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Waist Circumference-Related Performance of Tense Indices during Varying Pediatric Obesity States and Metabolic Syndrome

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***Abstract*—**Obesity increases the risk of elevated blood pressure, which is a metabolic syndrome (MetS) component. Waist circumference (WC) is accepted as an indispensable parameter for the evaluation of these health problems. The close relationship of height with blood pressure values revealed the necessity of including height in tense indices. The association of tense indices with WC has also become an increasingly important topic. The purpose of this study was to develop a tense index that could contribute to differential diagnosis of MetS more than the indices previously introduced. 194 children, aged 6-11 years, were considered to constitute four groups. The study was performed on normal weight (Group 1), overweight + obese (Group 2), morbid obese [without (Group 3) and with (Group 4) MetS findings] children. Children were included in the groups according to the recommendations of World Health Organization based on age- and gender-dependent body mass index percentiles. For MetS group, MetS components well-established before were considered. Anthropometric measurements as well as blood pressure values were taken. Statistical calculations were performed. 0.05 was accepted as the p value indicating statistical significance. There were no statistically significant differences between the groups for pulse pressure, systolic-to-diastolic pressure ratio and tense index. Increasing values were observed from Group 1 to Group 4 in terms of mean arterial blood pressure and ADTI, which was highly correlated with WC in all groups except Group 1. Both tense index and ADTI exhibited significant correlations with WC in Group 3. However, in Group 4, ADTI, which includes height parameter in the equation, was unique in establishing a strong correlation with WC. In conclusion, ADTI was suggested as a tense index while investigating children with MetS.

***Keywords*—**Blood pressure, metabolic syndrome, waist circumference.

I. Introduction

ANTHROPOMETRIC measurements are essential in obesity studies. These parameters are important particularly for the concise evaluation of children. The anthropometric panel includes height, weight, circumferences of waist, hip, head and neck. MetS is closely associated with the severe form of obesity. To diagnose MetS, clinicians use several parameters called MetS components. Waist circumference is roughly accepted as an indicator of central obesity, which is required for the diagnosis of MetS. Along with height, WC gains clinical use as an important waist-to-height ratio [1]-[4].

During the diagnosis of MetS, some physiological parameters other than central obesity are also taken into account. Two blood pressure (BP) values, systolic (SP) and diastolic (DP), must be above the predetermined values in order to be considered as MetS components. Donma tense index (TI), pulse pressure (PP), mean arterial blood pressure (MABP) are some useful formulas derived from these two BP values [3], [5]-[7]. The association between height and BP was also investigated [8]-[11]. To be more precise, many researchers have suggested to include the height parameter in their indices containing BP values [12]. Hypertension in children and adolescents has been a widely investigated topic [13]. In this context, height-based equations as well as BP-to height ratios were evaluated [14]-[18].

Obesity has been reported to increase the risk of developing high BP, which is called the silent killer [19], [20]. The close relationship between BP values and obesity as well as MetS requires the derivation of some indices, that may help in the differential diagnosis of MetS from morbid obesity.

The relationship between WC and BP has become the focus of attention in children and adolescents [21]-[24] as well as in adults [25]-[29].

Based on the above information, it would be extremely helpful to develop a height-based and WC-related equation, that exhibits different behaviors regarding BP mechanics during altered states of obesity and MetS.

The aim of this study was to develop a tense index exhibiting such an expected performance, compare it with the previously reported indices and make an evaluation among children with normal-body mass index (N-BMI) as well as overweight (OW), obese (OB), morbid obese (MO) children.

II. Patients and Methods

A. Patients and Groups

Ages of the study population vary between 6-11 years. Four groups were constituted. There were 33 children with N-BMI in Group 1. Group 2 was composed of 39 OW and OB children. Group 3 (n = 84) and Group 4 (n = 38) comprised MO children. MO children with MetS findings were included in Group 4.

Age, anthropometric measurements (weight, height, WC, hip circumference, head circumference, neck circumference), SBP and DBP values were recorded during pediatric physical examination.

Informed consent forms were obtained from the parents of the participants of the study.

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The study protocol was approved by Tekirdag Namik Kemal University, Faculty of Medicine Ethics Committee for Non-interventional Clinical Studies.

B. Classification of Varying Obesity States and Constitution of the Group with Normal Body Weight Index

World Health Organization recommended the use of BMI percentiles based on age and gender to constitute obesity groups. The ranges were expressed as 15-85 for the N-BMI group, 86-95 for the OW group, 96-99 for the OB group and greater than 99 for the MO group [30].

C. Metabolic Syndrom Group Features

Central obesity, elevated BP values (values above 80 mm Hg for diastolic, 120 mm Hg for SBP), elevated fasting blood glucose (above 100 mg/dl) concentrations, elevated triglycerides (above 100 mg/dl) or depressed high density lipoprotein cholesterol (below 40 mg/dl) levels were accepted as the MetS criteria [3].

D. Tense Indices

Five indices derived from SP and DP values were evaluated within the scope of this study. The first (Tense Index, TI) was introduced elsewhere [5]. The formula was (SP + DP)/2. The second index (ADTI) was developed during the course of the study. The formula for this index was [(SP + DP)/2]*Height. PP (SP-DP), SP-to-DP ratios and MABP index (2*DP + SP)/3 were the other indices for comparison.

E. Statistics

The statistical package SPSS was used for the calculations. Descriptive statistics was performed to obtain mean and standard deviation values. One way ANOVA was the test used for the comparison of the means to detect the potential statistical differences. In bivariate correlation analysis, correlation coefficients were calculated and t test for the significance control of correlation were performed. Linear regression plots with 95 percent confidence interval were created. The statistical significance degree was accepted as $p < 0.05$.

III. Results

A total of 194 children, whose ages vary between 6-11 years were included into the scope of the study.

Mean ± SD values for age were 8.8 ± 1.0, 8.5 ± 1.1, 8.2 ± 1.0 and 8.1 ± 1.1 years for Group 1 (N-BMI), Group 2 (OW + OB), Group 3 (MO) and Group 4 (MetS), respectively. The corresponding values for height were 130.4 ± 6.1, 133.5 ± 8.7, 135.7 ± 8.9 and 135.9 ± 10.3 cm. There was no statistically significant difference between the groups in terms of age and height values ($p > 0.05$). WC values were 54.2 ± 4.7 cm, 68.5 ± 8.7 cm, 79.6 ± 8.8 cm, 78.2 ± 9.5 cm for groups 1, 2, 3, 4, respectively.

Table I showed the values for some ratios and tense indices calculated in each group. Significantly increasing trends were recorded from Group 1 to Group 4 in MABP and ADTI.

Correlations between the groups were given in Table II.

TABLE I
VALUES FOR SOME RATIOS AND TENSION INDICES (MEAN ± SD)

	Group 1	Group 2	Group 3	Group 4	p
PP	36.5 ± 7.2	35.6 ± 5.3	38.2 ± 8.4	36.5 ± 6.2	NS
SP/DP	1.55 ± 0.15	1.53 ± 0.13	1.54 ± 0.15	1.52 ± 0.12	NS
MABP	79.9 ± 6.7	81.3 ± 7.8	83.9 ± 8.7	84.2 ± 8.0	1-3, 1-4
TI	0.86 ± 0.07	0.87 ± 0.08	0.90 ± 0.09	0.90 ± 0.08	NS
ADTI	111.9 ± 10.4	116.5 ± 12.5	122.7 ± 15.9	122.1 ± 14.5	1-3, 1-4

Group 1 = N-BMI, Group 2 = OW + OB, Group 3 = MO, Group 4 = MetS, TI = Tense Index, NS = not significant.

TABLE II
CORRELATIONS OF TENSE INDICES WITH WC VALUES

WC	Group 1	Group 2	Group 3	Group 4
MABP	r = 0.011; p = 0.953	r = 0.025; p = 0.880	r = 0.375; p = 0.000	r = 0.224; p = 0.177
TI	r = 0.039; p = 0.828	r = 0.036; p = 0.826	r = 0.384; p = 0.000	r = 0.223; p = 0.179
ADTI	r = 0.148; p = 0.411	r = 0.466; p = 0.033	r = 0.604; p = 0.000	r = 0.609; p = 0.000

Group 1 = N-BMI, Group 2 = OW + OB, Group 3 = MO, Group 4 = MetS, TI = Tense Index.

Upon evaluation of correlation coefficients (r values) as well as statistical significance degree (p values) for TI and ADTI, TI was highly correlated with WC only in Group 3. Considering the values obtained for ADTI, index was strongly correlated with WC in all groups except Group 1. In the first group, there was no statistically significant correlation between WC and ADTI.

There was not a significant correlation between WC and TI, however, ADTI was significantly correlated with WC in Group 4, which was composed of children with MetS (Figs. 1 (a) and (b)).

Strong correlations were observed between the values obtained for TI and ADTI (r values 0.859, 0.756, 0.849, 0.822, for Group 1, 2, 3, 4, respectively ($p = 0.001$)).

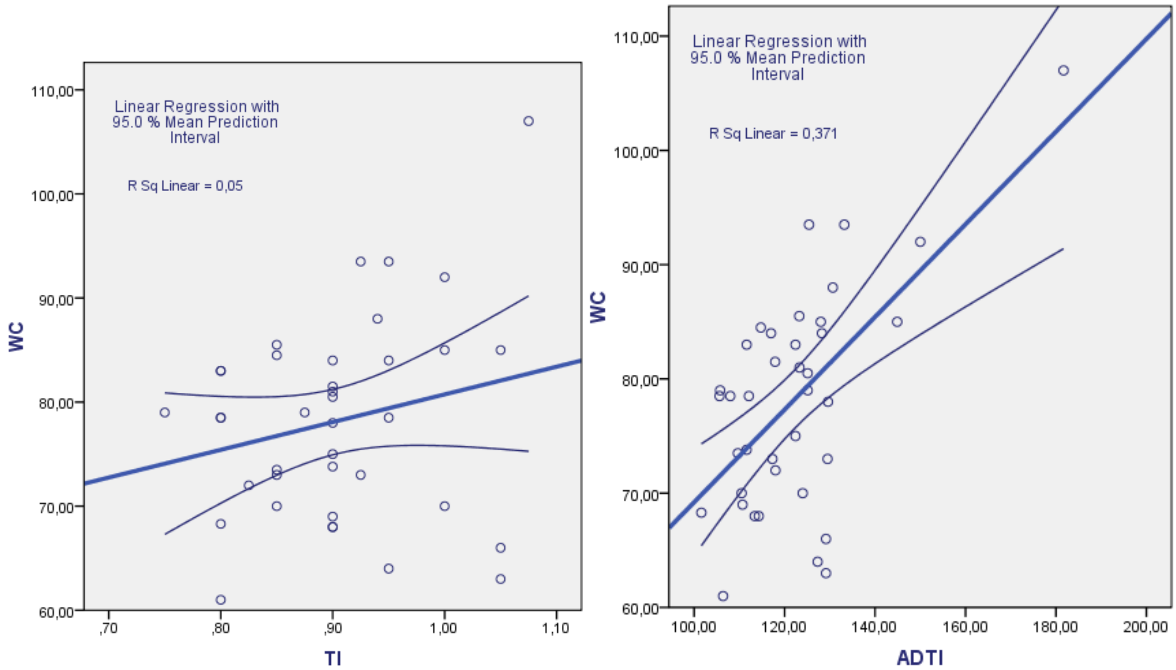
IV. Discussion

WC was suggested as a screening tool for early detection of metabolic risk in children [31] and introduced as a measure upon evaluation of the cardiometabolic risk related to fat distribution [28]. It has also been pointed out that it should be routinely measured both in normal and abnormal cardiometabolic profiles [27]. In both adults and adolescents, strong positive associations between WC and BP were reported [24]-[26].

Height is another parameter, which was widely investigated for its association with BP. Greater height was associated with lower or higher BP values. There are also studies reporting no association [7], [10], [11], [32].

MABP was defined by different equations [6], [7]. However, although these two equations seem different, they actually give the same results [6], [7].

The ratios such as SBP/height, DBP/height, SBP/DBP have recently been introduced as the new standards [7]. However, it would be more logical and informative to combine these two BP values in the same equation as in ADTI. PP, SBP/DBP, MABP and TI were also indices that included both SBP and DBP in their different-formatted equations.



(a) (b)

Fig. 1 Bivariate correlations with linear regression lines between (a) WC and TI and (b) WC and ADTI in Group 4

There was no statistically significant difference among the groups for PP, SBP/DBP and TI. In both MABP and ADTI, significant differences were observed between Group 1-Group 3 (p = 0.004-p = 0.024) and Group 1-Group 4 (p = 0.004-p = 0.030), respectively (Table I). However, when their correlations with WC were evaluated, MABP as well as TI exhibited a non-significant correlation in the MetS group. ADTI, which includes the height parameter, was found to have a significant correlation with WC (Table II).

This study highlighted WC as an important parameter associated with the contribution of height as well as BP to the diagnosis of MetS. In this context, it was concluded that ADTI is a valuable and informative index as it exhibits a significant WC-BP relationship among children with MetS.

ADTI has exhibited a better performance than the previously reported TI [5]. Considering that ADTI contains an additional height parameter, it is understood that height parameter should also be taken into account in addition to MetS components in the evaluation of MetS cases. The findings of the study indicated that both indices should be evaluated together to aid in the diagnosis of MetS.

V. Conclusion

In MO children without MetS findings, both indices (TI and ADTI) were functional. However, in MetS cases, significance appeared upon inclusion of height values for the correlation between WC and ADTI. In conclusion, it may be suggested that both indices should be considered for the diagnosis of MetS during the evaluation of MO children.

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