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Prevalence of Metabolic Syndrome in Thai Children: A Cross-sectional Study

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ABSTRACT

Background: Metabolic syndrome in children has become the focus of many research projects in recent years. The main goal of this study is to evaluate the prevalence of metabolic syndrome in Thai children and its correlation with overweight and obesity.

Material and Methods: A cross-sectional study of 348 children enrolled in grade 1 to grade 9 was done in Ongkhaluck province in Thailand. Demographic and anthropometric data were gathered. Blood tests were also performed to check for blood glucose, total cholesterol, and triglycerides.

Results: The overall prevalence of metabolic syndrome in our population was 4.0%. Metabolic syndrome was found in 0.7% of non-obese/non-overweight children and 17.6% of obese/overweight children. Participants with metabolic syndrome were found to be significantly older, heavier, and taller and to have higher parameters of adiposity when compared with those without metabolic syndrome. Obesity was significantly correlated with every criterion of diagnosis of metabolic syndrome except Impaired Fasting Glucose (IFG).

Conclusion: Findings of this study suggest that the prevalence of metabolic syndrome in Thai children is consistent with other reports from across the world.

Keywords: Children, Dyslipidaemia, Hypertension, Impaired fasting glucose, Metabolic syndrome

INTRODUCTION

Metabolic syndrome is a collection of some cardiovascular disease (CVD) risk factors including diabetes, obesity, hypercholesterolemia and hypertension [1]. It was long thought to be a condition only seen in adults [2,3]. In fact, metabolic syndrome is one of the most important public health problems around the world affecting approximately 25% of world population. The risk of myocardial infarction, stroke and type II diabetes dramatically increases in those adults who have metabolic syndrome [1].

More recently, the focus of research broadened to also include metabolic syndrome in children and adolescents. Early detection and management of metabolic syndrome is vital as evidence suggest that risk factors for CVD can frequently persist after childhood and adolescence into adulthood. Metabolic syndrome is not as common in children as it is in adults; nevertheless, because of the link between obesity and metabolic syndrome and with obesity being on the rise worldwide, it is estimated that metabolic syndrome in children will become more common in future [1-4].

This study aims to report on the prevalence of metabolic syndrome in children of school age in Thailand. We previously published a report on prevalence of dyslipidaemia in Thai school children [5]. The current study uses the same sample but further analyzes the findings with a primary focus on metabolic syndrome.

MATERIALS AND METHODS

From May to June 2009, a cross-sectional study was performed in school children, from grade 1 to grade 9, who were studying at a public school in Ongkhaluck province in Thailand. The majority of school children in Ongkahluck were from families with middle socio-economic status. All children who were scheduled to have blood examination as per the school policy for screening for ABO blood groups were eligible for the study. Children and their legal guardians were informed and approached for participation in the study. Children who already knew their blood group or refused to have their blood samples obtained were excluded from the study. The study protocol was approved by the Ethics Committee of the Faculty of Medicine, Srinakharinwirot University. Informed consent was obtained from children's parents or guardians and assent was obtained from participating children.

Demographic data and anthropometric characteristics were collected by a trained member of our research group. Weight was measured to the nearest 100 grams using an electronic scale -Tanita Body Composition Analyzer (Model no. BF-680W, Tokyo, Japan). Height was measured to the nearest 0.1 cm. The Body Mass Index (BMI) was calculated as the ratio of weight/ (height)^2 [kg/m^2]. Waist circumference was measured to the nearest 0.1 cm at the midpoint between the lower costal margin and the top of the iliac crest using a non-elastic flexible tape while the subject was in standing position [6]. Hip circumference was measured to the nearest 0.1 cm in standing position at the maximum circumference over the buttocks. Mid upper arm circumference was measured at the mid-point between olecranon process and the acromion process of the left arm. Triceps skinfold thickness was measured over the triceps muscle at the same level as mid arm circumference measurement using a lange skinfold caliper. Subscapular skinfold thickness was measured at the lower angle of the scapula of a relaxed left arm using the same caliper.

Blood pressure was measured using a standard mercury sphygmomanometer (Spirit™, Model CK101, Germany) with proper cuff sizes. Children were seated for at least 10 minutes before blood pressure measurement.

Blood sample was collected from a finger prick into a heparinized hematocrit tube after participant's overnight fasting of at least 10 hours. Blood glucose was measured by enzymatic cleavage methods using Accu-Check Advantage. Total cholesterol (TC) and triglyceride (TG) were measured using Accutrend GCT (Roche Diagnostics GmbH, Germany).

Metabolic syndrome was diagnosed based on the criteria proposed by De Ferranti et al., [7] with two modifications. Firstly, the impaired fasting glucose levels were based on the suggested criteria by the

Expert Committee on the Diagnosis and Classification of Diabetes Mellitus [8]. In addition, high-density lipoprotein cholesterol (HDL-C) level was not assessed and was not included as a component of diagnostic criteria for feasibility reasons. Children who met 3 or more of the following criteria were diagnosed as having metabolic syndrome: (1) waist circumference > 75th percentile of the same age and sex [9], (2) systolic blood pressure (SBP) or diastolic blood pressure (DBP) > 90th percentile of same age, sex and height, [10] (3) fasting glucose ≥ 100 mg/dL; (4) triglyceride ≥ 100 mg/dL.

Hypercholesterolemia was defined as total cholesterol of more than the 95th percentile for age and sex [11]. Overweight and obesity were defined, according to the World Health Organization (WHO) criteria, when BMI was higher than 1 standard deviation (SD) and 2 SD respectively [12].

Sample size was estimated from an anticipated prevalence of metabolic syndrome in children at 3.3% and an accepted error of 1.8% [2]. From a total of 4219 school children studied in Ongkhaluck province during the study, a sample size of 347 children was required.

STATISTICAL ANALYSIS

The normal distribution of data was tested by Kolmogorov-Sminov test. The normally distributed data were presented as means and standard deviations whereas the non-normally distributed data were presented as medians and interquartile ranges (IQR). Pearson Chi-square test or Fisher exact test were used to compare the differences for categorical variables. Student's t-test or Mann-Whitney U-test was used to compare the differences in continuous normally distributed and non-normally distributed variables respectively. Binary logistic regression was used for risk prediction of having metabolic syndrome criteria when the obesity was present. Statistical analysis was performed using SPSS 11.0 software package (SPSS Inc., Chicago, IL, USA). A two-tailed p-value of less than 0.05 was considered as statistically significant.

RESULTS

Of 426 school children eligible for the study, 78 refused to have blood examination. Three hundred and forty-eight children (189 male, 54.3%) were enrolled into the study. [Table/Fig-1] presents the demographic characteristics of study participants as well as their anthropometric characteristics and blood tests. Median (Interquartile range; IQR) age, weight and height of the participants were 10.1 (4.0) years, 32.0 (16.8) kg and 138.9 (14.5) cm, respectively. Ninety seven children (27.9%) had waist circumferences of more than 75th percentiles for their age and sex which was predefined as abdominal obesity. Overall, 34 children (9.8%) were overweight and an additional 34 children (9.8%) met the criteria for obesity. Twenty-three children (6.6%) had SBP of more than 90th percentile of same age, sex and height, whereas, 56 children (16.1%) had DBP of more than 90th percentile of same age, sex and height. Hypertension – defined as SBP and/or DBP > 90th percentile – was diagnosed in 64 children (18.4%). Impaired fasting glucose and hypertriglyceridemia were identified in 31 children (8.9%) and 44 children (12.6%) respectively. Four children (1.1%) had total cholesterol levels in excess of the 95th percentile for their age and sex.

Metabolic syndrome was identified in 14 children i.e. 4.0% of the study population. Children who had metabolic syndrome were significantly older, heavier and taller and had higher parameters of adiposity except for TSF when compared with children without metabolic syndrome. Prevalence of each component of metabolic syndrome is showed in [Table/Fig-2]. Children with overweight or obesity had significantly higher prevalence rates for all criteria of metabolic syndrome except for impaired fasting glucose as shown in [Table/Fig-2]. Overall, the prevalence of metabolic syndrome in overweight or obese children was 17.6% while the prevalence of metabolic syndrome in non-obese non-overweight participants was 0.7%. The odds ratio of having metabolic syndrome would increase by a factor of 29.7 (95% CI: 6.4 to 136.7) if the child had obesity. The odds ratio of meeting each of the metabolic syndrome criteria (except for Impaired Fasting Glucose; IFG) was also significantly increased in overweight and obese children [Table/Fig-3].

	Total (n=348)	Without metabolic syndrome (n = 334)	With metabolic syndrome (n = 14)	p-value
Age (years)	10.1 (4.0)	10.1 (3.9)	11.5 (3.0)	0.031
Male (%)	189 (54.3)	182 (54.5)	7 (50.0)	0.789
Weight (kg)	32.0 (16.8)	30.0 (15.3)	52.0 (20.25)	0.000
Height* (cm)	138.9 (14.5)	138.4 (14.4)	150.0 (10.7)	0.001
Body mass index (kg/m²)	16.37 (4.3)	16.01 (4.07)	22.15 (4.27)	0.000
Waist circumference (cm)	57.0 (15.0)	57.0 (14.0)	71.0 (8.5)	0.000
Hip circumference (cm)	70.0 (15.8)	70.0 (14.5)	87.5 (9.8)	0.000
Waist/hip circumference	0.83 (0.07)	0.81 (0.07)	0.86 (0.13)	0.091
Mid arm circumference (cm)	18.5 (5.0)	18.0 (5.0)	23.0 (5.0)	0.000
Triceps skin fold thickness (mm)	3.0 (1.0)	3.0 (1.0)	4.0 (2.3)	0.094
Subscapular skin fold thickness (mm)	9.0 (5.0)	8.0 (5.0)	18.0 (13.5)	0.002
Systolic blood pressure* (mmHg)	97.9 (17.0)	97.3 (16.9)	113.5 (8.9)	0.000
Diastolic blood pressure* (mmHg)	62.7 (12.0)	58.3 (11.2)	73.6 (6.7)	0.000
Fasting blood glucose (mg/dL)	88.0 (11.0)	88.0 (11.0)	93.5 (15.8)	0.010
Hypercholesterolemia†, n(%)	4 (1.1)	3 (0.9)	1 (7.1)	0.152
Abdominal obesity‡, n(%)	97 (27.9)	83 (24.9)	14 (100.0)	0.000
Arterial hypertension§, n(%)	64 (18.4)	52 (15.6)	12 (85.7)	0.000
Impaired fasting glucose‖, n(%)	31 (8.9)	25 (7.5)	6 (42.9)	0.001
Hypertriglyceridemia**, n(%)	44 (12.6)	33 (9.9)	11 (78.6)	0.000

[Table/Fig-1]: Demographic data, anthropometric characteristics and fasting blood glucose of children without and with metabolic syndrome [median (interquartile range; IQR)]
*present as mean (SD); †total cholesterol excess the 95 percentile for their age and sex; ‡Waist circumference > 75 percentile for age and sex; §systolic or diastolic blood pressure ≥ 90 percentile by age, sex and height percentile; ‖fasting glucose ≥ 100 mg/dL; **triglyceride ≥ 100 mg/dL

	Not obese (n=280)	Overweight or obese (n=68)	p-value
Abdominal obesity*	35 (12.5)	62 (91.2)	0.000
Arterial hypertension†	38 (13.6)	26 (38.2)	0.000
Impaired fasting glucose‡	24 (8.6)	7 (10.3)	0.638
Hypertriglyceridemia§	27 (9.6)	17 (25.0)	0.001
Presented criteria			
0 criteria	179 (63.9)	4 (5.9)	
1 criteria	81 (28.9)	28 (41.2)	
2 criteria	18 (6.4)	12 (17.6)	
3 criteria	1 (0.4)	12 (17.6)	
4 criteria	1 (0.4)	-	
Metabolic syndrome			0.000
No (< 3 risks)	278 (99.3)	56 (82.4)	
Yes (≥ 3 risks)	2 (0.7)	12 (17.6)	

[Table/Fig-2]: Prevalence of metabolic syndrome criteria
*Waist circumference > 75 percentile for age and sex; †systolic or diastolic blood pressure ≥ 90 percentile by age, sex and height percentile; ‡fasting glucose ≥ 100 mg/dL; §triglyceride ≥ 100 mg/dL

	OR	95% CI	p-value
Metabolic syndrome	29.7	6.4 to 136.7	0.000
Abdominal adiposity	72.3	29.1 to 179.6	0.000
Arterial hypertension	3.9	2.1 to 7.1	0.000
Impaired fasting glucose	1.2	0.5 to 2.9	0.655
Hypertriglyceridemia	3.1	1.5 to 6.1	0.001

[Table/Fig-3]: Risk prediction of having metabolic syndrome criteria by being overweight or obese

DISCUSSION

This study shows the prevalence of metabolic syndrome in school children in Thailand. Our findings suggest that the prevalence of metabolic syndrome in Thailand falls within the range of findings of other studies from around the world. A recent systematic review of published reports worldwide by Friend et al., [2] shows that the prevalence of metabolic syndrome ranged from 0% to 19.2% (median: 3.3%). Studies from Far East had an overall median prevalence of 3.3% (range: 0.15-17.3%) for children and adolescence population that is only slightly lower than the prevalence we found in this study (4.0%). The prevalence of metabolic syndrome in our overweight/obese population (17.6%) was modestly lower than the median prevalence found in other studies from Far East in similar populations (median: 21.8%; range: 10-38.1).[2] Studies suggest an association between childhood obesity and the likelihood of having metabolic syndrome; the prevalence of metabolic syndrome is clearly higher in overweight and obese children compared with non-obese, non-overweight population. In their systematic review, Friend et al [2] report a median prevalence of 11.9% and 29.2% for overweight and obese children respectively (versus 3.3% in whole children population). Our study also suggests that obesity is a major risk factor for every single criteria of metabolic syndrome diagnosis except for IFG. IFG was more common in study participants with obesity (10.3% of obese children *vs.* 8.6% of non-obese children) but the difference did not reach statistical significance (p=0.638). A recent study by Rodríguez-Moran et al., [13] suggests that IFG is correlated with family history of diabetes but is independent of obesity. However, the majority of studies confirm an association between IFG and obesity; therefore, the finding of our study can be because of our relatively small sample size. Apart from IFG, every other criteria of metabolic syndrome were met more commonly in obese and overweight children and the difference was statistically significant [Table/Fig-2]. In a study of obese children and adolescents in Thailand, Iamopas et al., [14] reported that 16.9% of those with various degrees of obesity met the criteria for the diagnosis of metabolic syndrome which is close to the prevalence we found in our obese and overweight population (17.6%). In another study of Thai children between the ages of 10 and 15, the prevalence of metabolic syndrome in overweight children was as low as 3.2% [15]. While prevalence rates are different from one study to another, it is generally agreed that metabolic syndrome is more common in overweight and obese children [3], a finding that is not surprising.

The observed disparity in prevalence of metabolic syndrome in children among different reports including the published reports from Thailand can – to a great extent – be because of the difference in their definition of metabolic syndrome and use of different criteria. The three commonly used definitions of metabolic syndrome differ in some details. In addition, most studies of children and adolescence population use a modified version of these definitions that adds to the complexity of a meaningful comparison. It has been shown that using a different set of clinical guidelines leads to a considerably different estimate of prevalence.[16] Without a general consensus among researchers, we chose to make a conservative approach by using a modified version of the criteria introduced by de Ferranti et al., [7].

The available reports on prevalence of metabolic syndrome also differ in terms of the age, gender, and ethnicity of the study population as well as participation rate and sample size which can further explain the difference in reported prevalence rates across studies. It is suggested that metabolic syndrome prevalence is generally higher in boys, older children and in the Americas and Middle East. Although in some cases, evidence to the contrary is also suggested by a smaller number of studies [2].

LIMITATIONS

This study has a number of limitations that are mostly due to feasibility reasons. We did not test for HDL-C as it required venipuncture and would significantly add to the study burden for both participants and researchers. Our hypothesis was that the number of participants with hypercholesterolemia is relatively low and the exclusion of HDL-C from the diagnostic criteria would not greatly impact the final prevalence rates. In fact, our analysis showed that there were only 4 participants (1.1%) with hypercholesterolemia in our study population [17]. Of these four children, three did not meet any criteria for diagnosis of metabolic syndrome and one had abdominal obesity. Therefore, even if we assume that they would have met the HDL criteria had we performed the test, none of them would satisfy the minimum of 3 components required for diagnosis of metabolic syndrome. Therefore, HDL-C results would not change the prevalence of metabolic syndrome.

There might be a concern that the results of our blood tests such as triglyceride, cholesterol, and blood glucose levels are less reliable because of the use of rapid tests. This was clearly a feasibility choice. However, we made sure that all the rapid tests we used in this study are established to have high accuracy, repeatability and reproducibility rates [18-20].

As at the time of study analysis, age-specific standards for waist circumference for Thai children were not available, we chose to use the standard sets for Hong Kong Chinese children [9]. While we hypothesize that the two standards are close enough, this can potentially introduce another limitation to our study.

CONCLUSION

In conclusion, our study confirms that metabolic syndrome is a relatively uncommon phenomenon in children overall; however, it is frequently seen in overweight and obese children. With a general global trend towards higher prevalence of obesity among children and adolescents, the prevalence of metabolic syndrome could rise in this population. We advocate a comprehensive research approach towards metabolic syndrome in children that also includes moving towards a consensus on definition and criteria for diagnosis. More studies are needed to explore different aspects of metabolic syndrome in children and to adequately address this important public health issue.

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