RESEARCH PAPER

Waist-to-Height Ratio and Elevated Blood Pressure Among Children in Taiwan

TA-LIANG CHEN, *CHEUK-SING CHOY, ‡WAN-YU CHAN, #CHIEN-HSIN CHEN AND CHIEN-CHANG LIAO

*From the Department of Anesthesiology, School of Medicine, College of Medicine, Taipei Medical University, Taipei Medical University Hospital, affiliated with Health Policy Research Center, College of Public Health and Nutrition, Taipei 110, *Department of Emergency Medicine and Department of Anesthesiology, Taipei Medical University Hospital, Taipei 110, Taiwan; ‡Department of Nursing, Min-Hwei College of Health Care Management, Tainan 736; and #Department of Surgery, Wan Fang Hospital affiliated with Taipei Medical University, Taipei, 111, Taiwan.*

Correspondence to: Dr Chien-Chang Liao, Assistant Professor, Department of Anesthesiology, School of Medicine, College of Medicine, Taipei Medical University and Department of Anesthesiology, Taipei Medical University Hospital, affiliated with Health Policy Research Center, College of Public Health and Nutrition, 250 Wu-Xing Street, Taipei 110, Taiwan.
jacky48863027@yahoo.com.tw

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Objectives: To study the association of waist-to-height ratio (WHtR) and elevated blood pressure (BP) in children.

Study design: Cross-sectional study.

Setting: Six elementary schools in Taipei, Taiwan.

Participants: All children aged 7 years at first grade.

Methods: We measured anthropometrics and BP during the regular health examinations among children.

Main Outcome Measures: Elevated BP in children was defined as an average systolic BP or diastolic BP greater than or equal to the gender, age, and height-percentile-specific 95th percentile BP value.

Results: Among 2,334 eligible school children, the averages of systolic BP and diastolic BP increased with quartiles of WHtR. The prevalence of elevated BP in children among the first quartile of WHtR was 8.8% and increased to 31.2% among the fourth quartile of WHtR ($P < 0.0001$). Children among the first quartile of WHtR being reference, the adjusted odds ratio of elevated BP for children among the fourth quartile of WHtR was 3.10. The odds ratio of elevated BP with per 0.01 increase of WHtR was 1.11.

Conclusions: WHtR, simple to measure, is an important factor associated with elevated BP in children.

Key words: *Anthropometry, Blood pressure, Child, Risk, Taiwan, Waist-to-height ratio*

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Hypertension is a silent threat to the health of people and is frequently undiagnosed in pediatric population [1]. Recent studies emphasize the increased prevalence of childhood hypertension, which is a predictor of adulthood hypertension, cardiovascular diseases and metabolic morbidities. Therefore, early detection and prevention for childhood hypertension is recommended [2-8].

Abdominal obesity has been recognized as a better predictor for cardiovascular disease and metabolic morbidities than body mass index [9,10]. The prevalence of abdominal obesity among US children and adolescents increased greatly from 1988 to 2004 [11], which might reflect the increasing risk of hypertension in children and adolescents. Waist-to-height ratio (WHtR) is a simple, easy, accurate, and non-age-dependent index and it is highly applicable to screening overweight and obesity in children and adolescents [12]. Studies on the association between WHtR and childhood elevated blood pressure (BP) are limited. Therefore, we examined the relationship of WHtR with elevated BP among children in Taiwan.

METHODS

Study design: With purposive sampling method, we conducted health examinations at 6 public elementary schools in Taipei County, Taiwan, among first-grade school children aged 7-year-old. The annual health examination at elementary schools for children includes height and weight measurements, oral check-up, vision test and physical examinations. With the informed consent from the parents and school administrators, neck circumference, waist circumference, and measurements of blood pressure were added. This study was approved by the Institutional Review Board of Taipei Medical University Hospital (IRB-2008-08-970910).

TABLE I CHARACTERISTICS OF SCHOOL CHILDREN BY QUARTILES OF WAIST-TO-HEIGHT RATIO

	Quartiles				
	1st (n=583) Mean (SD)	*2nd (n=583) Mean (SD)*	*3rd (n=584) Mean (SD)*	*4th (n=584) Mean (SD)*	*P value*
Height, cm	120.2 (4.7)	119.1 (4.9)	118.4 (5.2)	120.4 (5.5)	<0.0001
Weight, kg	21.7 (2.9)	22.3 (3.3)	23.2 (3.8)	28.1 (5.8)	<0.0001
BMI, kg/m^2	15.0 (1.3)	15.6 (1.4)	16.5 (1.6)	19.2 (2.8)	<0.0001
NC, cm	25.5 (1.2)	25.9 (1.4)	26.3 (1.5)	28.0 (2.1)	<0.0001
WC, cm	51.8 (2.5)	55.0 (2.5)	57.5 (2.8)	65.1 (5.80)	<0.0001
HC, cm	64.2 (3.4)	66.0 (4.8)	67.5 (5.0)	74.0 (6.2)	<0.0001
WHtR	0.43 (0.01)	0.46 (0.01)	0.49 (0.01)	0.54 (0.04)	<0.0001
SBP, mmHg	93.7 (13.7)	97.5 (13.8)	99.6 (14.6)	105.7 (15.5)	<0.0001
DBP, mmHg	57.5 (10.1)	60.5 (12.0)	61.9 (13.3)	65.2 (13.0)	<0.0001
Boys, %	52.5	51.1	52.7	52.2	0.95
Elevated SBP, %	5.5	10.6	15.6	25.7	<0.0001
Elevated DBP, %	5.2	9.3	12.5	16.1	<0.0001
Elevated BP, %	8.8	15.1	21.2	31.2	<0.0001

BMI: body mass index; NC: neck circumference; WC: waist circumference; HC: hip circumference; WHtR: waist-to-height ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; BP: blood pressure.

Six physicians, 2 dentists, 9 nurses, and 3 research assistants were responsible for all anthropometric and blood pressure measurements. Data of 103 children was excluded from database due to incorrect data entry or incomplete information.

Height (Stadiometer, Bodymeter 208; SECA, Hanover, Germany) and weight (Scale, HA-521; Tanita, Tokyo, Japan) were used to measure standing, lightly clothed children without shoes [4]. The smallest circumference between hip and chest was defined as waist circumference and the measurement was routinely taken around the level of the umbilicus and recorded to 0.1 cm. In the morning, after the students been sitting quiet for at least 5 minutes, we measured blood pressure (BP) by using a mercury sphygmomanometer on the right arm with an appropriate-sized cuff that covered more than two-thirds of the upper arm. The first and fifth Korotkoff sounds were recorded as systolic and diastolic BP, respectively. Elevated BP was defined in students found to have an average systolic BP or diastolic BP greater than or equal to the gender, age, and height-percentile-specific 95th percentile BP value [13]. The measurement of anthropometry and BP was verified by two well-trained medical research assistants under the supervision of a senior physician. There was no significant difference in the values of height, weight, body mass index, waist circumference, and BP between two research assistants except the systolic BP in girls.

Statistical analysis: Weight (kg) divided by the square of height (m^2) was used to calculate the body mass index and waist circumference (cm) divided by height (cm) to calculate WHtR. The average of height, weight, body mass index, neck circumference, waist circumference, and BP were compared between quartiles of WHtR by using analysis of variance. The Chi-square test was used to compare the proportions of boys, elevated systolic BP, elevated diastolic BP, and elevated BP between quartiles of WHtR. Spearman correlation coefficient was used to investigate the correlations between WHtR and anthropometry by quartiles of WHtR. The odds ratios (ORs) and 95% confidence intervals (CIs) of elevated BP in association with WHtR were calculated in the multi-variate logistic regressions. To eliminate the effects of the disparity in systolic BP measurement between the 2 observers, we included operator as a covariate in the final model. All analyses were performed with SAS software, version 8.0 (SAS Institute Inc., Carey, NC). Two-sided probability value < 0.05 was considered statistically significant.

RESULTS

Among 2,334 eligible school children, the averaged body mass index, neck circumference, and hip circumference increased incrementally with quartiles of WHtR (***Table* I**). Boys had higher prevalence of large WHtR and elevated BP compared with girls. The prevalence of elevated systolic and diastolic BP also increased with quartiles of WHtR. Compared with children with first quartile of WHtR, children with fourth quartile of WHtR had high prevalence of elevated BP (31.2% *vs* 8.8%, $P < 0.0001$).

WHAT IS ALREADY KNOWN?

- Waist-to-height ratio is associated with elevated blood pressure in Caucasian children and adults.

WHAT THIS STUDY ADDS?

- Waist-to-height ratio is significantly associated with elevated blood pressure in Taiwanese children at age 7.

Boys and girls with elevated BP had higher average of WHtR compared with subjects of the same sex with normal BP. Systolic BP and diastolic BP were correlated with WHtR.

The adjusted ORs of elevated systolic BP, elevated diastolic BP, and elevated BP increased from second to the fourth quartile, when compared with the first quartile of WHtR (***Table* II**).

DISCUSSION

In this study, we found that 7-year-old children of the highest WHtR quartile had the highest prevalence of elevated BP and the highest adjusted OR of elevated BP when compared with children in the lowest quartile of WHtR. It verified the association between abdominal obesity and elevated BP among this young population.

In this study, both average systolic and diastolic BP increased from the lowest quartile to the highest quartile of WHtR. Previous studies about the prevalence of hypertension or elevated BP among children with different WHtR are limited. Among 1,987 children aged 10-14 years in Greece, children with WHtR >75th percentile had higher average of BP than children with WHtR ≤75th percentile [14]. Among Italian children aged 5-15 years, obese children with WHtR >0.5 had the highest risk (OR=12.1) of metabolic syndrome compared with children with normal weight and WHtR <0.5 [10].

High WHtR increases risk of cardiovascular disease not only in children [14], but also in adults [15]. In Japanese women, the OR of hypertension for per standard deviation increased of WHtR was 1.59 [15]. It was previously suggested that a WHtR cut-point of 0.5 could estimate risk factors of cardiovascular disease similar to the sex-and age-adjusted cut-points for waist circum-ference and body mass index [16]. Keeping waist circumference to less than half of height was also suggested in previous studies [12-15].

Besides BP, WHtR is also a predictor of serum lipids and fasting glucose [5,9,17]. Ethnicity, socioeconomic status, and dietary factors were also associated with WHtR [18,19]. Our study was limited by lack of detailed information on dietary factors. Another limitation is that BP was measured at a single period. Therefore, we could not validate whether subjects had persistent hypertension, for which repeated measurements were needed. The measuring difference in systolic BP for girls between two research assistants is another study limitations, though it was adjusted in the logistic regression model.

This study indicated that WHtR is good predictor for elevated BP in school children aged seven. Further studies are needed to extend the findings in other specific groups to determine precise cut-off points for WHtR as a reliable predictor of elevated BP. We emphasize the need of prevention for elevated BP in childhood and BP measurements should be considered in routine health examinations for school children.

Contributors: TLC was involved in study design, manuscript writing, data interpretation, and revising manuscript. WYC was responsible for the manuscript preparation, study design, and data collection. CSC was involved in study design, data interpretation, and revising manuscript. CHC was involved in study design, data

TABLE II RISK OF ELEVATED BLOOD PRESSURE ASSOCIATED WITH QUARTILES OF WAIST-TO-HEIGHT RATIO IN CHILDREN*

Quartiles	*Elevated SBP OR# (95% CI)*	*Elevated DBP OR# (95% CI)*	*Elevated BP OR# (95% CI)*
1st	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
2nd	1.93 (1.24-3.01)	1.77 (1.11-2.82)	1.72 (1.19-2.49)
3rd	2.82 (1.83-4.34)	2.39 (1.51-3.76)	2.44 (1.70-3.50)
4th	4.19 (2.60-6.76)	2.61 (1.55-4.40)	3.10 (2.05-4.68)
WHtR per 0.01 increase	1.10 (1.06-1.15)	1.11 (1.06-1.16)	1.11 (1.07-1.15)

**P for trend <0.0001 for all blood pressure values;WHtR: waist-to-height ratio; SBP: systolic blood pressure; DBP: diastolic blood pressure; BP: blood pressure; #Adjusted for sex, neck circumference, and body mass index.*

interpretation, preparing and revising manuscript. CCL contributed to study design, manuscript preparation, data analysis, data interpretation and revising manuscript. All authors approved the final content of the manuscript.

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