The Relationship between Body Fat Percentage and Metabolic Syndrome Indices in Childhood Morbid Obesity

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Abstract**—**Metabolic syndrome (MetS) is characterized by a series of biochemical, physiological and anthropometric indicators and is a life-threatening health problem due to its close association with chronic diseases such as obesity, diabetes mellitus, hypertension, cancer and cardiovascular diseases. The syndrome deserves great interest both in adults and children. Particularly, children with morbid obesity have a great tendency to develop the disease. The diagnostic decision is not so easy and may not be complete particularly in the pediatric population. Therefore, preventive measures should be considered at this stage. The aim of the study was to develop a MetS index capable of predicting MetS, while children are at the morbid obesity stage. This study was performed on morbid obese (MO) children, which were divided into two groups. MO children, who do not possess MetS criteria comprised the first group (n = 44). The second group was composed of children with MetS diagnosis (n = 42). Anthropometric measurements including weight, height, waist circumference (WC), hip C, head C, neck C, biochemical tests including fasting blood glucose (FBG), insulin (INS), triglycerides (TRG), high density lipoprotein cholesterol (HDL-C) and blood pressure measurements (systolic (SBP) and diastolic (DBP)) were performed. Body fat percentage (BFP) values were determined by TANITA's Bioelectrical Impedance Analysis technology. Body mass index and MetS indices were calculated. Descriptive statistics including median values, t-test, Mann Whitney U test, correlation-regression analysis were performed within the scope of data evaluation using the statistical package program, SPSS. Statistically significant mean differences were determined by a p value smaller than 0.05. Median values for MetSI and ADMI in MO (MetS-) and MO (MetS+) groups were calculated as 25.9 and 36.5 and 74.0 and 106.1, respectively. Corresponding mean ± SD values for BFPs were 35.9 ± 7.1 and 38.2 ± 7.7 in groups. Correlation analysis of these two indices with corresponding general BFP values exhibited significant association with ADMI, close to significance with MetSI in MO group. Any significant correlation was found with neither of the indices in MetS group. In conclusion, important associations observed with MetS indices in MO group were quite meaningful. The presence of these associations in MO group was important for showing the tendency towards the development of MetS in MO (MetS-) participants. The other index, ADMI, was more helpful for predictive purpose.

Keywords**—**Body fat percentage, child obesity, metabolic syndrome index, morbid obesity.

I. Introduction

METS is an ever-increasing severe health problem due to the tremendous increases in the number of obese (OB) and MO individuals in high, middle and low-income countries [1], [2]. MetS criteria for the diagnosis of the disease in adults are well-defined. However, clear guidelines for diagnosing MetS in children and adolescents, particularly in some pediatric age groups, are still being developed. There are many publications reporting various diagnostic methods for MetS in adults [3], [4]. However, such publications performed on children and adolescents are rare [5].

So far different-formatted indices in the form of equations, scales, or formulas were introduced. In the first form, MetS index value may simply be the sum of the scores assigned each of MetS components [4]. Or the index may be calculated mathematically using biochemical parameters [TRG, HDL-C, FBG, INS] called MetS components [5].

Anthropometric measurements may also be considered. For example, waist circumference (WC) cut-off points may be proposed as the best predictors of MetS [3]. Or neck circumference (NC) can be used as a complementary tool in the screening and diagnosis of MetS in adults [6]. Some include height parameter into the studies. One reported that WC was a better indicator of MetS than WC-to-height ratio [7]. Another study suggested the use of metabolomic indices (the combinations of biochemical and anthropometric parameters) to identify MetS [8].

As a result of the wide-scoped literature review, any MetS index covering biochemical, anthropometric and physiological parameters could not be found. Aside from biochemical MetS components, components, which are of physiological nature [systolic (SBP) and diastolic blood pressure (DBP)] as well as anthropometric nature (height) should also be included in the index.

Height-based equations as well as BP-to height ratios were commonly investigated [9]-[13]. While developing a MetS index, due to the close association between BPs and anthropometric height parameter, addition of height into the formula will be plausible and will make the equation complete during the attempts for the diagnosis of MetS.

High body fat is related to obesity and MetS. BFP was suggested as a screening tool for the prediction of MetS [14].

The aim of this study was to test the performance of an integrative index combining anthropometric, physiological and biochemical parameters in childhood morbid obesity in association with MetS and present a potential relation between this index and BFP.

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II. Patients and Methods

A. The Study Population

86 MO children comprised the study population. Two groups were constituted. In Group 1, there were MO children, who do not exhibit MetS components. The other group was composed of MO children with MetS findings. The first and the second groups were called MO and MetS groups, respectively.

Parents of the participants signed informed consent forms for their children to be included in the study. Institutional non-interventional ethics committee approved the protocol of the study. Declarations of Helsinki have been complied with.

B. Constitution of the Groups

MO children were selected from the patients admitted to the Pediatrics Outpatient Clinic of Tekirdağ Namık Kemal University, Faculty of Medicine. The age and sex-adjusted body mass index (BMI) percentile tables prepared by World Health Organization were used for the purpose [15]. The children, whose BMI percentile values were above 99, were included into the study.

Values for biochemical tests including FBG, TRG, HDL-C as well as SBP and DBP as physiological measurements were recorded for selection of the children to be included into MetS group. The MetS criteria [16] used were listed in Table I.

TABLE I
METS CRITERIA

Parameter
BMI percentile above 99
SBP above 120 mm. Hg
DBP above 80 mm. Hg
FBG above 100 mg/dL
TRG above 100 mg/dL
HDL-C below 40 mg/dl

C. Anthropometric, Physiological, Biochemical Measurements and Bioelectrical Impedance Analysis

Anthropometric measurements including WC were performed. BMI values were calculated. SBPs and DBPs were measured. Routine biochemical tests including concentrations of FBG, TRG, HDL-C, INS were determined. Total BFP values were estimated by TANITA's Bioelectrical Impedance Analysis.

D. BMI and MetS

BMI values (kg/m^2) were calculated from weight and height values of participants.

Performances of two MetS indices were compared: The first was MetS index (MetSI) and the second was advanced Donma MetS index (ADMI). The value for the first index was obtained by the result of this calculation: [(INS/FBG)/(HDL-C/TRG)]*100. The result of the following calculation has given the value for ADMI: MetSI*[(SBP+DBP)/Height].

E. Statistics

The statistical package program, SPSS, was used to determine mean ± SD, median values of the parameters studied. Differences between MO and MetS groups were determined by the appropriate t-test. Correlation analysis was performed. Linear regression plots with 95% confidence intervals were drawn. Any value of p, which is smaller than 0.05, was accepted as the statistical significance degree.

III. Results

WC, BMI and BFP values of both MO and MetS groups were given in Table II.

TABLE II
WC, BMI AND BFP VALUES

Parameter	MO	MetS
WC	83.0 ± 13.4	96.2 ± 17.1
BMI	25.8 ± 4.3	31.5 ± 8.3
BFP	32.9 ± 4.9	38.2 ± 7.7

Statistically significant increases (mean ± SD) were observed in MetS group compared with the corresponding values obtained in MO group without MetS findings ($p < 0.001$).

Median values for MetSI and ADMI concerning MO and MetS groups were shown in Table III.

TABLE III
MEDIAN VALUES OF METS INDICES

Parameter	MO	MetS
MetSI	25.86	74.00
ADMI	36.53	106.14

Proportional increases in MetS group in comparison with the index values of MO group were noted. The magnitude of the increase was nearly threefold.

Table IV showed correlation coefficients (r values) and significance check of correlations (p values) between each MetS index and WC/BMI/BFP in both MO and MetS groups.

TABLE IV
CORRELATIONS OF METS INDICES WITH WC, BMI AND BFP

Parameter	MO		MetS	
	MetSI	ADMI	MetSI	ADMI
	r p	r p	r p	r p
WC	0.510; 0.001	0.508; 0.001	0.480; 0.001	0.488; 0.001
BMI	0.456; 0.002	0.470; 0.002	0.455; 0.002	0.499; 0.001
BFP	0.362; 0.054	0.412; 0.029	0.127; 0.449	0.203; 0.221

The correlation plot with regression line concerning the association between ADMI and BFP was shown in Fig. 1.

As shown in Table IV, BFP exhibited a strikingly different pattern compared to the performances of WC and BMI in MO group.

IV. Discussion

BFP was introduced as an index for the prediction of subcutaneous adipose tissue, visceral adipose tissue and total abdominal adipose among obese children [17].

High BFP in association with oxidative stress and inflammation may lead to diabetes mellitus, MetS and cardiovascular diseases [18]. BFP was the most important predictor of adiponectin-to-leptin ratio, a promising marker of cardiometabolic risk in children with MetS [19]. Identification and clinical management of high MetS risk groups were reported as important strategies for coronary heart disease prevention [20].

Body mass index along with BFP should be considered during the prediction of MetS risk factors [21]. BFP was also used for estimating and comparing the prevalence of obesity and metabolic risk factors [22].

The utility of BFP was tested in the screening of MetS [23]. In clinical and research settings, BFP was used for the establishment of MetS risk [24].

BFP along with adipose cell-type composition as well as adipose mitochondrial gene expression predicts insulin resistance (IR) in obesity [25]. Some data drew attention to problems in the interpretation of the relationships between IR and BFP [26]. In a study, the associations between IR and BMI as well as WC were found to be stronger than the association of IR and BFP [27]. In another report, BFP had the preponderance over the anthropometric measurements such as BMI and WC in terms of their correlation with IR [28].

In some reports, BFP was evaluated and its performance was compared with those of WC and BMI in adults and adolescents. In adults, BMI and WC were reported to be more accurate than BFP for screening metabolic risk factors. In adolescents, WC and BMI were introduced as the best predictors of MetS and hypertension, respectively [29], [30].

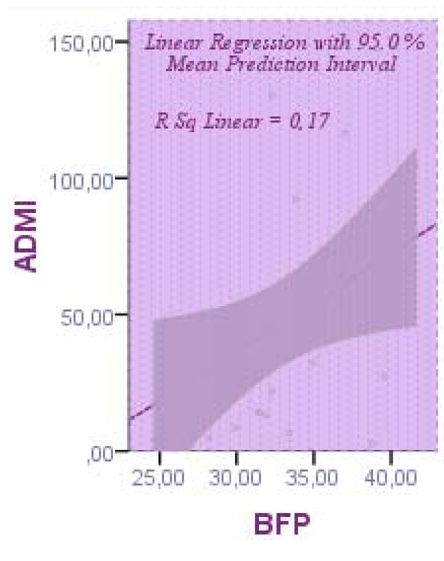

Fig. 1 Regression plot for the correlation between advanced Donma metabolic syndrome index (ADMI) and BFP in MO group

It was investigated whether there was a relationship between the findings in MO and the possible development of MetS. To date, many attempts have been made to prevent MetS when children are in MO state. Since MetS has serious complications such as cardiovascular diseases, diabetes, hypertension, cancer, it has a heavy burden and high economic cost to society. Therefore, it is of great importance to prevent this life-threatening syndrome during childhood obesity or morbid obesity [31]-[39].

In this study, WC, BMI and BFP were evaluated in MO children. The best predictor of MetS was investigated among all. When the correlations of three parameters with MetSI and ADMI were inspected, although strong correlations of MetS indices with both WC and BMI were observed, there was no difference between MO and MetS groups. However, clinically helpful results were obtained with BFP.

In children with MetS, in addition to the fact that BFP achieved saturation, due to the use of parameters exhibiting variations, relations between BFP and MetSI, which uses four biochemical parameters as well as ADMI, which uses also BP values, were found to be statistically insignificant.

In the MO group, statistically significant correlations between BFP and MetSI as well as ADMI indicated that both indices could be a predictive index from the point of view of onset to MetS during morbid obesity, which is a previous stage of MetS.

It was observed that the relationship between BFP and ADMI using BP values in addition to biochemical markers ($p = 0.029$) was more significant than the relationship between BFP and MetSI using only four biochemical markers ($p = 0.054$).

These findings strengthen the idea that ADMI is a predictive index in the morbid obesity stage, which is the stage before the development of MetS. These indices have appeared as indices with diagnostic importance in the MO stage. At this stage, ADMI emerged as a more functional index.

V. Conclusion

This study pointed to a different aspect of BFP and its association with developing MetS in children. The MetS index, ADMI, was able to differentiate between MO children with no signs of MetS but with the potential to develop MetS, and MO children, who met the criteria for MetS. This was important for the children in the first group for taking some preventive measures into consideration by health professionals and the family before the development of the disease.

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