Original Article

Anthropometric measurements and body composition analysis of obese adolescents with and without metabolic syndrome

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Aim: Obesity and risk of metabolic syndrome (MS) are rapidly increasing in children. Therefore, criteria for MS were aimed to be evaluated in obese children (OC).

Materials and methods: Anthropometric indices and body composition (bioimpedance) analysis (BIA) were compared in 32 obese and 32 normal-weight children. Biochemical parameters were evaluated in OC. Results of OC with/without MS were compared.

Results: Subscapular skinfold thickness (SST) was more sensitive and specific than triceps skinfold thickness in the diagnosis of obesity. According to BIA basal metabolism rate, fat mass (FM), FM%, and FM index were higher, while impedance, FFM%, fat-free-mass (FFM) index, and total-body-water% were lower in OC. Significant positive correlations were found between SST and waist (W) (P = 0.026, r = 0.392), hip (H) (P = 0.004, r = 0.491), and W/height ratio (WHR) (P = 0.002, r = 0.523). Increased body mass index (BMI), W, WHR, and SGPT in conjunction with decreased FFM index and HDL-cholesterol levels were the most important features in OC with MS. Significant negative correlations were found between HDL levels and W (P = 0.001, r = -0.571), H (P = 0.012, r = -0.437), and WHR (P = 0.004, r = -0.49).

Conclusion: In obesity SST is sensitive and specific and a valuable marker for central obesity like W, H, and WHR. Mild SGPT level elevation in OC with MS may be due to low HDL level and hepatosteatosis.

Key words: Obesity, metabolic syndrome, body composition, anthropometry, bioimpedance analysis

Metabolik sendromu olan ve olmayan obez adolesanların antropometrik ölçümler ve biyoimpedans analizi ile değerlendirilmesi

Amaç: Obesite ve metabolik sendrom (MS) riski çocukluk yaş grubunda giderek artmaktadır. Bu nedenle obez çocukların (OÇ) takibinde MS kriterleri araştırılmalıdır.

Yöntem ve gereç: Otuziki obez ve 32 normal ağırlıklı çocuğun antropometrik indeksleri ve biyoimpedans analizleri (BİA) karşılaştırıldı, OÇ'ın biyokimyasal parametreleri değerlendirildi. MS olan/olmayan OÇ'ların sonuçları karşılaştırıldı.

Bulgular: Subskapular cilt kıvrım kalınlığı (SCKK) obesite tanısında triseps cilt kıvrım kalınlığına göre daha sensitif ve spesifikti. OÇ'da BİA'ya göre; bazal metabolik hız, yağ kitlesi (YK), YK%, YK indeksi daha fazla; impedans, yağsız doku%, yağsız doku indeksi, total vücut suyu% daha azdı. SST ile sırasıyla bel çevresi (B) (P = 0,026, r = 0,392), kalça çevresi (K) (P = 0,004, r = 0.491) ve bel/boy oranı (BBO) (P = 0,002, r = 0,523) arasında anlamlı pozitif korelasyon bulundu. MS'u olan OÇ'da artmış beden kitle indeksi (BKİ), B, K, BBO ve SGPT ile azalmış yağsız doku indeksi ve HDL-kolesterol en belirgin özelliklerdi. HDL ile sırasıyla B (P = 0,001, r = -0,571), K (P = 0,012, r = -0,437) ve BBO (P = 0,004, r = -0.49) arasında anlamlı negatif korelasyon bulundu.

Sonuç: Obesitede SCKK sensitif ve spesifiktir, santral obesitede B, K ve BBO gibi değerli bir parametredir. MS'u olan OÇ'larda saptadığımız hafif SGPT yüksekliği düşük HDL ve hepatosteatoza bağlı olabilir.

Anahtar sözcükler: Kırım-Obesite, metabolik sendrom, vücut kompozisyonu, antropometri, biyoimpedans analizi

Introduction

The prevalence of obesity in children increased 45% in the last decade due to factors including increased food intake, reduced levels of physical activity, and an altered pattern of nutrition (1-3). As the prevalence of obesity increases the risk of metabolic syndrome (MS)—a cluster of anthropometric and biochemical abnormalities in addition to obesity—also increases, predisposing the obese to the development of diabetes and cardiovascular disease.

The abnormalities in MS are increased serum glucose and triglyceride levels, elevated blood pressure, large waist circumference (W), and low HDL cholesterol levels (4). In the evaluation of obese individuals MS parameters should be measured in addition to the anthropometric measures like weight, stature, body mass index (BMI), W and hip (H) circumference, and skinfold thicknesses. Other methods, namely bioelectrical impedance analysis (BIA), densitometry, isotope dilution, and dual energy X-ray absorptiometry (DXA), may also be used.

BIA is gaining popularity as it is clinically non-invasive, easy to perform, portable, and inexpensive (5-7). The aim of this study was to evaluate the anthropometric measurements and BIA in obese adolescents and to compare these parameters in obese children (OC) with and without MS.

Methods

Study design and participants

This was a cross-sectional analysis performed in the Pediatric Cardiology clinic from August to December 2007. All study procedures were approved by the institutional review board at the Yüksek İhtisas Education and Research Hospital, and written informed consent was obtained from the families of the children. The data from 32 obese and 32 age-matched normal weight (control) Turkish children were evaluated. The OC with cardiovascular and systemic problems and abnormal thyroid function test results were not included in this study in order to evaluate the effect of MS on the measured data specifically. The OC were divided into 2 groups according to the presence of MS.

The weight, stature, W and H, and skinfold-thicknesses (triceps, biceps, subscapular) of the children were measured, and body surface area and BMI values were calculated. The growth charts, including age- and sex-specific BMI references for children and adolescents developed by Ozturk et al., were used (8). Children with a BMI above the 95th percentile were considered obese, children with a BMI between the fifth and 85th percentiles were considered normal weight, and children with a BMI between the 85th and 95th percentiles were considered overweight (9). The overweight children were not included in the study.

The percentiles of W developed for Turkish children and adolescents were used (10). The ratio of W to height (WHR) was calculated.

Triceps, biceps, and subscapular skinfold thicknesses were measured by using the Harpenden Skinfold Caliper (Holtain Ltd, Bryberian, UK). Percentiles from triceps and subscapular skinfold thicknesses (TST and SST) were evaluated (11). The ratio of TST to SST was calculated in the groups to provide an estimate of relative fat distribution (12).

Body composition parameters, namely BMI, basal metabolism rate (BMR), fat mass (FM), fat-free mass (FFM), total body water (TBW), and impedance, were measured by BIA (Tanita TBF 300M). BIA measurements were performed in the morning after the subjects fasted for at least 12 h and after 15 min of rest. The subjects stood on the footplate electrodes keeping an upright posture so as to equalize the weight on the right and left legs (13,14). According to the BIA, fat mass index and fat-free mass index [fat mass index = fat-mass / (height)^2, fat-free mass index = fat free mass / (height)^2] were calculated.

Systolic and diastolic blood pressures (SBP and DBP) were measured on at least 3 separate occasions and evaluated according to the percentiles defined by Park et al. (15). Arterial hypertension was defined as average SBP and DBP in the 95th percentile or higher for age and sex.

The OC were evaluated for the presence of MS according to the criteria defined by Iannuzzi et al. (16). According to these criteria a child presenting with 3 out of 5 of the following measures [fasting glucose > 110 mg/dL; triglycerides > 100 mg/dL;

high-density lipoprotein cholesterol (HDL), < 45 (males), < 50 mg/dL (females); W, > 75th percentile for age and gender; SBP/DBP > 90th percentile (age, sex, height)] is accepted as having MS.

The complete blood count, biochemical analysis [glucose, creatinine, uric acid, total protein, albumin, SGOT (serum glutamic oxaloacetic transaminase), SGPT (serum glutamic pyruvic transaminase)], serum lipids, C-reactive protein (from 29 of 32 OC), fibrinogen, fasting insulin level (from 27 out of 32 OC), and TSH were evaluated in the obese group. For the assessment of insulin resistance the HOMA-IR (homeostasis model assessment-insulin resistance) index (17) was used.

Data analysis

The sensitivity, specificity, positive predictive, and negative predictive values were calculated for the TST and SST (the sensitivity = number of true positives / number of true positives + number of false negatives, the specificity = number of true negatives / number of true negatives + number of false positives, positive predictive value = number of true positives / number of true positives + number of false positives, negative predictive value = number of true negatives / number of true negatives + number of false negatives) (18).

Other statistical analysis was performed using the commercially available software SPSS 15.0 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov (K-S) test was used for data distribution. Parametric analysis (a 2-sample t test) was performed when the variable of interest was normally distributed; otherwise non-parametric analysis (Mann-Whitney U test) was performed. The chi-square test was used to analyze differences in qualitative variables of groups. Results are given as the mean ± standard deviation (SD) in parametric tests and median value (minimum and maximum values) in nonparametric tests. A P value < 0.05 is considered significant. Pearson analysis (2-tailed) was performed to determine the correlations between the variables.

Results

The demographic, clinical, and anthropometric characteristics of the groups are presented in Table 1. The W values of OC were above the 90th percentile. There was significant positive correlation between W and H (P < 0.0001, r = 0.784). There was significant positive correlation between SST and W (P = 0.026, r = 0.392), H (P = 0.004, r = 0.491), and WHR (P = 0.002, r = 0.523).

Table 1. The demographic and anthropometric characteristics of the groups.

Parameters	Obese group (n = 32)	Control group (n = 32)	P value
Age	12.63 ± 2.35	13.59 ± 2.09	NS
Gender (female/male)	11/21	12/20	NS
Body weight (kg)	67.54 ± 16.84	46.59 ± 12.4	< 0.001
Stature (cm)	154.56 ± 11.63	157.63 ± 13.86	NS
BSA (m2)	1.74 ± 0.23	1.40 ± 0.24	< 0.001
Waist (cm)	91 ± 10.33	67.23 ± 8.42	< 0.001
Hip (cm)	100.19 ± 10.07	81.84 ± 9.27	< 0.001
Waist/hip ratio	0.9 ± 0.06	0.82 ± 0.05	< 0.001
Waist/height ratio	0.59 ± 0.04	0.43 ± 0.03	< 0.001
Biceps ST (mm)	12 (8-40)	6 (3-16)	< 0.001
Triceps ST (mm)	25.81 ± 7.92	13.81 ± 5.78	< 0.001
Subscapular ST (mm)	24 (10-50)	10 (5-22)	< 0.001
Subscapular ST/triceps ST	1.13 ± 0.32	0.75 ± 0.21	< 0.001

BSA, body surface area; ST, skinfold thickness; NS, not significant.

TST and SST were above the 95th percentile in 54.7% and 45.3% of OC respectively. The sensitivity, specificity, positive predictive, and negative predictive ratios for TST and SST according to BMI were 81.3% (69.6%-89.8%), 68.8% (57.1%-77.3%), 78.6% (65.2%-88.3%), and 72.2% (61.8%-79.8%); and 84.4% (74.7%-88.7%), 93.8% (84%-98.1%), 85.7% (76.8%-89.7%), and 93.1% (82.4%-97.9%), respectively. SST was more specific and sensitive than TST in the evaluation of obesity in children.

The BIA results of the groups are presented in Table 2. There was significant negative correlation between the BMI and the impedance of muscle (P < 0.0001, r = -0.671).

Fifteen (6 girls, 9 boys) out of 32 OC (46.8%) were found to have MS. The ratio of MS was 6/11 (54.5%) in obese girls and 9/21 (42.8%) in obese boys.

The demographic, anthropometric characteristics, and BIA and biochemical analysis in OC with and without MS are presented in Tables 3, 4, and 5, respectively. Significant positive correlations were found between the BMI and both creatinine (P = 0.029, r = 0.387) and uric acid (P = 0.006, r = 0.474). Significant negative correlations were found between the BMI and both HDL (P = 0.001, r = -0.538) and muscle impedance (P < 0.0001, r = -0.671).

Significant positive correlations were found between W and creatinine (P = 0.003, r = 0.515), uric acid (P < 0.0001, r = 0.652), and SBP (P = 0.033, r = 0.378). Significant negative correlation was found between W and HDL (P = 0.001, r = -0.571).

Significant positive correlations were found between H and creatinine (P = 0.001, r = 0.559), uric acid (P = 0.002, r = 0.519), and SBP (P = 0.042, r = 0.362). Significant negative correlation was found between H and HDL (P = 0.012, r = -0.437).

Significant positive correlations were found between WHR and both SBP (P = 0.039, r = 0.367) and DBP (P = 0.048, r = 0.352). Negative correlation was found between WHR and HDL (P = 0.004, r = -0.490).

There were significant positive correlations between the waist/hip ratio and both SGPT (P = 0.036, r = 0.372) and CRP (P = 0.004, r = 0.384).

There was significant positive correlation between the SGPT and triglyceride levels (P = 0.012, r = 0.439).

Table 2. The bioimpedance analysis results of the groups.

Parameters	Obese group (n = 32)	Control group (n = 32)	P value
BMI (kg/m^2)	27.85 ± 3.83	18.4 ± 2.66	< 0.001
BMR (kcal)	1707.31 ± 291.86	1430.19 ± 239.91	< 0.001
Impedance (Ω)	482.13 ± 53.25	551.94 ± 76.45	< 0.001
Fat mass (kg)	21.79 ± 7.7	6.06 ± 3.74	< 0.001
Fat %	31.86 ± 6.27	12.70 ± 6.49	< 0.001
Fat mass index	9 ± 2.7	2.42 ± 1.43	< 0.001
FFM (kg)	45.74 ± 11.61	40.53 ± 10.78	NS
FFM %	0.68 ± 0.063	0.87 ± 0.064	< 0.001
FFM index	18.84 ± 2.1	15.97 ± 2	< 0.001
TBW (kg)	33.48 ± 8.50	29.66 ± 7.88	NS
TBW %	0.50 ± 0.047	0.64 ± 0.047	< 0.001

BMI, body mass index; BMR, basal metabolism rate; FFM, fat-free mass; TBW, total body water; NS, not significant.

Table 3. The demographic and anthropometric characteristics of obese children with/ without metabolic syndrome.

	Obese children		
Parameters	Metabolic syndrome (+) (n = 15)	Metabolic syndrome (-) (n = 17)	P value
Age	13 ± 2.03	12.3 ± 2.6	NS
Gender (female/male)	6/9	5/12	NS
Body weight (kg)	72.95 ± 16.85	62.78 ± 15.8	NS
Stature (cm)	157 ± 12.55	152.3 ± 10.6	NS
BSA (m^2)	1.81 ± 0.2	1.67 ± 0.23	NS
Waist (cm)	96.03 ± 10.29	86.56 ± 8.32	< 0.01
Hip (cm)	103.13 ± 8.73	97.59 ± 10.7	NS
Waist/hip ratio	0.93 ± 0.05	0.89 ± 0.07	NS
Waist/height ratio	0.61 ± 0.04	0.56 ± 0.03	< 0.005
Biceps ST(mm)	16.53 ± 8.39	13 ± 4.39	NS
Triceps ST(mm)	27.93 ± 9.47	23.94 ± 5.9	NS
Subscapular ST(mm)	26.67 ± 10.02	21.53 ± 5.53	NS
Subscapular ST/Triceps ST	1.1 ± 0.26	1.1 ± 0.36	NS

BSA, body surface area; ST, skinfold thickness; NS, not significant.

Table 4. Clinical and metabolic characteristics of obese children with/without metabolic syndrome.

	Obese children		
Parameters	Metabolic syndrome (+) (n = 15)	Metabolic syndrome (-) (n = 17)	P value
SBP (mmHg)	113 ± 12.79	108 ± 14.27	NS
DBP (mmHg)	71.2 ± 13.2	65 ± 8.84	NS
Hemoglobin (g/dL)	13.93 ± 1.01	13.42 ± 1.07	NS
Glucose (mg/dL)	86 ± 4.18	88.47 ± 8.1	NS
Creatinine (mg/dL)	0.61 ± 0.12	0.55 ± 0.09	NS
Uric acid (mg/dL)	5.57 ± 1.5	4.88 ± 1.3	NS
Albumin (g/dL)	4.73 ± 0.34	4.91 ± 0.37	NS
SGOT (IU/L)	28.17 ± 11.48	23.76 ± 5.58	NS
SGPT (IU/L)	30.86 ± 15.24	20.53 ± 7.86	< 0.05
Total cholesterol (mg/dL)	164.67 ± 24.59	184 ± 44.09	NS
Triglyceride (mg/dL)	136.07 ± 55.60	105.18 ± 56.41	NS
LDL (mg/dL)	94.47 ± 23.27	106.88 ± 36.36	NS
HDL (mg/dL)	43 ± 7.25	53.59 ± 11.73	< 0.01
Fibrinogen (g/L)	3.18 ± 1.05	3.4 ± 0.72	NS
C-reactive protein (mg/dL)	0.43 ± 0.28	0.34 ± 0.31	NS
Fasting insulin (μIU/mL)	16.73 ± 7.56	13.8 ± 4.68	NS
HOMA-IR	3.63 ± 1.71	3.08 ± 1.17	NS
Hb A1C (%)	5.65 ± 0.38	5.51 ± 0.28	NS

SBP, systolic blood pressure; DBP, diastolic blood pressure; HOMA-IR, homeostasis model assessment- insulin resistance index NS, not significant.

Table 5. The bioimpedance analysis results of obese children with/without metabolic syndrome.

Parameters	Obese children		P value
	Metabolic syndrome (+) (n = 15)	Metabolic syndrome (-) (n = 17)	
BMI (kg/m^2)	29.29 ± 3.78	26.58 ± 3.27	< 0.05
BMR (kcal)	1766.8 ± 348.25	1654.8 ± 229.52	NS
Impedance (Ω)	463.67 ± 44.3	498.41 ± 56.33	NS
Fat mass (kg)	23.7 ± 7.7	20.11 ± 7.54	NS
Fat%	32.45 ± 7.39	31.34 ± 5.28	NS
FM index	9.65 ± 3.13	8.42 ± 2.18	NS
FFM (kg)	49.24 ± 13.17	42.65 ± 9.38	NS
FFM%	0.67 ± 0.07	0.69 ± 0.05	NS
FFM index	18.14 ± 1.82	19.63 ± 2.18	< 0.05
TBW (kg)	36.05 ± 9.63	31.22 ± 6.86	NS
TBW%	0.49 ± 0.05	0.50 ± 0.04	NS

BMI, body mass index; BMR, basal metabolism rate; FFM, fat-free mass; TBW, total body water; NS, not significant.

Discussion

MS was first defined by Reaven [19] in 1988. After findings uncovered the strong association between diabetes and cardiovascular disease, the International Diabetes Federation defined MS as central obesity in association with of 2 of the following 4 criteria: raised triglyceride level, reduced HDL cholesterol level, raised blood pressure, and raised fasting plasma glucose [4].

MS predisposes people to the development of diabetes and cardiovascular disease. Thus control of obesity and MS from a young age is important. This includes regular exercise and diet, as well as follow-up examinations.

In this study the BMIs were higher (P < 0.05) and the HDL levels were lower (P < 0.01) in OC with MS compared to those without MS. We found negative correlation between the BMI and HDL (P = 0.0001, r = -0.538). Increase in the BMI is associated with decrease in HDL levels.

The MS criteria defined for children by Ianuzzi et al. was used in this study. There was MS in 15 (46.8%) out of 32 OC. In another study the MS prevalence was 26.6% in overweight children [20].

We found in this study that the SST was more sensitive and specific for the diagnosis of obesity than TST. The increased SST/TST ratio in the obese group shows increased relative fat distribution [12].

A W value above the 90th percentile was defined as central obesity [21]. The W of all OC was above the 90th percentile. W was higher in OC with MS than those without MS (P < 0.01).

We found positive correlations between the SST and W (P = 0.026, r = 0.392), H (P = 0.004, r = 0.491), and WHR (P = 0.002, r = 0.523). Thus, the SST—like W, H, and WHR—is a valuable marker in the diagnosis of central obesity.

Because it provides age- and sex-independent data, WHR has been recommended for identifying obese subjects with high metabolic and cardiovascular risk [22-24]. In this study WHR was higher in the obese group with MS (0.61 ± 0.04) compared with the obese group without MS (0.56 ± 0.03) (P < 0.005).

In the BIA analysis we found that the percentage of water (TBW%), FFM% and the impedance were lower and BMI, BMR, FM, and fat percentage were higher in the obese group. In the study by Bray et al. [25] the percentage of water, measured by the

DXA technique, was significantly higher in the fatter children. Das et al. (26) evaluated the body composition in severely obese individuals and the reference group with the Siri 3-compartment model and they found the percentage of water was low in the severely obese group in results similar to ours. An important result of our study is that the FFM index was found to be lower in OC with MS compared to those without MS.

There was negative correlation between the BMI and impedance of muscle (P < 0.0001, r = -0.671). Higher BMI and less muscle impedance may be due to reduced levels of physical activity.

In this study SGPT level elevation and HDL level decrease were significant in the OC with MS. In childhood obesity SGPT elevation is associated with features of MS (27,28). Low levels of HDL is among the criteria for MS. The function of HDL is to carry excess cholesterol to the liver for "re-packaging" or excretion in bile. Mild elevation of SGPT in OC with MS may be because of low HDL levels or the hepatosteatosis which occurs due to low HDL levels.

The association between low HDL levels and increased WHR is a known feature of MS. The negative correlations between the HDL and W, H, and WHR emphasize the importance of these markers in the evaluation of MS.

Cruz et al. (29) reported that the effects of adiposity on lipids and blood pressure were mediated via insulin resistance. In our study we found no difference between the mean fasting insulin and HOMA-IR values in OC with or without MS (Table 4).

As obesity and MS are common problems, standard percentile curves for MS parameters according to age and gender for Turkish children, and studies with larger cohorts are needed. OC with cardiovascular and systemic problems and abnormal thyroid function test results were not included in this study in order to specifically evaluate the effect of MS on the measured data. As a result we think that the correlations found are specific for MS.

In conclusion, this study showed the high sensitivity and specificity of the SST in the diagnosis of obesity. The SST and its age percentiles may also be used for determining central obesity in children. Negative correlations between HDL and W, H, and WHR were important points for the evaluation of MS. Increased BMI, W, WHR, and SGPT levels and decreased FFM index and HDL levels were found to be the most important features in obese adolescents with MS.

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