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The Link between Anthropometry and Fat-Based Obesity Indices in Pediatric Morbid Obesity

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***Abstract*—**Anthropometric measurements are essential for obesity studies. Waist circumference (WC) is the most frequently used measure and along with hip circumference (HC), it is used in most equations derived for the evaluation of obese individuals. Morbid obesity (MO) is the most severe clinical form of obesity and such individuals may also exhibit some clinical findings leading to metabolic syndrome (MetS). Then, it becomes a requirement to discriminate MO children with MetS (MOMetS+) from MO children without MetS (MOMetS-). Almost all obesity indices can differentiate obese (OB) children from children with normal body mass index (N-BMI). However, not all of them are capable of making this distinction. The aim of this study was to find out the clinical availability of (waist circumference + hip circumference)/2 ((WC+HC)/2) for the differential diagnosis of MOMetS+ and MOMetS- and to compare the possible preponderance of it over some other anthropometric or fat-based obesity indices. 45 MOMetS+ and 45 MOMetS- children were included in the study. Participants have submitted informed consent forms. The study protocol was approved by the Non-interventional Clinical Studies Ethics Committee of Tekirdag Namik Kemal University. Anthropometric measurements were performed. BMI, waist-to-hip circumference (WHR), (WC+HC)/2, trunk-to-leg fat ratio (TLFR), trunk-to-appendicular fat ratio (TAFR), trunk fat+leg fat/2 ((trunk+leg fat)/2), diagnostic obesity notation model assessment index-2 (D2I) and fat mass index (FMI) were calculated for both groups. Study data were analyzed statistically and 0.05 for p value was accepted as the statistical significance degree. Statistically higher BMI, WC, (WC+HC)/2, (trunk+leg fat)/2 values were found in MOMetS+ children than MOMetS- children. No statistically significant difference was detected for WHR, TLFR, TAFR, D2I and FMI between two groups. The lack of difference between the groups in terms of FMI and D2I pointed out the fact that the recently developed fat-based index; (trunk+leg fat)/2 gives much more valuable information during the evaluation of MOMetS+ and MOMetS- children. Upon evaluation of the correlations, (WC+HC)/2 was strongly correlated with D2I and FMI in both MOMetS+ and MOMetS- groups. Neither D2I nor FMI was correlated with W/H. Strong correlations were calculated between (WC+HC)/2 and (trunk+leg fat)/2 in both MOMetS- ($r = 0.961$; $p < 0.001$) and MOMetS+ ($r = 0.936$; $p < 0.001$) groups. Partial correlations between (WC+HC)/2 and (trunk+leg fat)/2 after controlling the effect of basal metabolic rate were $r = 0.726$; $p < 0.001$ in MOMetS- group and $r = 0.932$; $p < 0.001$ in MOMetS+ group. The correlation in the latter group was higher than the first group. In conclusion, recently developed anthropometric obesity index (WC+HC)/2 and fat-based obesity index (trunk+leg fat)/2 were of preponderance over the previously introduced classical obesity indices such as WHR, D2I and FMI during the differential diagnosis of MOMetS+ and MOMetS- children.

***Keywords*—**Hip circumference, metabolic syndrome, morbid obesity, waist circumference.

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I. Introduction

OBESITY is a life-threatening public health problem because it has the tendency to lead to severe chronic diseases such as diabetes, cardiovascular disease, cancer. The latest form of obesity called MO is one of the causes of MetS [1]-[5]. Weight and height are the primary measures to determine the degree of obesity. Using these two parameters, one of the most commonly used indices, BMI is calculated. However, this index may not be correlated with the amount of fat compartments of the body. In this case, new indices well-matched with the obesity stages as well as MetS are under investigation [6], [7].

In a recent previous report, a new index derived from two popular anthropometric measurements, WC and HC was introduced [8]. In the same report, the performance of this index, (WC+HC)/2, was evaluated on children with N-BMI and OB groups. It has been shown that this index was successful to discriminate children with N-BMI and OB cases [8]. However, it was not clear whether this index possesses the capacity to differ morbid OB cases with and without MetS findings.

WC is the most commonly used anthropometric measure and it is evaluated along with HC. First measure increases much more rapidly than the rate of increase in the latter parameter. A ratio derived from these two anthropometric measures, WHR, is being used in obesity studies.

In a very recent study, a new index [(WC+HC)/2] derived from both of these two popular anthropometric measurements has been introduced [8]. In the same report, the performance of this index was evaluated in children with N-BMI and obesity. It was found that this new index was more applicable during the clinical evaluation of obesity than WHR and was successful to discriminate children with N-BMI and obesity [8]. However, it was not clear whether this index possesses the capacity to differ morbid OB cases with and without MetS findings.

This study was organized as the second part of the previous study [8]. The performance of these recently introduced anthropometry and fat-based indices were investigated in another two groups. In this case, MO and MetS groups were compared.

The aim of this study was to evaluate (WC+HC)/2 as the anthropometry-based ratio and (TF+LF)/2 as the fat-based ratio between MO children with and without MetS findings. The link found between these two parameters in N-BMI and OB groups was also investigated from the MO point of view. Considering the association between obesity and basal metabolic rate (BMR) as well as fat-free mass, the possible effects of these parameters on possible correlations between the ratios [(WC+HC)/2 and (TF+LF)/2] were also considered.

II. Patients and Methods

A. Patients

The study population was composed of 90 MO children; their age- and sex-adjusted BMI percentile values were greater than 99. For this, selection tables prepared by World Health Organization were used [9]. MetS criteria were determined [10]. Two groups were constituted based upon the presence of MetS components. Group 1 comprised children without MetS findings. Group 2 was constituted by children with MetS findings. Elevated systolic/diastolic blood pressure values, increased fasting blood glucose, increased triglycerides/ decreased high density lipoprotein cholesterol concentrations in addition to central obesity were defined as MetS components. Children with at least two of these criteria were included in Group 2. Informed consent forms for joining in the study were filled by the parents of the children. The study protocol was approved by the Non-interventional Clinical Studies Ethics Committee of the institution.

B. Anthropometric Measurements and Related Ratios

Weight, height, WC, HC, head and neck C values of children were measured and recorded.

Within the scope of anthropometry-based indices BMI, WHR and (WC + HC)/2 were calculated.

C. Body Fat Compartments and Fat-Based Obesity Indices

BMR, mass of total body fat, trunk fat, leg fat and arm fat were determined by TANITA Bioelectrical Impedance Analysis.

Appendicular fat mass (sum of arm and leg fat), TLFR (trunk fat divided by leg fat), TAFR (trunk fat divided by appendicular fat), (trunk fat (TF) + leg fat (LF))/2 were calculated.

Values for FMI and D2I values were obtained by the related equations: FMI = total body fat (kg)/(height(m))^2 and D2I = total body fat (kg)*100/height (cm).

D. Statistical Analysis

The analysis of the study data was performed by appropriate tests using SPSS, a statistical package program. Descriptive statistics were done; t test was performed. Statistically significant differences between two groups were performed by t-test. Following correlation analyses, plots for linear regression were constituted.

III. Results

BMI, WC, two ratios using WC [WHR, and (WC+HC)/2], three ratios using trunk fat and leg fat mass [TLFR, TAFR, (TF+LF)/2] and two fat-based obesity indices (D2I, FMI) were considered. All of these parameters, ratios, indices and p values for the statistical significance of the difference between two groups were given in Table I.

Significantly higher values were observed for BMI and WC in Group 2 than those in Group 1 ($p < 0.001$).

TABLE I
Anthropometric, Measurements, Fat Distribution Ratios and Obesity Indices of the Groups (Mean ± SD)

Parameter	MO Group 1	MetS Group 2
BMI*	27.6 ± 5.3	30.3 ± 4.7
WC*	88.2 ± 14.2	97.1 ± 10.4
WHR^{NS}	0.91 ± 0.06	0.94 ± 0.11
(WC+HC)/2*	90.8 ± 15.5	100.9 ± 11.6
TLFR^{NS}	1.01 ± 0.17	0.98 ± 0.16
TAFR^{NS}	0.78 ± 0.12	0.76 ± 0.11
(TF+LF)/2$^{\#}$	9.20 ± 5.45	12.02 ± 4.92
FMI^{NS}	8.33 ± 3.43	9.69 ± 4.00
D2I^{NS}	12.59 ± 6.25	15.17 ± 6.86

Ht = Height, WHR = waist-to-hip ratio, TF = trunk fat, LF = leg fat, NS = not significant. [* $^{1\text{-}2 < 0.001}$. # $^{1\text{-}2 < 0.05}$].

WHR ratios did not differ between the groups. There was a statistically significant difference ($p < 0.001$) between (WC+HC)/2 ratios calculated for each group.

The differences between TLFR and TAFR values of the groups were not significant.

(Trunk fat+leg fat)/2 ratio considering the sum of body fat compartments trunk fat and leg fat was statistically higher in MetS group than MO group without MetS findings ($p < 0.05$).

Fat-based obesity indices, D2I and FMI, did not differ between two groups.

Bivariate correlation analyses have shown strong associations between the anthropometry-based ratio; (WC+HC)/2 and fat-based ratio; (TF+LF)/2 in both MOMetS- ($r = 0.961$; $p < 0.001$) and MOMetS+ ($r = 0.936$; $p < 0.001$) groups. Partial correlations between these two parameters after controlling the effect of BMR were $r = 0.726$; $p < 0.001$ and $r = 0.932$; $p < 0.001$ for MOMetS- and MOMetS+ groups, respectively (Figs. 1 and 2).

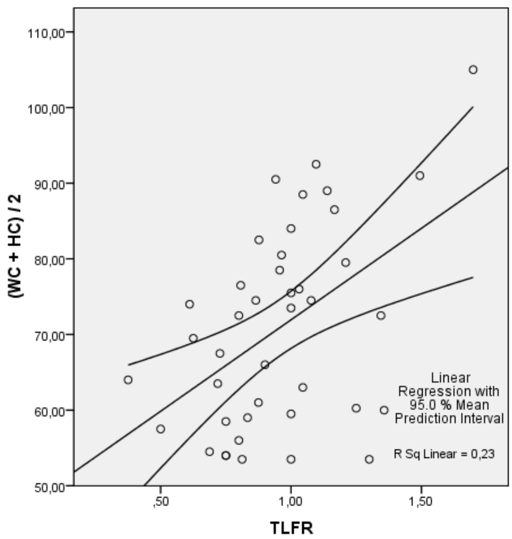

Fig. 1 Partial correlation between (waist circumference+hip circumference)/2 and (trunk fat+leg fat)/2 in MO group

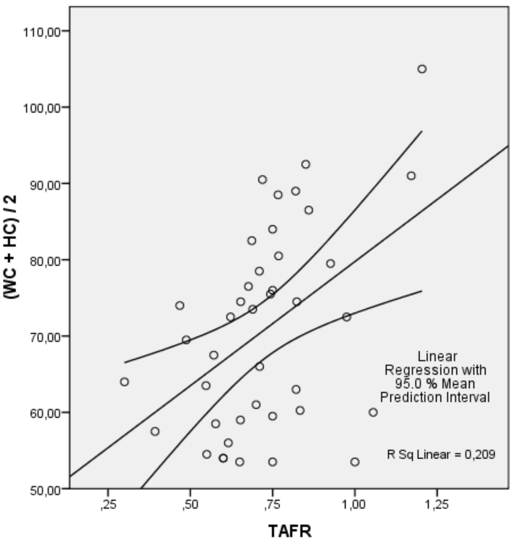

Fig. 2 Partial correlation between (waist circumference+hip circumference)/2 and (trunk fat+leg fat)/2 in MetS group.

The correlation calculated for MOMetS+ group was higher than MOMetS- group.

IV. Discussion

Anthropometric indices and indices related to fat distribution are of the major concern in obesity-related studies. The effect of BMR related to the matter has also drawn attention [3], [11]-[19].

One half of the sum of WC and HC is expected to give a more acceptable and reasonable information about the stages of obesity as well as MetS. The same is true for one half of the sum of amounts of trunk and leg fat compartments of the body.

In a previous study, the values for (WC+HC)/2 and (TF+LF)/2 were given as 71.1 ± 12.9 and 3.29 ± 2.27 for N-BMI group. For OB group, corresponding values were reported as 87.1 ± 9.5 and 7.61 ± 3.04 [8]. In this study, (WC+HC)/2 values for MO and MetS groups were 90.8 ± 15.5 and 100.9 ± 11.6. Values for (TF+LF)/2 for the same groups were calculated as 9.2 ± 5.5 and 12.0 ± 4.9. BMI values for these groups were 27.6 ± 5.3 and 30.3 ± 4.7 kg/m^2.

Strong associations between (WC+HC)/2 and (TF+LF)/2 were found in N-BMI ($r = 0.847$; $p < 0.001$) and OB groups ($r = 0.856$; $p < 0.001$) [8]. In the present study, these correlations were found as $r = 0.961$; $p < 0.001$ and $r = 0.936$; $p < 0.001$ for MO and MetS groups, respectively. The correlations calculated for two groups were strong, being higher in MO children.

In OB individuals, both fat mass and fat-free mass (FFM) were enlarged as compared with that of individuals with N-BMI [20]. BMR is proportional to FFM, OB individuals have greater BMR than children in N-BMI group. In our study, children in MetS group exhibit higher BMR as well as FFM than MO children without MetS findings. These findings agree with the results of a study reporting higher values of FFM in children with MetS [21].

In a recent study, it has been reported that FFM is associated with MetS and that a larger FFM is associated with alterations in cardiometabolic health in spite of the ideas supporting that a large FFM has a protective effect on health [22].

Another study reported the preponderance of some anthropometry as well indices over WHR. BMI and WC exhibited a better performance for the identification of cardiometabolic risks than WHR [23]. Besides, mathematically biased and anthropometrically inconsistent results were reported for WHR [24]. WHR-associated myocardial infarction risk was found to be higher than WC-associated risks. Our study showed that (WC+HC)/2 was a better index than WHR during obesity studies.

When correlations in MO groups were evaluated after controlling the effect of BMR, partial correlations were $r = 0.726$; $p < 0.001$ and $r = 0.932$; $p < 0.001$ for MO children without MetS and with MetS findings, respectively. The relatively higher correlation detected in MO children with MetS findings pointed out that the effect of BMR linked to FFM is more effective in this group of children than MO children without MetS.

There was no significant correlation between WHR and (WC+HC)/2 as well as (TF+LF)/2 in MO and MetS groups. Our study showed that (WC+HC)/2 was correlated with D2I and FMI, however no correlations were observed between WHR and the latter two fat-based obesity indices.

In conclusion, (WC+HC)/2 is a better index than WHR during the obesity studies comparing also MO children with and without MetS. The interesting association found between anthropometric obesity index (WC+HC)/2 and fat-based obesity index (TF+LF)/2 was also valid among MO children.

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