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Original Article

Metabolic syndrome and visceral fat thickness in obese adolescents

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Abstract

Background Metabolic syndrome (MS) is one of the long-term consequences of obesity which can be found in adolescents. MS is caused by excessive visceral fat accumulation. The visceral fat thickness (VFT) itself can be measured by using waist circumference (WC) measurement and abdominal ultrasonography. Until now, there are no WC and VFT cut-off points to predict MS in children and adolescents. This study used MS criteria based on National Cholesterol Education Program – Adult Treatment Panel III (NCEP-ATP III) which specifically modified.

Objective The objectives of this study are (a) to determine the MS ocurrence based on modified NCEP-ATP III in obese adolescents; (b) to measure the VFT by using abdominal ultrasonography in obese adolescent with MS and obese adolescent without MS.

Methods We conducted a cross-sectional study from March to May 2006. Fifty obese adolescents were recruited from several junior and senior high schools in Jakarta.

Results Of those 50 obese adolescents, there were 34 subjects with $WC \geq P_{80}$ and 16 subjects with $WC < P_{80}$. Of those 34 subjects with $WC \geq P_{80}$, 17 subjects had MS and the others had no MS. All the 16 subjects with $WC < P_{80}$ did not have MS. The VFT in 17 subjects with $WC \geq P_{80}$ who had MS was 5.19 cm (SD 2.07 cm). The VFT in 17 subjects with $WC \geq P_{80}$ who had no MS was 3.94 cm (SD 1.62 cm). The VFT in all 16 subjects with $WC < P_{80}$ who did not have MS was 3.54 cm (SD 0.92 cm). All obese adolescents with MS had $WC \geq P_{80}$ and they also had visceral fat which was thicker than obese adolescents without MS.

Conclusions All obese adolescents with MS have $WC \geq P_{80}$ and thicker visceral fat than obese adolescents without MS; the VFT of obese adolescents without MS, who had $WC \geq P_{80}$ was 3.94 cm (SD 1.62 cm), and the VFT of obese adolescents without MS, who had $WC < P_{80}$ was 3.54 cm (SD 0.92 cm). **[Paediatr Indones 2007;47:124-129]**.

Keywords: *obese adolescents, metabolic syndrome, waist circumference, visceral fat thickness*

Obesity is a disease caused by excessive fat accumulation in the body.[1] One of the long-term consequences of obesity, which can usually be found in adults is metabolic syndrome (MS) that consists of hypertension, dyslipidemia, and insulin resistance.[2,3] MS, which can also be found in adolescents as the results of excessive accumulation of visceral fat, and it is an important target in decreasing cardiovascular disease risks (coronary heart disease, miokard infark, and stroke) and type-2 diabetes mellitus.[2-4] Waist circumference (WC) and abdominal ultrasono-graphy are used to measure the visceral fat thickness (VFT), but there are no waist circumference and visceral fat thickness' cut-off in predicting metabolic syndrome for children yet.[5-7] The recent MS criteria are used only for adults;[8] therefore, this study used the National Cholesterol Education Program – Adult Treatment Panel III (NCEP-ATP III) which specifically modified only in this study.

The aims of this study were to examine (a) the proportion of metabolic syndrome, based on NCEP-ATP III specifically modified only in this study in obese

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adolescents with WC $<P_{80}$ and obese adolescents with WC$\geq P_{80}$, and (b) the VFT measurement, using abdominal ultrasonography in obese adolescents with MS and obese adolescents without MS, in the two groups of WC.

Methods

This study was conducted at Department of Child Health, Cipto Mangunkusumo Hospital, Jakarta. We enrolled 50 obese adolescents who fulfilled the inclusion criteria; they were recruited from several junior and senior high schools in Jakarta. The inclusion criteria were (a) adolescent aged 10-19 years old, (b) subject fulfilled obesity criteria (at or above the 95th percentile of body mass index based on age and sex), (c) subject was not in the course of hypertension, dyslipidemia, or type-2 diabetes mellitus treatments. The exclusion criteria include: (1) parents did not allow their child to participate in this study, or did not sign the informed consent, (2) subject was in severely sick during the time of study, (3) subject suffered from dehydration, organomegaly, edema or ascites, and (4) subject did not present on the day of study.

All subjects went thorough physical examina-tion included weight, height and waist circumfe-rence, blood pressure, blood specimen analysis, and visceral fat thickness measurements. Weight was measured in kilogram with calibrated digital Soehnle weight scale, and height was measured in standing position with vertical stadiometer, without wearing socks and shoes. Waist circumference was measured in cm with Soehnle unelastic tape in standing position at midpoint between lowest rib and iliac crest. Blood pressure was measured manually in mmHg with Nova sphygmomanometer after the subject had about five minutes in sitting position and repeated with the interval of 15 minutes. Blood specimen was collected after 10 hours of fasting to examine the triglyceride, high density lipoprotein (HDL) cholesterol, and plasma glucose concentra-tion in mg/dL. Visceral fat thickness was measured one cm above umbilicus with SonoAce 8800 ultrasonography by a pediatric radiologist with the accuracy of 0.1 cm. The waist, blood pressure, and visceral fat thickness measurements were performed twice and the average values were used.

MS based on NCEP-ATP III specifically modified only in this study was defined if subject met at least three out of five components of metabolic syndrome (hypertension, central/abdominal obesity, high triglyceride concentration, low HDL choles-terol concentration, and impaired fasting plasma glucose concentration). Hypertension was defined as the systolic or diastolic blood pressure was at or above the 95th percentile based on sex, age, and height.[9] Central/abdominal obesity was defined as waist circumference was at or above the level of Taylor's 80th percentile (**Table 1**).[10] Impaired fasting plasma glucose and high triglyceride concentrations were defined as their levels were at or above 110 mg/dL.[11] Low HDL concentration was defined as its level was at or less 40 mg/dL.[11] Visceral fat thickness was defined as the distance from internal face of the rectus abdominis muscle and the anterior wall of the aorta.[12] The VFT measurement was conducted at the end of quite expiration, while subject was in relax condition. All descriptive data were presented in text and tables.

Results

There were 31 (62%) obese adolescent boys and 19 (38%) obese adolescent girls from several junior and senior high schools from March to May 2006. The mean of age was 16.21 (SD 1.19) years old and VFT was 4.24 (SD 1.74) cm. Thirty-four (68%) obese adolescents had WC$\geq P_{80}$ and 16 (32%) obese adolescents had WC$<P_{80}$. About 21 (42%) obese adolescents had high triglyceride concentration, 21 (42%) obese adolescents had low HDL cholesterol concentration, and no subjects had impaired fasting plasma glucose. Twenty-three (46%) obese adoles-cents suffered hypertension, 12 (24%) obese adolescents suffered pre-hypertension, and 15 (30%) had normal blood pressure. Metabolic syndrome was found in 17 out of 50 obese adolescents (34%) **(Table 2.)**

Table 2 shows the characteristics of in all sub-jects based on waist circumference. MS was found in 17 out of 34 obese adolescents with WC$\geq P_{80.}$ On the other hand, none of 16 obese adolescents with WC $<P_{80}$ suffering MS. Of those 22 obese adolescent boys with WC$\geq P_{80}$, MS was found in 11 obese adolescent boys. Six out of 12 obese adolescent girls with WC$\geq P_{80}$ also suffered MS. The other characteristic

proportions in all subjects based on waist circumference varied **(Table 2)**.

Thirty-three obese adolescents with no MS consisted of 20 obese adolescent boys and 13 obese adolescent girls. The mean of age of obese adolescents with MS was 16.3 (SD 1.39) years old. The mean of age of obese adolescents without MS was 16.18 (SD 1.10) years old. **(Table 3)**

Table 1. Taylor's cut-off for identifying high trunk fat mass and waist circumference in growing children[10]

Age[1]	Girls: Trunk fat mass (kg)	Girls: Waist circumference (cm)[2]	Boys: Trunk fat mass (kg)	Boys: Waist circumference (cm)[2]
3	0.94	50.3	0.93	53.1
4	1.29	53.3	1.21	55.6
5	1.75	56.3	1.56	58.0
6	2.32	59.2	1.97	60.4
7	3.03	62.0	2.46	62.9
8	3.88	64.7	3.02	65.3
9	4.87	67.3	3.64	67.7
10	5.99	69.6	4.34	70.1
11	7.24	71.8	5.08	72.4
12	8.59	73.8	5.86	74.7
13	9.99	75.6	6.65	76.9
14	11.40	77.0	7.43	79.0
15	12.76	78.3	8.18	81.1
16	14.02	79.1	8.86	83.1
17	15.10	79.8	9.45	84.9
18	15.97	80.1	9.42	86.7
19	16.57	80.1	10.25	88.4

[1]Cut-off were calculated for the midpoint ages (i.e, 8.5 y for 8-y-old children)
[2]Best waist circumference cut-off (80th percentile)

Table 2. The characteristics proportion in all subjects based on waist circumference

Characteristics	Total (n=50), %	Total WC: WC≥P_{80} (n=34)	Total WC: WC<P_{80} (n=16)	Boys WC: WC≥P_{80} (n=22)	Boys WC: WC<P_{80} (n=9)	Girls WC: WC≥P_{80} (n=12)	Girls WC: WC<P_{80} (n=7)
Sex							
Boy	31 (62)		22	9			
Girl	19 (38)		12	7			
Age, years old (*mean* ± SD)	16.21±1.19	16.03±1.10	16.60±0.89	16.00±0.98	16.77±0.76	16.10±1.76	16.38±1.05
VFT, cm, (*mean* ± SD)	4.24 ±1.74	4.57±1.94	3.54±0.92	4.64±2.15	3.58±0.79	4.42±1.54	3.49±1.14
Waist circumference (WC)							
WC≥P_{80}	34 (68)						
WC<P_{80}	16 (32)						
Trygliceride							
High	21 (42)	17	4	10	2	7	2
Normal	29 (58)	17	12	12	7	5	5
HDL cholesterol							
Low	21 (42)	15	6	10	5	5	1
Normal	29 (58)	19	10	12	4	7	6
Fasting plasma glucose							
Impaired	0 (0)	0	0	0	0	0	0
Normal	100 (100)	34	16	22	9	12	7
Blood pressure							
Hypertension	23 (46)	16	7	12	3	4	4
Pre-hypertension	12 (24)	7	5	5	4	2	1
Normal	15 (30)	11	4	5	2	6	2
Metabolic syndrome							
Yes	17 (34)	17	0	11	0	6	0
No	33 (66)	17	16	11	9	6	7

SD: standard deviation; VFT: viseral fat thickness; WC: waist circumference; P_{80}: Taylor's 80th percentile[10]; HDL: high density lipoprotein

The VFT of obese adolescents with MS was 5.19 cm (SD 2.07 cm) and the VFT of obese adolescents without MS was 3.75 cm (SD 1.32 cm). Obese adolescent with MS had visceral fat thicker than that of obese adolescent without MS. The VFT of obese adolescent boys with MS was 5.32 cm (SD 2.47 cm) and the VFT of obese adolescent boys without MS was 3.80 cm (SD 1.30 cm). The VFT of obese adolescent girls with MS was 4.96 cm (SD 1.22 cm) and the VFT of obese adolescent girls without MS was 3.67 cm (SD 1.40 cm). **(Table 3)**

There were three obese adolescents who had no component of MS, 15 obese adolescents who had one component of MS, and 15 obese adolescents who had two components of MS. Of those 15 subjects who had one component of MS; six subjects had WC$\geq P_{80}$, four with hypertension, four with low HDL concentration, and one with high trygliceride concentration. **(Table 3)**

Fourteen obese adolescents had three components of MS, five of them had WC$\geq P_{80}$, high trygliceride and low HDL cholesterol concentration; four with WC$\geq P_{80}$, hypertension, and low HDl cholesterol concentration; and five with WC$\geq P_{80}$, hypertension, and high trygliceride concentration. Three obese adolescents had four components of MS which were WC$\geq P_{80}$, hypertension, high trygli-ceride and low HDL cholesterol concentration. **(Table 3)**

The VFT of all obese adolescents with MS who had WC$\geq P_{80}$ was 5.19 (SD 2.07) cm. The VFT of obese adolescents who had no MS with WC$\geq P_{80}$ was 3.94 (SD 1.62) cm and the VFT of obese adolescents who had no MS with WC $<P_{80}$ was 3.54 (SD 0.92) cm . **Table 4** also shows the VFT in the two groups of WC and sexes with and without MS.

Table 3. The characteristics proportion between obese adolescents with metabolic syndrome and obese adolescents without metabolic syndrome

Characteristics	Obese adolescents With MS (n=17)	Obese adolescents Without MS (n=33)
Sex		
Boys	11	20
Girls	6	13
Age, years old (*mean* ± SD)	16.29 ± 1.39	16.18 ± 1.10
VFT, cm, (*mean* ± SD)	5.19 ± 2.07	3.75 ± 1.32
Boys	5.32 ± 2.47	3.80 ± 1.30
Girls	4.96 ± 1.22	3.67 ± 1.40
No component of MS	-	3
1 component of MS	-	15
2 components of MS	-	15
3 components of MS	14	-
4 components of MS	3	-
5 components of MS	0	-

Discussion

There are several limitations in this study. Firstly, the number of subjects in both of WC groups was different, because many subjects with WC $<P_{80}$ refused to join the study, and it was very difficult to find obese adolescents with WC $<P_{80}$. It caused the proportion of MS in both WC groups could not be compared one to another. Secondly, use of percentile of WC from different population (New Zealand) due to the lack of Indonesian WC data, has caused the proportion of MS in Indonesian children could not be accurately determined. Third, none of subjects with WC $<P_{80}$ suffering MS was found. Therefore, VFT in this group could not be compared to VFT in the other three groups (WC$<P_{80}$ without MS, WC$\geq P_{80}$ with MS, and WC$\geq P_{80}$ without MS groups). It was due to the difference of sample size in both groups of WC and the small sample size of the study as a whole.

In this study, the proportion of high triglyceride concentration, low HDL cholesterol concentration, hypertension, and pre-hypertension varied in both of WC groups for boys, girls, and all subjects. It seemed there were no tendency of higher proportion of subject's characteristics in each of WC groups. It was probably caused by the small sample size in both of WC groups.

There were no subjects suffering from impaired fasting plasma glucose, because insulin resistance might not have happened in all of the subjects yet. In order to prove that, insulin resistance test should better be conducted.

Tabel 4. Visceral fat thickness based on waist circumference and metabolic syndrome in boys, girls, and all subjects

	Visceral Fat Thickness LP $<P_{80}$ MS (-) (cm)	LP $<P_{80}$ MS (+) (cm)	LP $=P_{80}$ MS (-) (cm)	LP $=P_{80}$ MS (+) (cm)
Total	3.54 ± 0.92	-	3.94 ± 1.62	5.19 ± 2.07
Boys	3.58 ± 0.79	-	3.97 ± 1.63	5.32 ± 2.47
Girls	3.49 ± 1.14	-	3.88 ± 1.74	4.96 ± 1.22

All of the subjects suffering from MS had $WC \geq P_{80}$, and no subjects having $WC < P_{80}$ suffered from MS. This result is in accordance with other reports emphasizing that MS is usually detected in children and adults with large WC compared to the small one.[13-15] Waist circumference has a strong correlation with VFT,[16] which has correlation with MS.[2,3,8,17]

We noted that visceral fat in all obese adolescents, obese adolescent boys, and obese adolescent girls with MS were thicker than that of other subjects without MS. This is also in accordance with other literature mentioning that visceral fat plays a role in the occurence of MS.[18] MS could be due to dysfunctional energy storage and obesity caused by abnormalities in the processing and storage of fatty acids and triglyceride. This will result in excessive triglyceride accumulation in hepatocytes, skeletal myocytes, and visceral adipocytes which lead to the development of insulin resistance followed by the occurence of MS.[2,8]

Goran *et al*[19] mentioned that visceral fat and MS start to occur in childhood, and MS might be exacerbated by the accumulation of visceral fat. This study also revealed similar results with those of Stolk et al[20] which stated that the visceral fat measured by abdominal ultrasonography in adults with MS was thicker than that in adults without MS, although the MS criteria and the measurement of VFT in both studies were different. Eventhough visceral fat was thicker in obese adolescents with MS, there are no VFT cut-off to predict MS in children yet.

We conclude that (1) all obese adolescents with MS have $WC \geq P_{80}$ (17/34 subjects with $WC \geq P_{80}$); (2) none of obese adolescents with MS have $WC < P_{80}$ (0/16 subjects with $WC < P_{80}$); (3) obese adolescents with MS have visceral fat thicker than that of obese adolescents without MS; (4) the VFT of obese adolescents without MS who have $WC \geq P_{80}$ is 3.94 (SD 1.62) cm; (5) the VFT of obse adolescents without MS who have $WC < P_{80}$ is 3.54 (SD 0.92) cm.

Further studies consisting of larger sampel size and stratified by age groups are needed to determine (1) the correlation and prevalence ratio between MS and $WC \geq P_{80}$, (2) the role of VFT measured by abdominal ultrasonography in the occurence of MS, and (3) WC cut-off and VFT cut-off measured by abdominal ultrasonography in predicting MS in children.

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