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Clinical and paraclinical characteristics of metabolic syndrome in children with overweight and obesity in Dong Nai province, Vietnam

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Abstract:

Background: childhood overweight is increasingly common worldwide as are its consequences, which include increased risk of later cardiovascular disease and diabetes. Although metabolic syndrome (MetS) has been extensively studied in adults, not much is known about the condition in children and adolescents. MetS and its individual components are detectable during childhood, and both commonly persist throughout adolescence and adulthood.

Objective: to determine the prevalence of MetS and cut-off values of waist circumference (WC) and body mass index (BMI) for predicting MetS in children with overweight and obesity.

Methods: we conducted cross-sectional analysis of 510 children with overweight and obesity aged 10 to 15 years in Bien Hoa city, Dong Nai province (2012-2014). MetS diagnosis was defined according to the 2007 International Diabetes Federation definition.

Results: a relationship existed between BMI and dyslipidaemia (p<0.05). Among all participants, 31.37% met the criteria for MetS (female>male, p>0.05). The most common manifestation of MetS in this study was WC-blood pressure-triglyceride (41.15%). The cut-off anthropometry values for predicting MetS were as follows: BMI of 25.00 in boys and 24.50 in girls, and WC of 82 cm in boys and 80 cm in girls.

Conclusions: the prevalence of MetS was 31.37% among children with overweight and obesity. The cut-off values of WC and BMI in this study could be the optimal threshold for predicting MetS in such children aged 10 to 15 years.

Keywords: **MetS in children, MetS in overweight, obesity, overweight, Vietnam.**

Classification number: **3.2**

Introduction

Metabolic syndrome (MetS) is one of the most concerning public health problems of the 21st century. According to the International Diabetes Federation (IDF), MetS is a cluster of risk factors for two major pandemics - cardiovascular disease (CVD) and type 2 diabetes - affecting quality of life and incurring significant costs to the health-care economy of multiple countries worldwide [1, 2].

Obesity is rapidly increasing with MetS in adults as well as in children. In Bolivia, M. Caceres, et al. studied 61 children aged 5-18 years with a body mass index (BMI)>95th percentile by age and gender (2006-2007); the results revealed that the proportion of children with MetS was 36% (40% in boys and 32.2% in girls). The prevalence of impaired glucose tolerance, elevated triglyceride (TG), low high-density lipoprotein cholesterol (HDL-C), high blood pressure (BP), and insulin resistance were 8.2, 42.6, 55.7, 24.5, and 39.4%, respectively [3]. Children at high risk of CVD could be identified from their waist circumference (WC) and waist-to-hip ratio [4].

A.P. Ferreira, et al. [5] studied 52 obese children aged 7-10 years, and found the prevalence of MetS was 17.3% with BMI>95th percentile, elevated TG, low HDL-C, high blood glucose, and hypertension. According to R. Weiss, et al.' 2004 study, the prevalence of MetS was also increasing in children. The figures were 38.7 and 49.7% in children with moderate and severe obesity, respectively [6].

MetS is closely related to overweight and obesity. This has prompted interest in terms of epidemiology and preventive approaches in the aspect of chronic noncommunicable diseases. CVDs in adults derive from metabolic disorders in childhood [6], and thus, early prevention of atherosclerosis would be conducive to enhanced results [7, 8]. CVD and its mortality are just the tip of the iceberg, of which series of metabolic abnormalities appeared silently before.

To construct an effective MetS monitoring and intervention system, having access to basic data on the nature of this problem is imperative. However, few studies

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have been conducted on MetS in children with overweight and obesity in Vietnam. Based on the abovementioned arguments, we conducted a study of MetS in such children aged 10 to 15 years. The aim was to contribute to the detection and prevention of the consequences caused by MetS, thereby contributing to reducing spending on treatment fees and improving patients' quality of life. This study had the following objectives:

1. To identify characteristics of dyslipidemia and blood glucose in children with overweight and obesity.

2. To determine clinical and subclinical characteristics of MetS as well as the cut-off values of WC and predictive BMI in children with overweight and obesity aged 10 to 15 years.

Material and methods

Study design

The study was conducted based on a cross-sectional study design.

Subjects: students aged 10-15 years who met an eligible diagnosis of overweight or obesity and were studying at secondary schools in Bien Hoa city, Dong Nai province.

Sampling

To determine the prevalence of MetS in overweight - obese children in the community, the sample size was calculated according to the formula of estimated sample size n=$\frac{Z^2}{d^2}.P.q$ (the testing sample size of prevalence of MetS in overweight - obesity children was approximately 15%); $n=\frac{1.96^2 x\, 0.15x0.85}{0.04^2}=306$.

Because of school sampling, adjusting to limit the design impact was done by multiplying by the design effect=1.5. Accordingly, the sample size was 306x1.5=459. The estimated participation rate was 95%; therefore, the necessary sample size was n=459/0.95=483. We chose approximately 500 overweight and obese students aged 10-15 years.

Sampling technique: multistage sampling.

Step 1: from a list of 32 secondary schools in Bien Hoa city, 16 were randomly chosen. Overweight and obese children were classified based on CDC classification 2000 by age and gender (2000 CDC BMI for ageing growth charts for girls and boys); 85^{th} percentile $\leq$BMI<95^{th} percentile was overweight and BMI$\geq 95^{th}$ percentile was obese.

We divided the children into three levels: level 1=$85^{th}\leq$ BMI<90^{th}; level 2=$90^{th}\leq$BMI<95^{th}; and level 3: BMI$\geq 95^{th}$ percentile.

Height was measured twice with subjects barefoot to an accuracy of ±0.1 cm. Furthermore, weight was measured twice with subjects lightly dressed to an accuracy of ±0.1 kg. BMI (kg/m^2) was calculated as weight (kg) divided by the square of height (m). WC was measured to an accuracy of ±0.1 cm with a nonelastic measuring tape. Moreover, it was measured at a point halfway between the lower border of the thorax and the iliac crest at the end of expiration.

Body fat ratio (BFP) measurements were based on bioelectrical impedance analysis and performed using an Omron device (Japan). Subjects were required to fast for 8 hours prior to taking a blood test.

Step 2: overweight and obese students were selected from the 16 secondary schools.

- The calculated sample size was 500. We selected an average of 32 overweight, obese students in each school, among which the number of boys and girls was nearly equal.

- All students of the selected classes were invited to join the study. A fact sheet explaining the purpose and procedure was provided to each student and their parents.

Step 3: diagnostic criteria of MetS.

- WC $\geq 90^{th}$ percentile based on the percentile of Y.T.S. Rita, et al. [4].

- TG≥150 mg/dL; HDL-C<40 mg/dL; systolic BP (SBP) ≥130 mmHg or diastolic BP (DBP) ≥85 mmHg; blood glucose ≥100 mg/dL [9].

- According to IDF (2007): WC$\geq 90^{th}$ percentile and the presence of at least two standards listed by age and gender considering that children had MetS.

Step 4: data processing using the EPI.DATA software package.

Receiver operator characteristic (ROC) curve analysis was used to estimate risk cut-off points (WC and BMI by gender). Sensitivity, specificity, and positive and negative predictive values were calculated for each cut-off point. We used logistic regression odds ratios to determine the risk index of indicators according to the cut-off point of MetS. A p-value<0.05 was considered statistically significant.

Ethical issues

- These tests were conducted in agreement with families and schools prior to proceeding (with informed consent forms - ICF).

- The study was approved by the Science Council and Ethics Committee of Dong Nai Department of Health.

Results

The sample size included a total of 510 children with overweight and obesity. The proportions of boys and girls were 49.80 and 50.20%, respectively; 41.96% of participants were overweight and 58.04% were obese.

Characteristics of dyslipidemia and blood glucose (Tables 1, 2)

Table 1. Average values of blood lipid and blood glucose.

Criteria	General (X±SD) n=510	Male (X±SD) n=254	Female (X±SD) n=256	p-value
CT (mg/dL)	184.78±45.48	182.50±45.84	187.04±45.11	0.307
TG (mg/dL)	157.29±78.81	156.27±70.31	158.31±67.41	0.738
HDL-C (mg/dL)	51.58±7.86	52.14±7.39	51.03±8.28	0.111
LDL-C (mg/dL)	110.20±39.04	107.15±36.91	113.27±40.89	0.076
Glucose (mg/dL)	88.51±14.36	88.30±15.54	88.72±13.10	0.739

A t-test was used for the average data (all values are average±SD). Cholesterol (CT); triglyceride (TG); high-density lipoprotein cholesterol (HDL-C); low density lipoprotein cholesterol (LDL-C).

No differences existed in the average values of blood lipids, including CT, TG, HDL-C, LDL-C, and blood glucose between both genders (p>0.05).

Table 2. Blood lipid disorder according to BMI levels.

Blood lipid	BMI *Level 1* *n=34*	*Level 2* *n=180*	*Level 3* *n=296*	Total n=510	p-value
No disorder	14	49	49	112 (21.96%)	
Disorder	20	131	247	398 (78.04%)	
1 index	9 (3.77%)	91 (38.07%)	139 (58.16%)	239 (60.05%)	
2 indexes	6 (5.56%)	32 (29.63%)	70 (64.81%)	108 (27.14%)	0.001
≥3 indexes	5 (9.81%)	8 (15.68%)	38 (74.51%)	51 (12.81%)	

The percentages of the groups without and with blood lipid disorder were 21.96% and 78.04%, respectively. In the group with blood lipid disorder, the proportion of the disorder greater than or equal to three blood lipid indexes was a low percentage (12.81%), whereas the proportion of the disorder of one blood lipid index was a high percentage (60.05%). BMI at level 3 with a proportion of the disorder greater than or equal to three lipid indexes concurrently was higher than BMI at levels 1 and 2. This difference was statistically significant (p<0.05).

MetS

Clinical and subclinical characteristics of MetS (Tables 3-5):

Table 3. Proportion of MetS in total and by gender.

Gender	MetS	No MetS	Total	p-value
Male	71 (44.38%)	183 (52.29%)	254 (49.80%)	0.097
Female	89 (55.62%)	167 (47.21%)	256 (50.20%)	
Total	160 (31.37%)	350 (68.63%)	510 (100.00%)	

The proportion of MetS was 31.37%, with a higher percentage in females than males (p>0.05).

Table 4. Clinical and subclinical characteristics of MetS.

Criteria	No MetS (X±SD, n=350)	MetS (X±SD, n=160)	p-value
WC (cm)	84.07±6.12	87.44±7.11	0.001**
WC/HC	0.94±0.05	0.95±0.06	0.233
WC/Height	0.55±0.04	0.56±0.04	0.158
BMI	25.91±2.63	26.94±2.67	0.001**
SBP (mmHg)	117.30±11.31	130.91±13.53	0.001**
DBP (mmHg)	69.29±8.57	75.34±9.73	0.001**
TG (mg/dL)	139.17±57.57	196.94±74.67	0.001**
HDL-C(mg/dL)	53.01±6.76	48.45±9.41	0.001**
CT/HDL-C	3.63±1.17	3.79±1.08	0.144
Glucose (mg/dL)	86.04±12.59	93.92±16.39	0.001**

A t-test was used for the average data, $p^{*}<0.05$ and $p^{**}<0.001$. Waist circumference (WC); hip circumference (HC); Body Mass Index (BMI); systolic blood pressure (SBP); diastolic blood pressure (DBP); triglyceride (TG); high-density lipoprotein cholesterol (HDL-C); cholesterol (CT).

A statistically significant difference existed between the two groups with and without MetS with respect to WC, BMI, SBP, DBP, TG, HDL-C, and blood glucose (X±SD), p<0.05.

Table 5. Combined forms of MetS.

	WC-BP-TG	WC-TG-Glucose	WC-BP-Glucose	WC-BP-HDL-C	WC-TG-HDL-C	WC-Glucose-HDL-C
%	41.15%	21.05%	14.84%	9.57%	8.61%	4.78%

Blood pressure=BP.

The most common combination form was WC-BP-TG (41.15%).

Values of anthropometric cut-off points for predicting MetS (Figs. 1-4):

BMI cut-off point:

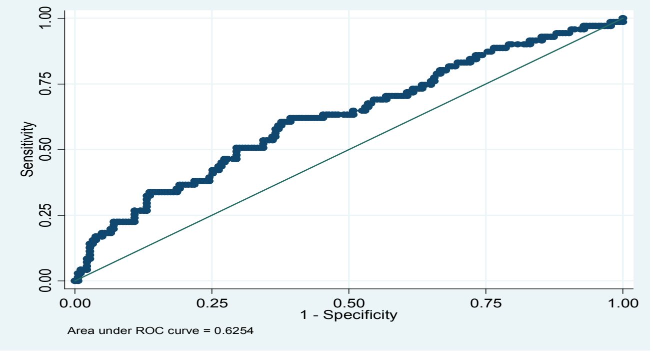

Fig. 1. ROC curve of the BMI to predict MetS in males.

For males: BMI=25.00; sensitivity (Se)=70.42%; specificity (Sp)=39.34%. Youden index=0.0976 was chosen as the value of the predictive cut-off point of MetS (95% confidence interval (CI): 54.68-70.39). Area under the curve ROC, AUC=0.6254.

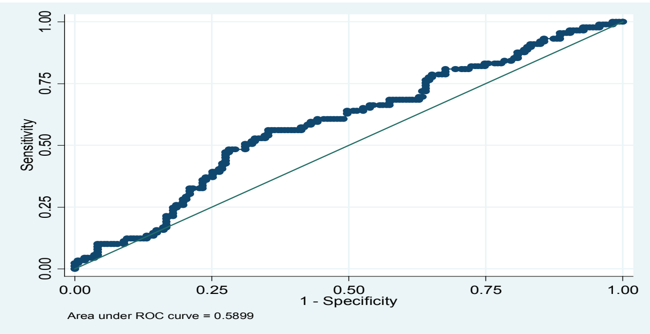

Fig. 2. ROC curve of the BMI for predicting MetS in females.

For females: BMI=24.50; Se=78.63%, Sp=33.93%. Youden index=0.1256 was chosen as the value of the predictive cut-off point of MetS (95% CI: 51.68-66.30). Area under curve ROC, AUC=0.5899.

WC cut-off point:

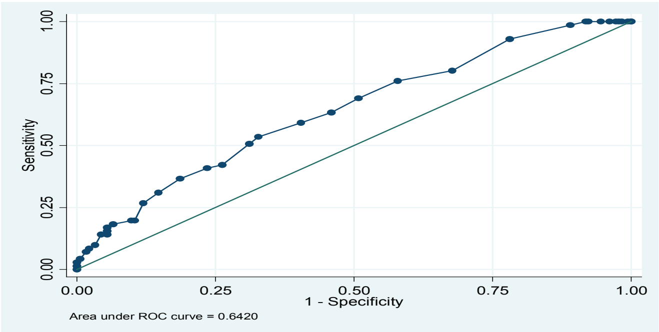

Fig. 3. ROC curve of the WC for predicting MetS in males.

For males: WC=82 cm; Se=76.06%, Sp=43.08%. Youden index=0.1914 was chosen as the value of the predictive cut-off point of MetS (95% CI: 56.73-71.66). Area under the curve ROC, AUC=0.6420.

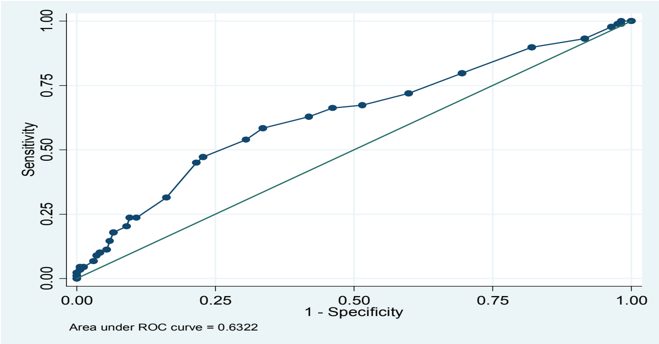

Fig. 4. ROC curve of WC for predicting MetS in females.

For females: WC=80 cm; Se=79.78%, Sp=31.54%. Youden index=0.1062 was chosen as the value of the predictive cut-off point of MetS (95% CI: 55.88-70.56). Area under the curve ROC, AUC=0.6322.

Discussion

Characteristics of dyslipidaemia and blood glucose

In South Korea, Kim studied 2,272 males and females aged 10-18 with overweight - obesity. Results revealed that variations existed in TG ($p<0.0001$), HDL-C ($p=0.001$), LDL-C ($p=0.001$), and CT ($p<0.0001$) in males, and in TG ($p<0.0001$), HDL-C ($p=0.003$), LDL-C ($p=0.004$), and CT ($p<0.002$) in women when compared with the results of a group with normal BMI [2].

In 2013, Khashayar conducted a study of 5,738 children in Iran aged 10-18 years (among whom 17.7% had overweight - obesity). Results showed that the proportion of the disorder of 1, 2, 3, and 4 blood lipid indexes were 34.7, 6.4, 1.2, and 0.4%, respectively [10].

Because Khashayar's study had only 17.7% overweight - obese children, the proportion of characteristics of dyslipidaemia might be lower than that in our study. The prevalence of MetS in our study was 2.5%, particularly for the overweight - obese group; according to IDF standards, this figure was found to be 15.4% [10]. Our research results were in relative agreement with other authors' findings.

MetS

Clinical and subclinical characteristics of MetS: Ferreira, et al. (2011) conducted a cross-sectional study of 958 children aged 7-11 years in Brazil, among whom the proportions of overweight and obesity were 10.8 and 7.7%, respectively. The prevalence of MetS was 23% in obese children (13.3% in males and 36% in females, $p<0.05$) [5]. In 2011, J. Olza, et al. [11] studied 478 obese children (213 females and 265 males) in Spain, and the results demonstrated a relatively high prevalence of MetS in prepubescence from 8.3 to 34.2% and in puberty from 9.7 to 41.2%. In the study of Caceres, the prevalence of MetS in obese children was 36% [3]. In the present study, the prevalence of MetS was 31.37% (female>male, $p>0.05$), which was similar to the abovementioned studies [3, 5].

Significant differences existed in the prevalence of TG, HDL-C, glucose, WC, SBP, and DBP between the groups with and without MetS [3]. Similar findings were found by D.A. Caranti, et al. [12]. In addition, we found that differences existed in each criterion between groups (Table 4).

W. Liu, et al. studied 1,844 children aged 7-14 years, the proportions of overweight and obesity were 11.1 and 7.2%, respectively. The proportion of the group with MetS was 6.6%, of which 33.1% were overweight children and 20.5% were obese; this figure was 2.3% in the group without MetS. Furthermore, 49.3% of children had at least one component of MetS [13]. The common combination forms were WC-BP-TG and WC-TG-glucose, which accounted for 41.15 and 21.05%, respectively.

Values of the anthropometric cut-off points for predicting MetS: in 2005, a study conducted in Italy showed that overweight - obese children with WC>90th percentile had more cardiovascular risk factors than did children with WC<90th percentile. The cut-off value of WC>70th percentile predicted an abnormal transformation based on the ROC (Se=76%, Sp=81%) [12].

In 2007, Hirschler studied BMI and WC for predicting MetS in children with a mean age of 8.7±2.4. A cut-off value of WC ≥75th percentile was the optimal threshold for predicting MetS in children. The optimal threshold for WC was 71.3 cm with Se=58.9% (95% CI: 48.4-68.9) and Sp=63.1% (95% CI: 58.4-67.7) to diagnose MetS [14].

A.P. Ferreira, et al. (2011) conducted a cross-sectional study on 958 children aged 7-11 years in Brazil, among which the proportion of children with overweight and obesity were 10.8 and 7.7%, respectively. The prevalence of MetS was 23% in obese children (13.3% in males and 36% in females, $p<0.05$) according to NCEP-ATP III criteria. The cut-off value of BMI was 24.5 kg/m^2, that of BFP was 41% based on dual energy X-ray absorptiometry, that of WC was 78 cm, and that of WC/HC was 0.92 to predict MetS in overweight and obese children [5].

In 2012, F. Saffari, et al. [15] conducted a study on more than 100 healthy children aged 6-16 years in Iran (58% were female) with BMI=26.02±4.38, of which overweight and obese children accounted for 20% and 80%, respectively. The frequency of insulin resistance was 81%; MetS accounted for 50% in the target group and 66.2% in the obese group (NCEP-ATP III standard). By contrast, in the study of Weiss, et al., MetS accounted for 25% in the overweight group and 42.5% in the obese group.

Our study focused on children aged 10-15 years with overweight - obese. The proportion of children with BMI>95th was 58.04%. The prevalence of MetS was 31.37% and the value of the predictive cut-off point of MetS was similar to foreign authors' findings. Moreover, we did not find many other studies for comparison; thus, the given value was used as a reference. Future studies should acquire more research data to determine the cut-off points of WC and BMI for predicting MetS.

Conclusions

In this study, the prevalence of dyslipidaemia among overweight - obese children aged 10-15 years old was 78.04%. A correlation existed between BMI levels and blood lipid disorders, $p<0.001$. Furthermore, the prevalence of MetS in this study was 31.37%, and the most common combined form of MetS among these subjects was WC-BP-TG, accounting for 41.15%.

The optimal values of the cut-off points for predicting MetS were as follows:

For males, BMI=5.00, AUC=0.6254; and for females, BMI=24.50, AUC=0.5899.

For males, WC=82 cm, AUC=0.6420; and for females, WC=80 cm, AUC=0.6322.

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