inexpensive, simple, fast, safe, portable, and easy to perform, as well as requires minimum operator training (King et al. 2005). In addition, limited data are available using more direct measurements of body adiposity in Syrian populations. For these reasons more accurate measurement of body composition, and particularly body fat, of adolescents is of increasing importance.

The objective of this study was: evaluating the main metabolic risk factors and some clinical important parameters

in Syrian young men (18–19 years old) and assessing the correlations between BF% determined by BIA and metabolic risk factors in the same group.

Materials and methods

Study population

A cross-sectional study consisted of a sample of 1596 healthy young men aged 18–19 years from Damascus city, in Syria. All participants underwent a clinical examination by physicians to exclude those with clinical history of chronic diseases including cardiovascular, renal, hepatic, or any abnormalities might affect body composition. Subjects were asked to abstain completely from consuming food and drink in the 12 hours before visiting the testing field. All anthropometry measurements and sampling were completed during a single visit to the testing area. The study protocol was approved by the scientific research and the ethical committee of the Atomic Energy Commission of Syria (AECS). Each participant provided informed consent prior to participation after a detailed explanation of the study protocol. This study was performed in accordance with guidelines prescribed by Helsinki declaration of the world medical association.

Anthropometry measured

Body weight clothing was measured using calibrated an electronic scales (Seca, Model: 7671321004; Germany; D=0.05 to 0.1 kg). The accuracy of the scales was confirmed by using weight of known mass (20 kg). Height was measured to the nearest 0.5 cm with a wall-mounted stadiometer (Seca, Model: 225 1721009;

Germany). Participants were measured barefoot in light underwear. Using non-stretchable standard tapes, waist circumference was measured over the unclothed abdomen at the narrowest point between the costal margin and iliac crest, and hip circumference was measured over light clothing at the level of the widest diameter around the buttocks.

Bioelectrical impedance analysis

Resistance (R) and reactance (X) were measured at 50 kHz using a bioimpedance analyzer (Quadscan 4000, Hydration/Body composition, monitoring unit, Bodystal Limited, UK). These measurements were carried out after overnight fasting with an empty bladder. All metal accessories were removed and the participant asked to lie supine for 5 min before starting measurements. During the measurements, the young man asked to have the arms near but not touching the body and the legs abducted. The skin of the right hand and foot was swabbed with alcohol before the electrodes were placed. Source electrodes were placed on the dorsal surface of the foot over the distal portion of the second metacarpal. Sensing electrodes were placed at the anterior ankle between the tibia and fibular malleoli and at the posterior wrist between the styloid processes of the radius and ulna. The participant was lying still for at least 5 min before the measurements were made. The average of repeated measurements of R and X agreeing to within 2 of each other was used in subsequent analyses.

During the measurement, the instrument recorded whole body impedance from the hands to the feet by applying an electric alternating current flux of 0.2 mA at operating frequency of 50 kHz. Fi-

nally, percentage of body fat was calculated from the whole impedance value and the pre-entered personal data (weight, height, physical activity level, waist and hip circumference) of corresponding subject. BW, BF % were calculated from the measurements of resistance made at 50 kHz using the formula provided by the instrument manufacturer (BIA-man).

Biochemical and clinical tests

The main metabolic syndrome risk factors and some clinical important parameters were included in this study. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured in adolescents in a sitting position after 15 min rest using a mercury sphygmomanometer. Blood samples were collected from all participating adolescents after 12 hours of overnight fasting. Serum was separated by centrifugation. Serum glucose (GOD-PAP method, Human Co.), cholesterol (Chol), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C), (CHOD-PAP method, Human Co.), triglycerides (TG) (GPO-PAP method, Human Co.), fasting blood sugar (FBS), Hematocrit (Ht), and hemoglobin (Hb) were determined using commercial kits (Hadidy et al. 1985).

Biochemical, clinical, and overweight/obesity cut-off values

The normal range for each studied factor was defined as follows: SBP (90–135 mm Hg); DBP (60–89 mm Hg); FBS (65–110 mg/dl); TG (25–200 mg/dl); Chol (50–200 mg/dl); HDL-C (40–75 mg/dl); LDL-C (less than 155 mg/dl); Ht (40–45 mg/dl); Hb (13–18 g/dl) (Hadidy et al. 1985). TG/HDL-C (less than

3) (Marotta et al., 2010). The BF% cut-points ($\geq 20\%$ for overweight and $\geq 25\%$ for obesity) defined by Okorodudu et al. (2010) were used.

Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Science SPSS for windows (Version 17.0.1, 2001, SPSS Inc., Chicago, USA). Continuous variables were expressed as mean \pm standard deviation (SD), whereas categorical variables were represented by frequency and percentage. The level of significance was determined as a p -value < 0.05 .

Results

The mean values (mean \pm SD, max and min) of the tested metabolic risk factors and other clinical parameters of 1596 participated adolescent are illustrated in Table 1. These values were as follows: %BF as determined by BIA-man (15.2%), SBP (124.45 mm Hg), DBP (75.06 mm Hg), FBS (89.48 mg/100 ml),

TG (93.53 mg/100 ml), Chol (137.99 mg/100 ml), HDL-C (57.89 mg/100 ml), LDL-C (61.88 mg/100 ml), TG/HDL-C (1.63 ± 0.76), Ht (45.58%), and Hb (14.68 mg/100 ml).

The correlations between BF% in three groups (normal $< 20\%$, overweight 20-25% and obese $> 25\%$) as determined by BIA, and biochemical and clinical parameters of the studied group are presented in Figs 1–3.

These results indicating that DBP (Fig. 1b), TG (Fig. 2c), Chol (Fig. 3b), LDL (Fig. 2a) and TG/HDL-C (Fig. 2d) were significantly ($p < 0.05$) higher in overweight and obese subjects in comparison to normal weight subjects. Whereas, SBP (Fig. 1a), FBS (Fig. 3a) and Ht (Fig. 3c) were significantly ($p < 0.05$) higher in obese subjects in comparison to normal weight subjects. However, there were no significant differences in HDL-C (Fig. 2b) and Hb (Fig. 3d) values among the three groups (normal, overweight and obese). Obese group exhibited a higher SBP (126.61 mm Hg), DBP (77.88 mm Hg), FBS (91.26 mg/dl),

Table 1. Body fat percentage, biochemical variables, and clinical parameters of Syrian adolescents (18–19 years)

Max	Min	(Mean \pm SD)	Characteristics
46.88	1.22	15.20 \pm 7.62	%BF(BIA)
180.00	90.00	124.45 \pm 14.63	SBP (mm Hg)
105.00	50.00	75.06 \pm 10.25	DBP (mm Hg)
126.00	65.00	89.48 \pm 8.17	FBS (mg/100 ml)
362.00	12.90	93.53 \pm 42.06	TG (mg/100 ml)
288.00	17.00	137.99 \pm 31.24	Chol (mg/100 ml)
90.00	37.00	57.89 \pm 6.59	HDL (mg/100 ml)
195.00	1.00	61.88 \pm 27.78	LDL (mg/100 ml)
6.96	0.18	1.63 \pm 0.76	TG/HDL
53.00	37.00	45.58 \pm 2.70	Ht (%)
17.00	11.90	14.68 \pm 0.87	Hb (mg/100 ml)

%BF(BIA) – body fat percentage assessed by bioelectrical impedance analysis, SBP – systolic blood pressure, DBP – diastolic blood pressure, FBS – fasting blood sugar, TG – triglycerides, Chol – total cholesterol, HDL – high density lipoprotein, LDL – low density lipoprotein, Ht – haematocrit, Hb – hemoglobin

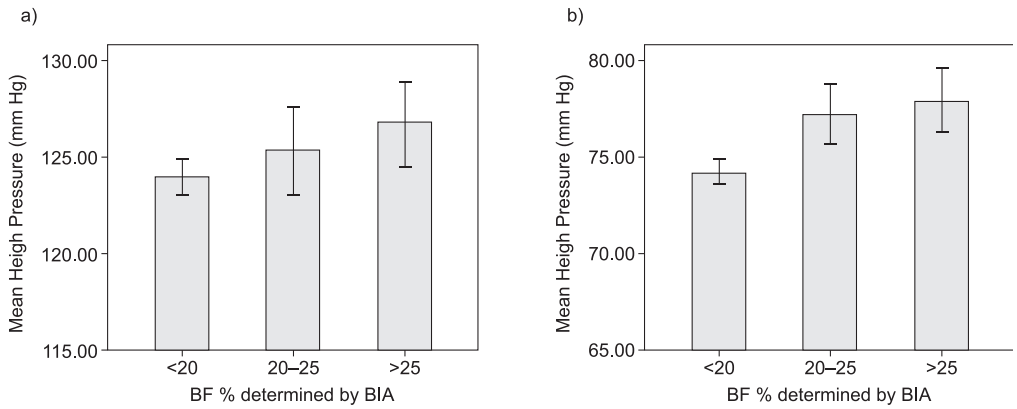


Fig. 1. Correlation between BF % determined by BIA and blood pressure (systolic and diastolic) (mmHg) for Syrian young boys (18-19 years). (Figures 1a and 2b)

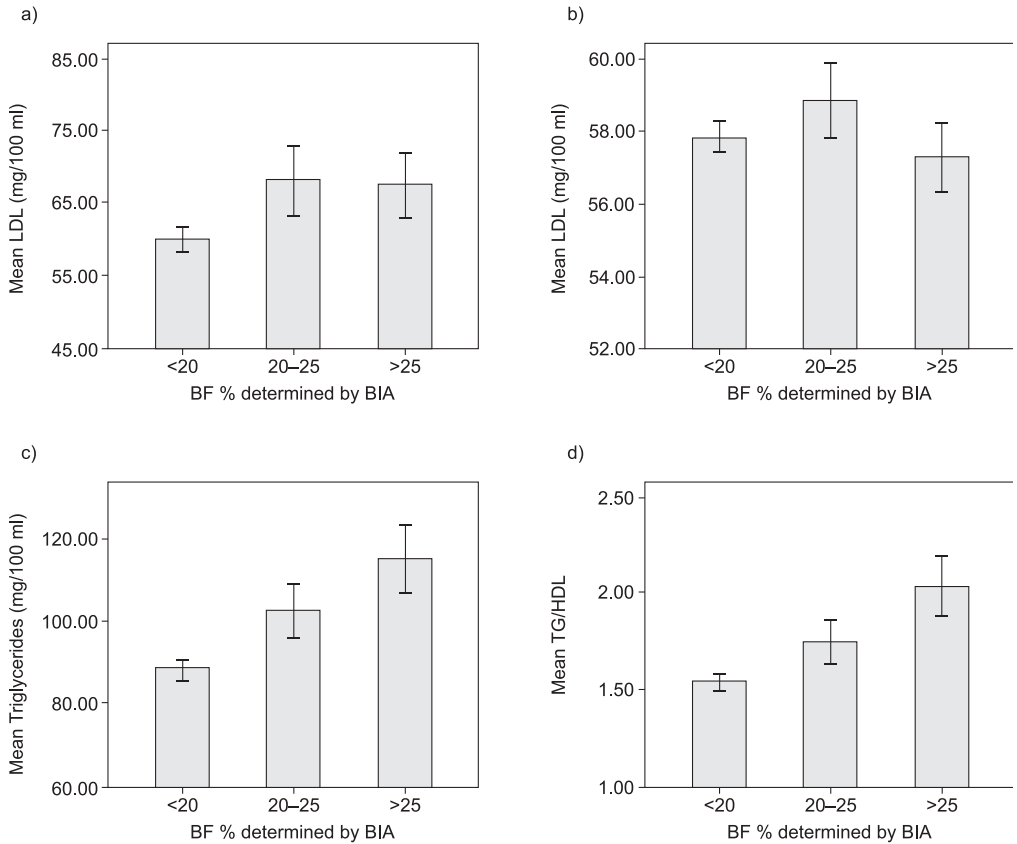


Fig. 2. Correlation between BF % determined by BIA and some serum lipid fractions (LDL, HDL, TG and TG/HDL) (mg/100 ml) for Syrian young boys (18-19 years) (Figures 2a-d)

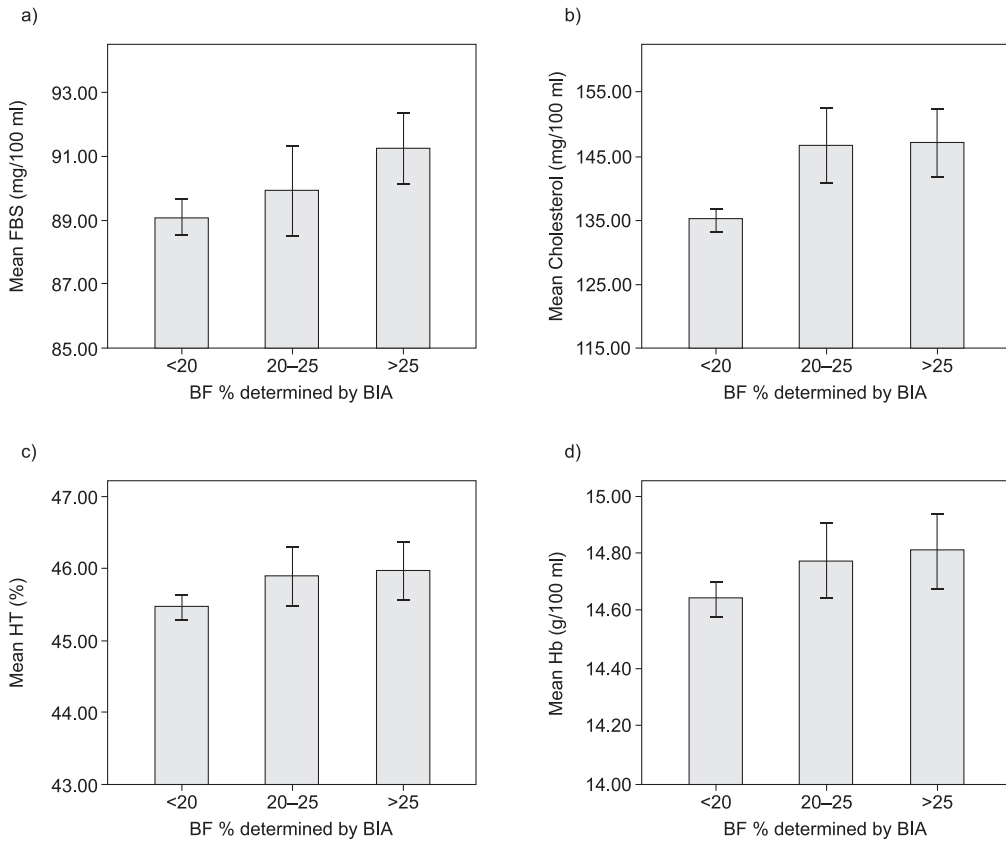


Fig. 3. Correlation between BF % determined by BIA and biochemical parameters indexes (FBS (mg/100 ml), cholesterol (mg/100 ml), HT (%) and Hb (g/100 ml)) for Syrian young boys (18-19 years) (Figures 3a-d)

Chol (147.21 mg/dl), TG (114.87 mg/dl), LDL-C (67.52 mg/dl), TG/HDL-C (2.04), and Ht (45.98 mg/dl), in comparison to overweight group. The results of overweight group were as follows: SBP (125.30 mm Hg) DBP (77.30 mm Hg), FBS (89.93 mg/dl), Chol (146.83 mg/dl), TG (102.40 mg/dl), TG/HDL-C (1,75), and Ht (45.88 mg/dl), while the normal weight group exhibited the following results: SBP (123.93 mm Hg) DBP (74.23 mm Hg), FBS (89.10 mg/dl), Chol (135.03 mg/dl), TG (88.48 mg/

dl), LDL-C (59.97 mg/dl), TG/HDL-C (1,54), and Ht (45.47 mg/dl).

Discussion

The abdominal obesity, similar to other metabolic syndrome components such as blood pressure (BP), fasting blood glucose (FBG), triglycerides (TG), cholesterol (Chol), low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C) (Wakabayashi 2011), is one of the important

factors of metabolic syndrome (MetS) (Pongsatha et al. 2012). The prevalence of metabolic syndrome in obese children and adolescents has increased worldwide (Marjani 2014). It has been reported that MetS itself gives a higher risk for cardiovascular diseases CVD, as the most common cause of death in the world, when compared to every single component of MetS (Kamalesh et al. 2010; Lu et al. 2011). Several studies have actually shown that abdominal obesity more strongly associated with cardiovascular heart diseases (CHD) (Singh et al. 2010). Excess abdominal fat is associated with hyperinsulinism and cardio-metabolic alterations (Freedman et al., 2007; Franco et al. 2009). The complex relation between body weight and morbidity and mortality was reflected in recent publication from the US National Center for Health Statistics (Flegal et al. 2007). The published studies have indicated that the risk of developing the metabolic syndrome increases markedly in a BMI above 25 (Bintvibok et al. 2013, Brown et al. 2008). Park et al (2003) reported recently a prevalence of metabolic syndrome in 4.8%, 22.8%, and 60.2% of normal-weight (BMI: 18.5–24.9), overweight (25.0–29.9), and obese (≥ 30) men in the US population, respectively. Although, studies have shown that the BMI is a useful general measure of adiposity, the interest of using the actual amount of body fat and their link with health abnormalities have been increased recently. These mainly due to recognizing the association between the total and regional body fat with glucose metabolism, serum lipid concentrations, insulin resistance and blood pressure.

This study is the first, to our knowledge to evaluate the major metabolic risk factors and some clinical important pa-

rameters in Syrian adolescent, and the correlations between BF% determined by BIA-man prediction equation and the mentioned risk factors. The results of study shows that the mean of % BFas determined by BIA-men was 15.20%. Also, this study demonstrates that, when BF% cut-points ($\geq 20\%$ for overweight and $\geq 25\%$ for obesity) as defined by Okorodudu et al. (2010) were used, the overall prevalence of overweight and obesity was 25% (324 from 1314 subjects). This high figure of overweight and obesity in Syrian adolescents may require a more sensitive criterion to identify metabolic and clinical risk factors for metabolic syndrome. However, Overweight and obesity are important health issues globally, and their prevalence is rapidly escalating in both developed and developing countries. This issue is becoming an important public health problem among middle-east countries during the second part of the twenty century, along-side great increases in population size in many of the middle-east countries, and migration the rural to urban centers. (Miromohammadi et al. 2011; Gbary et al. 2014; Godfrey and Juilin 2005). Our results suggest the need to develop strategies in order to reverse today's obesity trends in Middle-east countries. The fact that the annual increase in overweight and obesity rates affects both men and women indicates that not only diets and physical exercise are the main contributors to the current epidemic. Other environmental factors, in particular those related to policies, economics and advertising also have an impact on choice of less healthy options by individuals (Millstone and Lobstein 2007). The present study revealed significant differences in all biological variables measured except HDL-C among overweight and obese Syrian

adolescents. The persons studied with higher % BF, as determined by BIA-man, showed significant increases in the major risk factors of metabolic syndrome, like blood pressure, Chol, TG, FBS, LDL and TG/HDL-C. This is in agreement with studies of the general population. Washino et al. (1999) in their study on Japanese children demonstrated that the %BF of 23% measured by BIA was associated with high ratio of total cholesterol to HDL-C. Another study on Caucasian children indicated the %BF of 25% determined by skin-fold predicted the adverse lipid profiles and elevated blood pressure (Williams et al. 1992). Zeelie et al. (2010) reported a significant positive association between %BF and blood pressure. In Chinese children, Sung et al. (2007) reported that waist circumference (WC) was strongly associated with blood pressure also. However, BMI was a better predictor of high blood pressure as reported by Menke et al. (2007). The obtained results in this study highly support these findings. Insulin resistance and hyperinsulinemia appear to develop in obese children at an early stage of age as documented by Gower et al. (1999) work. In addition, it has been demonstrated that increased adiposity enhance the effect of blood pressure on left ventricular (LV) mass growth (Norton et al. 2009). Heart study performed by Brown et al. (2008) has shown that obesity is an important determinant of high blood pressure levels. Actually, LDL-C closely related to CVD disease and mortality, remains the cornerstone of lipid management (Superko and Gadesam 2008).

Triglyceride to high-density lipoprotein cholesterol (TG/HDL-C) ratio has been identified as a reliable marker of metabolic syndrome (MetS), and TG-to- HDL-C ratio was positively corre-

lated with several cardiovascular risks (Marotta et al., 2010). The cutoff value of 3.0, measuring concentration in mg/dl, has the best specificity and sensitivity, taking the method of steady-state plasma glucose as reference (McLaughlin et al. 2003). This study demonstrates that, TG/HDL-C increased significantly with increasing the %BF (overweight and obese group in comparison with normal weight group). Generally, our findings indicate that the %BF as determined by BIA-man equation has high correlation with the major metabolic and clinical risk factors for metabolic syndrome. However, Willett et al. (2006) reported that, percent body fat estimated from BIA was minimally predictive of the physiological markers (blood glucose, HDL-C, SBP and TG) independent of BMI.

Finally, the obesity indicator that is most useful in screening adolescents for risk of diabetes, hypertension, and dyslipidemia has not been established. There is no concordance in the literature for an obesity indicator specific for each racial/ethnic group (Vaccaro and Huffman 2013).

Conclusion

Our findings indicate that, the %BF as determined by BIA-man equation has high correlation with the major metabolic and clinical risk factors for metabolic syndrome. We found that the Syrian adolescents who were overweight or obese are more likely to show high blood pressure (SBP and DBP), Chol, TG, FBS, LDL and TG/HDL-C than normal-weight adolescent. This result suggests that % BF by BIA is good predictor of metabolic risks in Syrian adolescents.

Abbreviations

AECS Atomic Energy Commission of Syria, BF% Body Fat Percentage, BIA bioelectrical impedance analysis, Chol cholesterol, CHD cardiovascular heart diseases, FBS fasting blood sugar, DBP diastolic blood pressure, Hb haemoglobin, HDL-C high density lipoprotein cholesterol, Ht hematocrit, LDL-C low density lipoprotein cholesterol, LV left ventricular, R resistance, SBP systolic blood pressure, SD standard deviation, SPSS Statistical Package for Social Science, TG triglycerides, X reactance.

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Author contribution

The authors equally contributed to this paper.

Conflict of interest

The authors declare that there is no conflict of interest regarding publication of this paper.

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