Iran J Public Health, Vol. 44, No.12, Dec 2015, pp.1643-1654

Original Article

Lean Body Mass as a Predictive Value of Hypertension in Young Adults, in Ankara, Turkey

***Yashar VAZIRI** [1], **Sidika BULDUK** [1], **Zhaleh SHADMAN** [2,3], **Emre Ozgur BULDUK** [4], **Mehdi HEDAYATI** [5], **Haluk KOC** [6], **Fatmanur ER** [6], **Ceren Suveren ERDOGAN** [6]

1. Dept. of Household Economy and Nutrition Education, Gazi University, Ankara, Turkey
2. Diabetes Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran
3. Endocrinology and Metabolism Research Center (EMRC), Endocrinology and Metabolism Research Institute (EMRI), Tehran University of Medical Sciences, Tehran, Iran
4. Meram School of Medicine, Selcuk University, Meram-Konya, Turkey
5. Cellular and Molecular Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences, Tehran, IR Iran
6. Dept. of Physical Education and Sports, Gazi University, Ankara, Turkey

***Corresponding Author:** Email: yashar_vaziri@yahoo.com

(Received 11 Aug 2015; accepted 12 Nov 2015)

Abstract

Background: The aim of this study was to assess the predictive capacity of body composition estimated by bioelectrical impedance analysis (BIA) to identify abnormal blood pressure in physical education and sport teaching students in the city of Ankara.

Methods: Data for this cross-sectional study were obtained in the city of Ankara in 2014. A total of 133 students aged 20-35 yr participated in this study. Anthropometric measurements were measured. Body composition was assessed by BIA. Physical activity level (PAL) and usual dietary intake were assessed. Pre-hypertension and hypertension were defined, respectively, as BP ≥120 and/or 80, and ≥140 and /or 90 mmHg.

Results: More overweight students showed abnormal BP especially SBP (P=0.005 and 0.002, respectively). Age adjusted regression showed significant association between arm circumference (β= 0.176, P 0.044), mid arm muscle circumference (MAMC) (β= 0.235, P 0.007), lean body mass (LBM) (β= 0.238, P 0.006), basal metabolism rate (BMR) (β= 0.219, P 0.012) and SBP and, also, MAMC (β= 0.201, P 0.022), LBM (β= 0.203, P 0.021), BMR (β= 0.189, P 0.030) and DBP. Fat intake was associated with DBP (β= 0.14, P =0.040). Multivariate regression models adjusted for age, BMI, WC and fat intake/kg body weight showed positive association of SBP with MAMC, BMR and LBM (P<0.05).

Conclusion: The relationship between blood pressure and body composition in young adults may be associated to LBM and MAMC. LBM or MAMC in this population may be indirect indicators of heart muscle mass and heart pumping power.

Keywords: Lean body mass, Body mass index, Hypertension, Young adults, Turkey

Introduction

High blood pressure is of major risk factors of preventable death with a dramatic rise in the prevalence in the last decade, even in young people (1). Adiposity has been established to be a risk factor for hypertension development (2-5). People with elevated blood pressure showed high levels of body mass index (BMI), waist circumference (WC), skin-fold thickness (SFT) and poor physical activity levels (PAL) (6). However, hypertension would not appear in all obese patients. Differences in adiposity distribution may contribute to the heterogeneity dependent manifestations of obesity (7, 8). The BMI is a crude index of body fat mass (BFM), which may not distinguish abdominal obesity from other types of obesity. Abnormal fat distribution may exist in normal weight subjects with high blood pressure (9). In some studies, WC as an indicator of abdominal obesity has been associated with hypertension independent of BMI (3-5). However, some studies found BMI, WC and waist to hip ratio similar in degree of association with the prevalence of hypertension (3, 10) and other reported BMI to be more predictive than WC and BFM (11). Other indexes, also, were tested in the relationship with blood pressure and metabolic disorders. As an example, a body shape index (ABSI) more associated with blood pressure than BMI or WC (12, 13). People who deposit fat viscerally rather than elsewhere in the body are at higher risk for hypertension (7, 14) and alterations in the localization of body fat throughout life are associated with an increase in blood pressure (15). On the contrary, a few studies reported the association of lean body mass (LBM) with blood pressure (2, 16).

Physical activity level and nutritional intakes, also, were associated with percent body fat (17-19) and may interact with site-specific adipose tissue accumulation in controlling blood pressure. Physical activity may play a role in decreasing blood pressure and cardiovascular disease by several mechanisms. However, hypertension remains the most prevalent cardiovascular risk factor among athletes (20-22) and a relevant proportion of middle-aged athletes had masked hypertension (23).

Since the relative contributions of the distribution of body composition to blood pressure in active young adults may be different from that in other populations, the purpose of this study was to determine which portion of the body composition, fat or lean body mass is more influencing blood pressure in physical education and sport teaching students in the city of Ankara.

Materials and Methods

Study population

This cross-sectional study was approved by the Bioethical Committee of the Gazi University (Ankara, Turkey). Data was collected during the 2014 school year from physical education and sport teaching department in the city of Ankara. The study population invited through announcements posted on the wall at the university and included self-referred 75 male and 58 female students, aged 20 to 35. All students from fourth grade of four university degrees including physical education-sport teacher and trainer education with sport as compulsory course and degrees of sport management and recreation with sport as optional/elective course were invited to participate. The subject of the project was informed via declaration to invite students to participate in the voluntary measurements. Permissions were collected in the form of written informed consent obtained from all students who participated in the study. The exclusion criteria were: 1) student refusal 2) Preexisting medical conditions such severe hormonal abnormalities (e.g. Cushing's disease/syndrome); diseases leading to swelling of subcutaneous tissues; diseases leading to muscle wasting; and metabolic bone diseases 3) Taking medication that might affect body indexes 4) BMI>30 kg/m². Of totally 445 students roughly 40% voluntary participated (177 students). Forty-four were excluded due to the presence of the previously listed medical conditions, refusal or obesity.

Anthropometric data

Weight and height were measured by standard methods to the nearest 0.1kg and 0.1 cm, respectively. BMI was calculated and later classified as under-weight (BMI<18.5 kg/m2), normal (18.5≤BMI<25 kg/m2) and overweight (25≤BMI<30 kg/m2) (24). Waist circumference was measured in a horizontal plane just between the iliac crest and costal margin of the lower rib to the nearest 0.1 cm (Seca201). Hip circumference was measured at the widest part over the buttocks to the nearest 0.1 cm. Participants were classified according to cutoff point 90 for waist circumference. A body shape index (ABSI) was calculated as waist circumference/(BMI$^{2/3}$ height$^{1/2}$) with the cutoff point 40 (13). Wrist circumference was measured just distal to the styloid process at the wrist crease on the right arm using a tape measure. The formula r=height/wrist circumference was used to estimate body frame size. Frame size was determined as small (r>10.4, 11.0), medium (r 9.6-10.4, 10.1-11.0) and large (r<9.6, 10.1) respectively in males and females (24).

Skinfold thickness was measured on the right side of the body at four sites (biceps, triceps, subscapular, and suprailiac) using Holtain calipers (Holtain, Crymych, UK) to the nearest 0.1 cm. In all cases, two measurements were obtained and averaged; with a third measurement taken if the first two differed by 0.1 cm. The sum of four skinfolds was calculated. Subscapular/triceps ratio (STR), an index of subcutaneous adipose tissue distribution (central/peripheral), was also calculated.

Mid-arm circumference (MAC) was measured to the nearest 0.1 cm between the acromion process of the scapula and the olecranon process at the tip of the elbow (midpoint of the upper arm) and mid-arm muscle circumference (MAMC) was estimated combined MAC with TSF measurements using standard methods (24).

Bioelectrical impedance analysis (BIA)

Body composition was assessed by leg-to-leg bioelectrical impedance analysis (25) with a Tanita TBF-300MA body composition analyzer (Tanita Corporation, Tokyo, Japan). BIA measurements were done according to the manufacturer's guidelines at a frequency of 50 kHz. Participants were asked to void their bladder prior to measurement. Fat mass index (FMI) calculated as fat mass/height^2 and classified according the cutoff point of 8.2 in males and 11.8 in females (26). Basal metabolism rate (BMR) and BMR/kg body weight were estimated by the same instrument and according to BIA derived body composition. Then, grouping was done by percent body fat and sex (15% in men and 25% in women) (24).

Physical Activity Assessment

Physical activity level was assessed by a validated questionnaire in which nine different metabolic equivalent (MET) levels were ranged on a scale from sleep/rest (1 METs) to high-intensity physical activities (7 METs) (27). Participants were categorized into 3 groups as low, active and very active, according to the MET values (>1.4-1.6, >1.6-1.9 and >1.9-2.5 respectively) (24). In addition, participants were grouped as low or active/very active.

Dietary intake

Usual dietary intake was obtained using a validated 52-item food frequency questionnaire (FFQ) by trained dietitians and face-to-face interviews. Participants were asked to report their dietary intake of foods based on questions with eight choices as follows: every meal, every day, 5-6 times a week, 3-4 times a week, 1-2 times a week, every 15 days, every month, rarely and never. Dietary analysis of energy and macronutrients intake was done using a computer program BeBis (version 7.2, Pasific Compony, Istanbul, Turkey).

Blood pressure measurements

Blood pressure (BP) was measured in the morning hours (8:30 am to 11:30 am) by a trained expert. The subjects were advised to avoid tea, coffee, energy drinks, and physical exercises in the morning of the examination day until the measurements were taken. Measurements were done after resting for at least 5 minutes in a sitting position two times (with a 5-minute rest interval) on the right arm using a mechanical sphygmomanometer (model, SPENGLER, France) and the average of two BP measurements was calculated. Prehypertension and hypertension were defined, respectively, as blood pressure ≥120 and/or 80, and ≥140 and /or 90mmHg.

Statistical analysis

All statistical analyses were performed by SPSS software version 20 (SPSS Inc., Chicago, IL, USA) and a P-value < 0.05 showed statistical significance. The normality of all variables was confirmed by Kolmogorov-Smirnov test (P > 0.05) combined with normality plots. We used independent t test to compare body composition indexes, blood pressure, dietary intakes and physical activity level between two genders and all independent variables between two groups with normal and high blood pressure. The Chi-square test was used to compare the distribution of high blood pressure, overweight and levels of physical activity between males and females abnormal BP by categorical BMI, WC, ABSI, BF% and FMI. To determine associated factors with systolic and diastolic blood pressure, at first, we used age adjusted linear regression for all individual variables. Regression residual plots showed two outliers that after excluding them the assumptions of linear regression were confirmed. Multivariable regression models were performed to test the association between independent variables and blood pressure, adjusting for age, BMI, WC and fat intake. With the sample size of 133; a power value of 80% was generated.

Results

Characteristics of subjects

Overall, 133 (response rate of 75.1%, 75 males and 58 females) participants completed all measurements and the characteristics of them are presented in Table 1.

Distribution of categorical variables by genders has been shown in Table 2. The distribution of participants according to exercise course as compulsory or optional/elective and doing exercise as professional sport were not significant between two groups (*P*=0.904 and *P*=0.635 respectively).

Table 2: Distribution of categorical variables by genders

Variable	Total (n=133) n (%)	Female (n=58) n (%)	Male (n=75) n (%)	*P*-value*
SBP				
Normal	79 (59.4)	42 (72.4)	37 (49.3)	0.024
12-13.9	43 (32.3)	12 (20.7)	31 (41.3)	
≥14	11 (8.3)	4 (6.9)	7 (9.3)	
DBP				
Normal	80 (60.2)	39 (67.2)	41 (54.7)	0.328
8-8.9	35 (26.3)	13 (22.4)	22 (29.3)	
≥9	18 (13.5)	6 (10.3)	12 (16.0)	
BP				
Normal	74 (55.6)	38 (65.5)	36 (48.0)	0.131
Pre-hypertension	41 (30.8)	14 (24.1)	27 (36.0)	
Hypertension	18 (13.5)	6 (10.3)	12 (16.0)	
BMI				
Normal	114 (85.7)	52 (89.7)	62 (82.7)	0.253
overweight	19 (14.3)	6 (10.3)	13 (17.3)	
PAL				
Low	19 (14.3)	12 (20.7)	7 (9.3)	0.063
Active/very active	114 (85.7)	46 (79.3)	68 (90.7)	

SBP systolic blood pressure, DBP diastolic blood pressure, BP Blood pressure (definition by systolic and diastolic), BMI body mass index, PAL Physical activity level/* *P*-value for Chi-square test for differences of distribution between males and females

Comparing body composition indexes, dietary intake and physical activity level between two groups categorized by normal and abnormal blood pressure showed statistical significant differences in neither males nor females (data not shown).

Chi-square test for comparing the distribution of abnormal blood pressures by categorical BMI, WC, ABSI, BF% and FMI showed that the prevalence of abnormal BP especially SBP is higher in overweight persons (*P*=0.005 and 0.002, respectively) (Table 3). An increase in the mean SBP was associated with an increase in daily calorie (β= 0.19, *P* =0.029), protein (β= 0.19, *P* =0.027), fat (β= 0.22, *P* =0.011), fat/kg body weight (β= 0.19, *P* =0.029) and DBP was associated with fat (β= 0.14, *P* =0.040) intake. However, in each group, no associations were seen between dietary components and blood pressure (Table 4).

Table 3: Distribution as number (%) of abnormal BP by categorical BMI, WC, ABSI, BF% and FMI*

	SBP	DBP	BP
BMI			
Normal	40 (35.1)	42 (36.8)	45 (39.5)
Overweight	14 (73.7)	11 (57.9)	14 (73.7)
P-value	0.002	0.083	0.005
WC			
<90	48 (40.0)	49 (40.8) 4 (30.8)	53 (44.2)
≥90	6 (46.2)	0.563	6 (46.2)
P-value	0.668		0.891
ABSI			
≤40	26 (48.1)	26 (48.1)	29 (53.7)
>40	28 (35.4)	27 (34.9)	30 (38.0)
P-value	0.143	0.106	0.073
BF%			
Normal	31 (39.7)	31 (39.7)	34 (43.6)
>15%(m), 25%(f)	23 (41.8)	22 (40.0)	25 (45.5)
P-value	0.810	0.976	0.831
FMI			
Normal	53 (41.4)	52 (40.6)	58 (45.3)
>8.2(m), 11.8(f)	1 (20.0)	1 (20.0)	1 (20.0)
P-value**	0.648	0.648	0.382

BMI body mass index, WC waist circumference, ABSI A body shape index, BF% Body fat percent, FMI Fat mass index, BMR basal metabolism rate/**P*-value for Chi-square test for differences of distribution of abnormal BP by categorical BMI, WC, ABSI, BF% and FMI/** *P*-value for Fisher's exact test

Table 4: Age adjusted calorie and macronutrient intake association with BP*

	Total** (n=133)			
Model	**R^2**	**β**	**SE**	***P* (95.0% *CI*)**
SBP				
Calorie (Kcal)	0.036	0.191	0.002	0.029(0.000-0.008)
Protein (g)	0.037	0.195	0.033	0.027(0.008-0.138)
Protein (%)	0.001	0.033	0.453	0.713(-0.729-1.063)
Fat (g)	0.049	0.221	0.037	0.011(0.022-0.167)
Fat (%)	0.028	0.167	0.238	0.057(-0.015-0.926)
Carbohydrate (g)	0.011	0.104	0.015	0.235(-0.012-0.049)
Carbohydrate (%)	0.028	-0.167	0.211	0.056(-0.825-0.011)
Fiber (g)	0.000	0.015	0.147	0.865(-0.266-0.316)
Cholesterol (mg)	0.021	0.144	0.006	0.100(-.002-.022)
Proteinper (g/Kg)	0.011	0.107	3.438	0.227(-2.62-10.97)
Carbohydrate (g/kg)	0.001	-0.022	1.480	0.801(-3.303-2.554)
Fat (g/kg)	0.036	0.191	3.635	0.029(0.84-15.23)
DBP				
Calorie (Kcal)	0.025	0.158	0.001	0.072(0.000-0.005)
Protein (g)	0.024	0.157	0.025	0.077(-0.005-0.093)
Protein (%)	0.000	0.009	0.340	0.922(-0.640-0.707)
Fat (g)	0.032	0.179	0.028	0.040(0.003-0.113)
Fat (%)	0.020	0.141	0.179	0.109(-0.065-0.645)
Carbohydrate (g)	0.10	0.099	0.012	0.260(-0.010-0.036)
Carbohydrate (%)	0.016	-0.126	0.160	0.151(-0.546-0.085)
Fiber (g)	0.010	0.026	0.111	0.772(-0.187-0.251)
Cholesterol (mg)	0.013	0.111	0.005	0.205(-0.003-0.015)
Proteinper (g/Kg)	0.005	0.067	2.592	0.451(-3.168-7.087)
Carbohydrate (g/kg)	0.001	-0.015	1.112	0.862(-2.395-2.007)
Fat (g/kg)	0.022	0.148	2.752	0.092(-0.77-10.11)

*regression R-squared, β Standardized beta coefficient, SE standard error of the regression, *P*-value of linear regression, *CI* Confidence Interval for beta/** No significant difference within both genders

Furthermore, after adjustment for calorie intake, the association between systolic blood pressure and dietary macronutrients were disappeared.

Age adjusted association of anthropometric measurements and body composition with SBP and DBP were shown in Table 5-6.

Table 5: Age adjusted association of anthropometric measurements and body composition with SBP

	Total** (n=133)			
Model	**R^2**	**β**	**SE**	***P* (95.0% *CI*)**
Weight (kg)	0.026	0.161	0.093	0.067(-0.012-0.354)
BMI (kg/m²)	0.005	0.071	0.362	0.422(-0.424-1.007)
WC (cm)	0.013	0.115	0.130	0.191(-0.086-0.427)
HC (cm)	0.002	0.040	0.162	0.649(-0.247- 0.394)
Waist/hip	0.013	0.117	17.632	0.187(-11.46-58.29)
Waist/height	0.002	0.042	26.540	0.632(-39.77-65.24)
AC (cm)	0.031	0.176	0.353	0.044(0.020-1.416)
MAMC (cm)	0.055	0.235	0.319	0.007(0.243-1.507)
Biceps SFT (mm)	0.006	-0.076	0.385	0.385(-1.099-0.426)
Triceps SFT (mm)	0.021	-0.147	0.206	0.095(-0.755-0.061)
Subscapular SFT (mm)	0.002	-0.045	0.212	0.608(-0.529-0.310)
Supra iliac SFT (mm)	0.012	-0.110	0.204	0.211(-0.662-0.147)
Subscapular/triceps	0.015	0.123	2.586	0.163(-1.489-8.744)
Sum of SFT (mm)	0.010	-0.102	0.064	0.245(-0.201-0.052)
BMR (kcal)	0.048	0.219	0.005	0.012(0.003-0.021)
BMR/Kg	0.002	0.039	0.646	0.663(-0.996-1.561)
BF (%)	0.025	-0.159	0.152	0.069(-0.581-0.022)
BF (kg)	0.005	-0.072	0.184	0.412(-0.516-0.213)
LBM (kg)	0.056	0.238	0.108	0.006(0.086-0.514)
ABSI	0.000	-0.018	13.401	0.838(-29.26-23.76)
FMI	0.011	-0.106	0.514	0.228(-1.641-.395)

BMI body mass index, WC waist circumference, HC hip circumference, AC arm circumference, MAMC mid arm muscle circumference, Biceps SFT Biceps skinfold thickness, Triceps SFT Triceps skinfold thickness, Sub scapular SFT Sub scapular skinfold thickness, Supra iliac SFT Supra iliac skinfold thickness, Sum of SFT Sum of skinfold thicknesses, BMR basal metabolism rate BF Body fat, LBM Lean body mass, ABSI A body shape index, FMI Fat mass index/ *regression R-squared, β Standardized beta coefficient, SE standard error of the regression, *P*-value of linear regression, *CI* Confidence Interval for beta/** No significant difference within both genders

Table 6: Age adjusted association of anthropometric measurements and body composition with DBP

	Total (n=133)			
Model	**R^2**	**β**	**SE**	***P* (95.0% *CI*)**
Weight (kg)	0.020	0.141	0.070	0.108(-0.025-0.251)
BMI (kg/m²)	0.003	0.055	0.272	0.534(-0.369-0.708)
WC (cm)	0.01	0.100	0.098	0.259(-0.082-0.304)
HC (cm)	0.002	0.036	0.122	0.683(-0.191-0.291)
Waist/hip	0.010	0.101	13.270	0.256(-11.11-41.38)
Waist/height	0.001	0.032	19.948	0.718(-32.25-46.67)
AC (cm)	0.023	0.151	0.266	0.084(-0.064-0.990)
MAMC (cm)	0.040	0.201	0.242	0.022(0.083-1.040)
Biceps SFT (mm)	0.004	-0.058	0.290	0.510(-0.765-0.382)
Triceps SFT (mm)	0.015	-0.123	0.155	0.160(-0.527-0.088)
Subscapular SFT (mm)	0.002	-0.038	0.159	0.666(-0.384-0.246)
Supra iliac SFT (mm)	0.014	-0.116	0.153	0.186(-0.508-0.100)
Subscapular/triceps	0.009	0.094	1.949	0.284(-1.760-5.952)
Sum of SFT (mm)	0.008	-0.089	0.048	0.313(-0.144-0.046)
BMR (kcal)	0.036	0.189	0.004	0.030(0.001-0.015)
BMR/Kg	0.001	0.024	0.486	0.782(-0.826-1.096)
BF (%)	0.016	-0.126	0.115	0.151(-0.393-0.061)
BF (kg)	0.003	-0.053	0.138	0.543(-0.358-0.189)
LBM (kg)	0.041	0.203	0.082	0.021(0.030-0.354)
ABSI	0.000	-0.004	10.070	0.966(-20.35-19.49)
FMI	0.007	-0.083	0.387	0.343(-1.135-0.397)

BMI body mass index, WC waist circumference, HC hip circumference, AC arm circumference, MAMC mid arm muscle circumference, Biceps SFT Biceps skinfold thickness, Triceps SFT Triceps skinfold thickness, Sub scapular SFT Sub scapular skinfold thickness, Supra iliac SFT Supra iliac skinfold thickness, Sum of SFT Sum of skinfold thicknesses, BMR basal metabolism rate BF Body fat, LBM Lean body mass, ABSI A body shape index, FMI Fat mass index/*regression R-squared, β Standardized beta coefficient, SE standard error of the regression, P-value of linear regression, CI Confidence Interval for beta/** No significant difference within both genders.

In addition, independent *t* test showed significant difference only in the cases arm circumference (P=0.040), MAMC (P=0.008), BMR (P=0.029) and, LBM (P=0.014) between the two groups with normal and abnormal BP (data not shown).
Because the variables identified to associate with blood pressure (MAMC, BMR, LBM, calorie, protein and fat intake) showed a strong significant correlation with each other (r>0.8 P<0.001) and considering these variables as cause and effect, the adjustment models did not include each of them for another. Instead, according to the studies reported the association of BMI, WC and FM with blood pressure, multivariate regression models were done for those variables (Table 7). When adjusted for age, BMI and WC (M1), MAMC, BMR, LBM but not calorie intake were associated with SBP and DBP. After additional adjustment for fat intake/kg body weight (M2), MAMC, BMR and LBM maintained positive correlations with SBP.

Table 7: Adjusted correlation of obesity-related indexes with blood pressure

Variable	Systolic blood pressure				Diastolic blood pressure			
	R^2	β	SE	*P*(95.0%CI)	R^2	β	SE	*P*(95.0%CI)
MAMC (cm)								
M1	0.056	0.25	0.399	0.018 (0.16-1.74)	0.042	0.22	0.302	0.046 (.010-1.20)
M2	0.070	0.23	0.423	0.048 (0.07-1.59)	0.049	0.18	0.321	0.120 (-0.13-1.13)
BMR (kg/m²)								
M1	0.060	0.37	0.008	0.013 (0.004-0.037)	0.045	0.32	0.426	0.032 (0.001-0.02)
M2	0.075	0.33	0.009	0.047 (0.000-0.03)	0.053	0.22	0.007	0.080 (-.001-.024)
LBM (kg)								
M1	0.065	0.35	0.167	0.009 (0.11-0.77)	0.046	0.29	0.127	0.030 (0.03-0.53)
M2	0.079	0.29	0.175	0.035 (0.02-0.79)	0.054	0.25	0.133	0.078 (-0.027
Calorie intake								
M1	0.041	0.25	0.003	0.057 (0.000-0.01)	0.028	0.20	0.002	0.127 (-0.001-0.007)
M2	0.052	0.14	0.003	0.38 (-0.004-0.01)	0.034	0.12	0.003	0.47 (-0.003-0.007)

MAMC, mid arm muscle circumference; BMR, basal metabolism rate; FFM, fat free mass; M1, adjustment for age, BMI and WC; M2, adjustment for dietary fat intake/kg body weight in addition to M1

Discussion

The main finding of this study is that although BMI is associated with abnormal BP, LBM may be a more determinant factor linearly associated with BP in people with studied profile. Whereas no relationship was found between BP and other anthropometric or body composition indexes especially the distribution of body fat and WC, which have, been reported in other studies. The prevalence of pre-hypertension and hypertension was significantly higher in males (41.3% and 9.3% in males vs. 20.7% and 6.9% in females, respectively). SBP and DBP were significantly higher in males than females; that is consistent with other studies (11). In a systematic review, the prevalence of high blood pressure varied from 0% to 45% in different elite athletes (28) and masked hypertension has been reported in 38% of male runners (23).

Despite the established association between adiposity and hypertension development (5, 11, 12, 29-31), we were unable to show a linear association between BMI and BP. However, the overweight participants were more likely to be hypertensive. The prevalence of abnormal BP in overweight participants was higher than in normal (73.7% vs. 39.5%) that is consistent with other studies (6, 11). However, both SBP and DBP were higher in overweight compared to normal-weight groups; this did not reach to significant levels about DBP. On the other hand, people with elevated BP may have high levels of BMI, WC, and SFT (6) which were not seen in the present study. The association of BP with BMI, WC and BF% has been reported previously (11, 12, 29-31). Some studies reported BMI, WC and WHR similar in degree of association with the prevalence of hypertension (3, 10); whereas some others as BMI more significant than WC and FM (11, 31). A study showed ABSI as a better predictor of BP than BMI or WC (12) and a survey the ABSI less associated with incident hypertension than waist circumference and BMI (29). The inconsistency in the results of studies may be due to e.g. the BMI is a crude index of weight for height and does not distinguish the distribution of fat in the body or LBM from FM (3) or WC may not be in all cases an appropriate surrogate for visceral fat (32). No entry of obese people in this study may be of reasons making unable to show the relative association with obesity indexes. On the other hand, high BMI values associated with abnormal BP may be as likely to be because an individual has a high muscle-mass for their stature, the predictor seen in this study.

The results of this paper agree with the findings of the few studies reported the association between LMB and BP. Those studies have been reported BMI and LBM as significant predictors of SBP and DBP (2, 16) with stronger positive correlation with the LBM index than that with FM index irrespective of gender (16). It is possible in athletes, especially who emphasizes on building muscles, subcutaneous fat around the arm or other muscular sites would burn as a source of fuel for working muscles. This may make visceral fat, according to calorie intake, to remain or ever increase along with muscle enlargement (33) and lead to metabolic abnormalities (34) in spite of exercise or higher physical activity levels. In other words, under conditions of less subcutaneous adipose tissue, excess triglyceride may be stored in other depots, such as visceral adipose tissue, which may be more predictors of metabolic disorders (7, 14, 34, 35). Furthermore, as the proportion of visceral fat increases, subcutaneous fat decreased (36) and may no longer be a good method of estimating body fat. Thus, the ability to retain fat in the subcutaneous depot rather than visceral and hepatic fat may be beneficial, since it is associated with reduced metabolic disorders (36). Indeed, BMI is believed to affect indirectly blood pressure through changes in LBM. Another possibility of a relationship between LBM and BP may be related to training induced left ventricular hypertrophy (LVH) (37). Exercise affected androgen synthesis (38) may contribute to increase LBM including heart muscle mass (39) in athletes. As, a significant negative association was shown between SBP and body FM in girls (16) which attributed to the protective effect of estrogens on blood pressure (40, 41). On the contrary, androgens appear to be vasoconstriction and cause cardiac hypertrophy (42, 43). Furthermore, high BP may be associated with LVH (28, 44) or a higher left ventricular mass/volume ratio (23). In other words, LBM or MAMC in this population may be indirect indicators of heart muscle mass and heart pumping power.

On the relationship between dietary intakes and BP, SBP was associated with daily calorie intake and DBP was associated with fat intake. The beneficial effects of low fat diet on both SBP and DBP have been reported earlier (45). People on low fat diet have lower BP, and the benefit was attributed to a more favorable lipid profile (46-48). However, some others did not show the beneficial effects (49). It seems that, according the present study, high calorie and high fat intake may be determinants of abnormal SBP and DBP, respectively. As, lifestyle changes, including a combination of caloric restriction and exercise are performed to control BP levels in obese hypertensive patients (45, 50-52).

Limitation

Despite these findings, there are a number of limitations with the present study, e.g. the cutoffs for BF% with better properties for screening hypertension had been identified 20.4% for men and 34.1% for women (53). In our study, percent body fat ranged from 5.1 to 25.5% and from 6.7 to 40.9% with the third tertile of 16.4% and 27.07% in males and females, respectively. Lack of sample size above the identified cutoffs may be of causes not to show the relationship between body fat and blood pressure. Unfortunately, we were unable to enroll all students in this study. Therefore, voluntarily participating of invited subjects may have caused tending to miss some subjects with especial characteristics.

Conclusion

This study confirms the association of BMI with abnormal BP, but LBM may be a more determinant factor for abnormal BP in active non-obese young adults. LBM or MAMC may be indirect indicators of heart muscle mass and heart pumping power, which affects BP. The association of BMI with high blood pressure may not always be due to body fat mass but also to LBM especially in athletes or who do exercise. Thus, considering the characteristics of the target population and identifying major risk factors of abnormal BP would be important in prevention and treatment of hypertension.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Acknowledgements

We are grateful for the consideration and cooperation of all the participants of the study. The authors declare that there is no conflict of interests.

References

1. Ostchega Y, Hughes JP, Terry A, Fakhouri TH, Miller I (2012). Abdominal obesity, body mass index, and hypertension in US adults: NHANES 2007-2010. *Am J Hypertens*, 25(12):1271-8.
2. Liu L, Ikeda K, Sullivan DH, Ling W, Yamori Y (2002). Epidemiological evidence of the association between dietary protein intake and blood pressure: a meta-analysis of published data. *Hypertens Res*, 25(5):689-95.
3. Deng WW, Wang J, Liu MM, Wang D, Zhao Y, Liu YQ, et al. (2013). Body mass index compared with abdominal obesity indicators in relation to prehypertension and hypertension in adults: the CHPSNE study. *Am J Hypertens*, 26(1):58-67.
4. Kang SM, Yoon JW, Ahn HY, Kim SY, Lee KH, Shin H, et al. (2011). Android fat depot is more closely associated with metabolic syndrome than abdominal visceral fat in elderly people. *PloS One*, 6(11):e27694.
5. Cassano PA, Segal MR, Vokonas PS, Weiss ST (1990). Body fat distribution, blood pressure, and hypertension. A prospective cohort study of men in the normative aging study. *Ann Epidemiol*, 1(1):33-48.
6. Zhang YX, Chen M, Xue LH, Zhao JS, Chu ZH (2013). Comparison of body shape and physical activity among adolescents with normotensive and elevated blood pressure in Shandong, China. *Ann Hum Biol*, 40(1):88-93.
7. Fox CS, Massaro JM, Hoffmann U, Pou KM, Maurovich-Horvat P, Liu CY, et al. (2007). Abdominal visceral and subcutaneous adipose tissue compartments: association with metabolic risk factors in the Framingham Heart Study. *Circulation*, 116(1):39-48.
8. Neeland IJ, Turer AT, Ayers CR, Powell-Wiley TM, Vega GL, Farzaneh-Far R, et al. (2012). Dysfunctional adiposity and the risk of prediabetes and type 2 diabetes in obese adults. *JAMA*, 308(11):1150-9.
9. Yan S, Zhao X, Shen X, Yang L, Yuan X, Huang L, et al. (2013). Abnormal regional body fat distribution also exists in non-obese subjects with high blood pressure. *Clin Exp Hypertens*, 35(7):528-33.
10. Lin S, Cheng TO, Liu X, Mai J, Rao X, Gao X, et al. (2006). Impact of dysglycemia, body mass index, and waist-to-hip ratio on the prevalence of systemic hypertension in a lean Chinese population. *Am J Cardiol*, 97(6):839-42.
11. Mehdad S, Hamrani A, El Kari K, El Hamdouchi A, El Mzibri M, Barkat A, et al. (2013). Prevalence of elevated blood pressure and its relationship with fat mass, body mass index and waist circumference among a group of Moroccan overweight adolescents. *Obes Res Clin Pract*, 7(4):e284-9.
12. Duncan MJ, Mota J, Vale S, Santos MP, Ribeiro JC (2013). Associations between body mass index, waist circumference and body shape index with resting blood pressure in Portuguese adolescents. *Ann Hum Biol*, 40(2):163-7.
13. Krakauer NY, Krakauer JC (2012). A new body shape index predicts mortality hazard

independently of body mass index. *PloS One*, 7(7):e39504.
14. Hayashi T, Boyko EJ, Leonetti DL, McNeely MJ, Newell-Morris L, Kahn SE, et al. (2003). Visceral adiposity and the prevalence of hypertension in Japanese Americans. *Circulation*, 108(14):1718-23.
15. Park JK, Lim YH, Kim KS, Kim SG, Kim JH, Lim HG, et al. (2013). Changes in body fat distribution through menopause increase blood pressure independently of total body fat in middle-aged women: the Korean National Health and Nutrition Examination Survey 2007-2010. *Hypertens Res*, 36(5):444-9.
16. Verma V, Sinah SK (2014). Influence of lean body-mass index versus that of fat mass index on blood pressure of gujarati school going adolescents. *Indian J Physiol Pharmacol*, 58(1):39-44.
17. Uritani D, Matsumoto D, Asano Y, Yoshizaki K, Nishida Y, Shima M (2013). Effects of regular exercise and nutritional guidance on body composition, blood pressure, muscle strength and health-related quality of life in community-dwelling Japanese women. *Obes Res Clin Pract*, 7(2):e155-e63.
18. Westcott WL, Apovian CM, Puhala K, Corina L, Larosa Loud R, Whitehead S, et al. (2013). Nutrition programs enhance exercise effects on body composition and resting blood pressure. *Phys Sportsmed*, 41(3):85-91.
19. Hearst MO, Sirard JR, Lytle L, Dengel DR, Berrigan D (2012). Comparison of 3 measures of physical activity and associations with blood pressure, HDL, and body composition in a sample of adolescents. *J Phys Act Health*, 9(1):78-85.
20. Bruno RM, Cartoni G, Taddei S (2012). Hypertension in special populations: athletes. *Future Cardiol*, 7(4):571-84.
21. Karpinos AR, Roumie CL, Nian H, Diamond AB, Rothman RL (2013). High prevalence of hypertension among collegiate football athletes. *Circ Cardiovasc Qual Outcomes*, 6(6):716-23.
22. Berge HM, Isern CB, Berge E (2015). Blood pressure and hypertension in athletes: a systematic review. *Br J Sports Med*, 49(11):716-23.
23. Trachsel LD, Carlen F, Brugger N, Seiler C, Wilhelm M (2015). Masked hypertension and cardiac remodeling in middle-aged endurance athletes. *J Hypertens*, 33(6):1276-83.
24. Lucinda K (2012). Nutrition in weitgh management. In: *Krause's food and the nutrition care process*. 13th ed. Elsevier Inc. New York, pp. 470.
25. Pietrobelli A, Rubiano F, St-Onge MP, Heymsfield SB (2004). New bioimpedance analysis system: improved phenotyping with whole-body analysis. *Eur J Clin Nutr*, 58(11):1479-84.
26. Schutz Y, Kyle UU, Pichard C (2002). Fat-free mass index and fat mass index percentiles in Caucasians aged 18-98 y. *Int J Obes Relat Metab Disord*, 26(7):953-60.
27. Karaca A, Ergen E, Koruç Z (2000). The Reliability and The Validity of The Physical Activity Assessment Questionnaire (PAAQ). *Hacettepe J Sport Sci*, 11(1-2-3-4):17-28.
28. Berge HM, Isern CB, Berge E (2015). Blood pressure and hypertension in athletes: a systematic review. *Br J Sports Med*, 49(11):716-23.
29. Cheung YB (2014). "A Body Shape Index" in middle-age and older Indonesian population: scaling exponents and association with incident hypertension. *PloS One*, 9(1):e85421.
30. Kim NY, Hong YM, Jung JW, Kim NS, Noh CI, Song YH (2013). The relationships of body mass index, waist-to-height ratio, and body fat percentage with blood pressure and its hemodynamic determinants in Korean adolescents: a school-based study. *Korean J Pediatr*, 56(12):526-33.
31. Mushengezi B, Chillo P (2014). Association between body fat composition and blood pressure level among secondary school adolescents in Dar es Salaam, Tanzania. *Pan Afr Med J*, 19:327.
32. Pausova Z, Mahboubi A, Abrahamowicz M, Leonard GT, Perron M, Richer L, et al. (2012). Sex differences in the contributions of visceral and total body fat to blood pressure in adolescence. *Hypertension*, 59(3):572-9.
33. Dorfman L (2012). Nutrition in exercises and sports performance. In: *Krause's food and the nutrition care process*. 13th ed. Elsevier Inc. New York, pp. 507-528.
34. Victor RG, Haley RW, Willett DL, Peshock RM, Vaeth PC, Leonard D, et al. (2004). The Dallas Heart Study: a population-based probability sample for the multidisciplinary study of ethnic differences in cardiovascular health. *Am J Cardiol*, 93(12):1473-80.
35. Chandra A, Neeland IJ, Berry JD, Ayers CR, Rohatgi A, Das SR, et al. (2014). The

relationship of body mass and fat distribution with incident hypertension: observations from the Dallas Heart Study. *J Am Coll Cardiol*, 64(10):997-1002.
36. Taksali SE, Caprio S, Dziura J, Dufour S, Cali AM, Goodman TR, et al. (2008). High visceral and low abdominal subcutaneous fat stores in the obese adolescent: a determinant of an adverse metabolic phenotype. *Diabetes*, 57(2):367-71.
37. Pelliccia A, Maron BJ, De Luca R, Di Paolo FM, Spataro A, Culasso F (2002). Remodeling of left ventricular hypertrophy in elite athletes after long-term deconditioning. *Circulation*, 105(8):944-9.
38. Okamoto M, Hojo Y, Inoue K et al.. (2012). Mild exercise increases dihydrotestosterone in hippocampus providing evidence for androgenic mediation of neurogenesis. *Proc Natl Acad Sci U S A*, 109(32):13100-5.
39. Davey DA (2012). Androgens in women before and after the menopause and post bilateral oophorectomy: clinical effects and indications for testosterone therapy. *Womens Health (Lond Engl)*, 8(4):437-46.
40. Bolego C, Cignarella A, Sanvito P, Pelosi V, Pellegatta F, Puglisi L, et al. (2005). The acute estrogenic dilation of rat aorta is mediated solely by selective estrogen receptor-alpha agonists and is abolished by estrogen deprivation. *J Pharmacol Exp Ther*, 313(3):1203-8.
41. Khalil RA (2010). Potential approaches to enhance the effects of estrogen on senescent blood vessels and postmenopausal cardiovascular disease. *Cardiovasc Hematol Agents Med Chem*, 8(1):29-46.
42. Kienitz T, Quinkler M (2008). Testosterone and blood pressure regulation. *Kidney Blood Press Res*, 31(2):71-9.
43. Ziemens B, Wallaschofski H, Volzke H, Rettig R, Dorr M, Nauck M, et al. (2013). Positive association between testosterone, blood pressure, and hypertension in women: longitudinal findings from the Study of Health in Pomerania. *J Hypertens*, 31(6):1106-13.
44. Leischik R, Spelsberg N, Niggemann H, Dworrak B, Tiroch K (2014). Exercise-induced arterial hypertension - an independent factor for hypertrophy and a ticking clock for cardiac fatigue or atrial fibrillation in athletes? *F1000Res*, 3:105.
45. Papakonstantinou E, Triantafillidou D, Panagiotakos DB, Koutsovasilis A, Saliaris M, Manolis A, et al. (2010). A high-protein low-fat diet is more effective in improving blood pressure and triglycerides in calorie-restricted obese individuals with newly diagnosed type 2 diabetes. *Eur J Clin Nutr*, 64(6):595-602.
46. Rosa EM, Scatola RP, Possa R (2008). Cardiovascular risk in vegetarians and omnivores: a comparative study. *Arq Bras Cardiol*, 91(4):263.
47. Fontana L, Meyer TE, Klein S, Holloszy JO (2007). Long-term low-calorie low-protein vegan diet and endurance exercise are associated with low cardiometabolic risk. *Rejuvenation Res*, 10(2):225-34.
48. Yang SY, Zhang HJ, Sun SY, Wang LY, Yan B, Liu CQ, et al. (2011). Relationship of carotid intima-media thickness and duration of vegetarian diet in Chinese male vegetarians. *Nutr Metab (Lond)*, 8(1):63.
49. Key TJ, Appleby PN, Davey GK, Allen NE, Spencer EA, Travis RC (2003). Mortality in British vegetarians: review and preliminary results from EPIC-Oxford. *Am J Clin Nutr*, 78(3 Suppl):533S-8S.
50. Bento VF, Albino FB, Moura KF, Maftum GJ, Santos MC, Guarita-Souza LC, et al. (2015). Impact of Physical Activity Interventions on Blood Pressure in Brazilian Populations. *Arq Bras Cardiol*, 105(3):301-8.
51. Stevens VJ, Obarzanek E, Cook NR, Lee IM, Appel LJ, Smith West D, et al. (2001). Long-term weight loss and changes in blood pressure: results of the Trials of Hypertension Prevention, phase II. *Ann Intern Med*, 134(1):1-11.
52. Masuo K, Rakugi H, Ogihara T, Lambert GW (2012). Different mechanisms in weight loss-induced blood pressure reduction between a calorie-restricted diet and exercise. *Hypertens Res*, 35(1):41-7.
53. Santos Silva DA, Petroski EL, Peres MA (2012). Is high body fat estimated by body mass index and waist circumference a predictor of hypertension in adults? A population-based study. *Nutr J*,11:112.

Table 1: The characteristics of anthropometric measurements and dietary intake in participants*

	Female (n=58)				Male (n=75)					
	Mean ± SD	**Q1**	**Q2**	**Q3**	**Mean ± SD**	**Q1**	**Q2**	**Q3**	***P*****	**95%CI*****
Age (years)	23.36 ± 2.14	22.00	23.00	24.00	23.80 ± 2.16	22.00	23.00	25.00	0.247	-0.30-1.18
Weight (kg)	59.70 ± 9.98	51.97	58.50	63.47	73.45 ± 9.47	68.00	71.90	78.60	<0.001	10.39-17.10
BMI (kg/m^2)	21.50 ± 3.47	19.20	20.50	22.70	23.06 ± 2.49	21.80	23.20	24.20	0.005	0.48-2.62
ABSI	0.41 ± .09	0.36	0.42	0.46	0.42 ± 0.07	0.37	0.41	0.45	0.42	-0.01-0.04
WC (cm)	73.78 ± 7.71	68.37	73.00	77.50	83.27 ± 6.63	78.50	82.00	88.00	<0.001	7.02-11.95
HC (cm)	98.81 ± 8.27	92.75	97.00	102.00	99.91 ± 5.43	95.00	100.00	103.00	0.382	-1.38-3.59
Waist/hip	0.74 ± 0.04	0.70	0.73	0.77	0.82 ± 0.04	0.80	0.83	0.86	<0.001	0.07-0.10
Waist/height	0.43 ± 0.04	0.41	0.43	0.46	0.46 ± 0.03	0.44	0.46	0.48	0.001	0.01-0.03
AC (cm)	25.13 ± 2.40	23.87	24.65	26.00	28.69 ± 2.63	26.50	28.50	30.50	<0.001	2.68-4.44
MAMC (cm)	20.31 ± 1.66	19.17	20.20	21.62	25.65 ± 2.37	23.90	25.70	26.70	<0.001	4.64-6.03
Biceps SFT (mm)	6.83 ± 3.03	4.97	6.05	8.47	4.94 ± 2.43	3.20	4.10	5.90	<0.001	-2.86- -9.27
Triceps SFT (mm)	15.32 ± 5.47	11.95	14.20	17.85	9.67 ± 3.63	7.00	9.00	12.20	<0.001	-7.30- -3.99
Subscapular SFT (mm)	14.10 ± 5.94	10.00	12.10	16.12	12.16 ± 4.41	9.10	11.00	14.50	0.032	-3.72- -0.17
Supr iliac SFT (mm)	14.29 ± 5.49	10.80	13.20	16.25	10.71 ± 4.75	7.00	10.00	13.30	<0.001	-5.34- -1.82
Sum of SFT (mm)	50.73 ± 18.58	37.70	46.75	58.57	37.62 ± 13.56	28.50	35.50	45.70	<0.001	-18.62- -7.59
subscapular/triceps	0.94 ± 0.29	0.74	0.88	1.09	1.33 ± 0.43	1.01	1.30	1.47	<0.001	0.25-0.51
BF (%)	22.83 ± 7.42	17.10	22.65	27.07	14.18 ± 4.00	11.50	14.30	16.40	<0.001	-10.78- -6.49
BF (kg)	14.28 ± 7.26	8.97	13.10	16.95	10.70 ± 4.20	7.70	10.40	12.70	0.001	-5.70- -1.44
LBM (kg)	45.41 ± 3.52	43.85	44.80	46.92	62.76 ± 5.97	59.00	61.70	66.60	<0.001	15.70-18.99
TBW (kg)	33.25 ± 2.58	32.07	32.80	34.32	45.95 ± 4.37	43.20	45.20	48.80	<0.001	11.49-13.90
FMI	5.12 ± 2.58	3.23	4.50	6.06	3.36 ± 1.27	2.51	3.33	4.01	<0.001	-2.50- -1.02
BMR (Kcal)	1432± 105	1364	1422	1486	1812± 144	1724	1782	1880	<0.001	334-424
BMR/Kg (Kcal)	24.33 ± 2.13	23.21	24.37	26.01	24.82 ± 1.28	24.00	24.82	25.54	0.126	-0.13-1.11
PAL (MET)	1.72 ± 0.15	1.62	1.71	1.86	1.82 ± 0.16	1.73	1.82	1.92	0.001	0.03-0.15
Calorie (Kcal/d)	2411 ± 377	2179	2371	2503	3267 ± 470	2907	3214	3618	<0.001	710-1002
Protein (g/d)	108.4 ± 23.4	90.2	106.1	121.7	147.9 ± 30.1	128.0	147.0	166.5	<0.001	30.3-48.7
Protein (%)	18.4 ± 2.6	16.7	18.5	20.0	18.5 ± 2.4	17.0	18.0	20.0	0.877	-0.79-0.92
Fat (g/d)	86.9 ± 19.9	76.3	83.3	98.0	120.6 ± 27.0	105.4	118.9	133.2	<0.001	25.23-41.97
Fat (%)	32.1 ± 4.2	30.0	32.0	35.0	32.8 ± 4.9	30.0	32.0	36.0	0.364	-0.86-2.33
Carbohydrate (g/d)	288.0 ± 43.0	265.6	281.5	310.0	380.0 ± 63.8	341.4	377.0	421.3	<0.001	73.69-110.43
Carbohydrate (%)	49.2 ± 4.3	46.0	49.0	52.0	47.8 ± 5.6	45.0	48.0	51.0	0.115	-3.20-0.35
Fiber (g/d)	23.4 ± 6.3	18.8	22.1	26.6	29.0 ± 7.6	24.2	28.6	32.5	<0.001	3.11-8.04
Cholesterol (mg/d)	469.0 ± 137.1	375.1	483.7	525.7	627.4 ± 184.0	529.1	600.9	689.1	<0.001	101.20-215.53
Calorie (Kcal/Kg)	40.6 ± 4.0	38.1	40.3	43.2	44.5 ± 4.5	41.9	44.2	47.5	<0.001	2.46-5.45
Protein (g/Kg)	1.8 ± 0.3	1.6	1.8	2.0	2.0 ± 0.3	1.7	2.0	2.2	0.001	0.08-0.29
Carbohydrate (g/Kg)	4.8 ± 0.6	4.4	4.8	5.1	5.2 ± 0.7	4.6	5.3	5.8	0.009	0.08-0.57
Fat (g/Kg)	1.4 ± 0.2	1.3	1.3	1.6	1.6 ± 0.3	1.4	1.6	1.7	<0.001	0.08-0.28
SBP (mmHg)	115 ± 11	106	114	121	120 ± 12	113	120	128	0.010	1.34-9.87
DBP (mmHg)	77 ± 8	71	77	81	80 ± 9	74	79	86	0.028	0.39-6.85

BMI body mass index, ABSI A body shape index, WC waist circumference, HC hip circumference, AC arm circumference, MAMC mid arm muscle circumference, Biceps SFT Biceps skinfold thickness, Triceps SFT Triceps skinfold thickness, Sub scapular SFT Sub scapular skinfold thickness, Supra iliac SFT Supra iliac skinfold thickness, Sum of SFT Sum of skinfold thicknesses, BF Body fat percent, LBM Lean body mass, TBW Total body water, FMI Fat mass index, BMR basal metabolism rate, PAL Physical activity level, SBP systolic blood pressure, DBP diastolic blood pressure/*mean± standard deviation and 1st, 2nd and 3rd quartiles/**P-value of independent t-test/ ***95% CI Confidence interval on the difference between mean