Original Article

The Relationship between the Waist-to-Height Ratio and Glucose and Lipid Metabolism in Han Adolescents

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ABSTRACT

Objective. To evaluate the relationship between waist-to-height ratio (WHtR) and glucose and lipid metabolism in Han adolescents aged 13-15 years.

Methods. A study was conducted on 1665 Han adolescents aged 13-15 years. Measurements included height, weight, waist circumference, fasting plasma glucose(FPG), triglyceride and high-density lipoprotein cholesterol. The subjects were divided into two groups according to WHtR.

Results. Compared with the control group (n=1340,WHtR<0.46), the abdominal obesity group(n=325,WHtRe”0.46) had significantly higher levels of body mass index (BMI) (26.3±3.6 *vs* 18.9±2.3), WHtR (0.51±0.04 *vs* 0.40±0.03), FPG (4.99±0.48 *vs* 4.86±0.46), and triglyceride (1.21±0.62 *vs* 0.87±0.41), and a lower level of high-density lipoprotein cholesterol (1.26±0.27 *vs* 1.46±0.30) (P<0.01). Logistic regression analysis showed that after controlling for age, sex and BMI, the elevated FPG and dyslipidemia risk odds ratios of the abdominal obesity group were 1.954 (95% CI :1.250~3.054) and 2.012 (95% CI:1.204~3.362) (*P*<0.01) respectively. When clustered, the odds ratio of elevated FPG and dyslipidemia was 6.659 (95% CI: 1.337~33.159) (*P*<0.01).

Conclusions. The waist-to-height ratio is an appropriate measure to assess dyslipidemic-diabetic adolescents and should be used to guide early intervention with the aim of future prevention of these linked diseases. **[Indian J Pediatr 2010; 77 (5): 547-550]** *E-mail: yinfuzai62@sina.com*

Key words : *Waist-to-height ratio; Obesity; Glucose and lipid metabolism; Adolescent*

With the development of the economy and the change of lifestyle in China, the prevalence of obesity is increasing rapidly in Chinese adolescents.[1] Childhood and adolescent obesity is an important risk factor for type 2 diabetes, dyslipidemia and cardiovascular disease in adult life.[2,3] Earlier screening of obese adolescents for correlation factors of dyslipidemic-diabetic and taking intervention are particularly important for prevention of obesity-related mobidities in adolescents. However, identifying obesity in children and adolescents is more complicated than in adults, given that the current measure of Body Mass Index (BMI) is based on a set of age- and gender-specific references, which are not race-dependent. Recent studies, have demonstrated, that the ratio of waist circumference to height [waist-to-height ratio (WHtR)], is a superior measure to predict cardiovascular risk factors in both adults and adolescents, than waist circumference or BMI alone.[4,5] This study explores the relationship between WHtR and glucose and lipid metabolism in Han ethnic adolescents aged 13-15 years.

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MATERIAL AND METHODS

Subjects

This study was performed on the Han ethnic group of Hebei province in China, which accounts for 95.69% of the total population of this province (2000 national census). In 2006, 1665 Han (846 male and 819 female) adolescents aged, 13-15 years, were selected from six middle schools, from Qinhuangdao in the Hebei province in China. Written informed consent was obtained, from the parents of the adolescents and also the adolescents themselves. The cohort was recruited, by systematic and cluster sampling, according to age and gender and was selected to represent the cross-sectional constituent ratio of the relevant age group, within Qinhuangdao. Subjects fasted for at least 10 hours before anthropometric assessment and blood collection.

Measurements

Anthropometric measurements including weight, height and waist circumference were recorded using standard protocols and instruments by professional nurses. Weight was measured with minimal clothing and standing height was measured without shoes, with a precision of 0.1kg and 0.1cm respectively. Waist circumference was measured using a constant tension tape to the nearest 0.1cm midway between the lower rib margin and the iliac crest, with the subjects standing and clothing shifted from this region. BMI was calculated by dividing weight (kg) by height squared (m^2). WHtR was calculated by dividing waist circumference (cm) by height (cm).

After a 10-hour overnight fast, blood samples were collected from an antecubital vein into heparinised tubes. Fasting plasma glucose (FPG) concentration was measured using the glucose oxidase method, and plasma lipids were measured using enzymatic procedures with the autoanalyzer (model 27170A; Hitachi, Tokyo, Japan).

Definition of Groups

The subjects were divided into two groups according to WHtR 0.46,[6] the control group (WHtR <0.46, n=1340, 650 boys and 690 girls, aged 14.1 ± 0.8 years) and abdominal obesity group (WHtR ≥0.46, n=325, 196 boys and 129 girls aged 14.1 ±0.8 years).

Definition of Cardiovascular Risk Factors

Elevated FPG was defined according to the 2003 American Diabetes Association definition as FPG ≥100 mg/dL (5.6 mmol/L).[7] Dyslipidemia was defined as triglyceride (TG) ≥1.70 mmol/L and/or high-density lipoprotein (HDL) cholesterol <1.03 mmol/L according to the 2004 IDF definition of metabolic syndrome.

Statistical Methods

The data was expressed as means with standard deviations or as frequencies as indicated. The data was analysed by covariance and logistic regression analysis using the computer software SPSS v11.5 (SPSS Inc., Chicago, IL, U.S.A.). A level of $p<0.05$ was used to indicate statistical significance in all analyses. The results of the logistic regression analysis were expressed as odds ratios with a 95% confidence interval.

RESULTS

After controlling for age and sex, the abdominal obesity group had significantly higher levels of BMI, FPG, TG and a lower level of HDL than the control group (Table 1) ($P<0.01$).

Frequencies of elevated FPG and dyslipidemia are displayed in Table 2. After controlling for age, sex and BMI, the odds ratios for elevated FPG and dyslipidemia in the abdominal obesity group were 1.954 (95% CI : 1.250~3.054) and 2.012 (95% CI : 1.204~3.362) respectively, when compared to the control group ($P<0.01$) (Table 2). Of the abdominal obesity group, 3.1% had two metabolic dysfunctions compared with 0.4% of the control group. After adjusting for age, sex and BMI, the risk of two metabolic dysfunctions existing in the abdominal obesity group was 6.659 times higher (95% CI : 1.337~33.159) than the control group ($P<0.01$) (Table 3).

Table 1. Clinical and Biochemical Characteristics of the Adolescents

Variable	Control group n=1340	Obesity group n=325	*F*	*P*
WHtR	0.40 ± 0.03	0.51 ± 0.04	3464.026	0.000
BMI (kg/m^2)	18.9 ± 2.3	26.3 ± 3.6	2131.916	0.000
FPG (mmol/L)	4.86 ± 0.46	4.99 ± 0.48	22.810	0.000
TG (mmol/L)	0.87 ± 0.41	1.21 ± 0.62	158.228	0.000
HDL (mmol/L)	1.46 ± 0.30	1.26 ± 0.27	117.836	0.000

The data was analysed by covariance analysis. All results were adjusted for age and gender. WHtR: waist-to-height ratio, BMI: body mass index, FPG: fasting plasma glucose, TG: triglyceride, HDL: high-density lipoprotein.

DISCUSSION

It is estimated that between 1 and 2 billion people worldwide have obesity, with one in five of these being Chinese. Obesity rates are increasing in every country, where it has taken hold, and it affects ages, all races and both sexes.[8] Obesity is a major risk factor for the development of chronic noncommunicable diseases and associated morbidities, with the risk of cardiovascular events rising with increased body mass index (BMI).[9] Accordingly, the age- and gender-specific BMI cut-off points defined by The International Obesity Task Force to define overweight and obese children and adolescents across international reference populations have been widely adopted. However, despite BMI being generally accepted as a reasonable measure of body fat, it fails to account for fat distribution and in particular abdominal fat. Increased abdominal fat has been shown to increase the risk of diabetes, hypertension and cardiovascular disease.[9] Recently, waist circumference (WC) has been recommended as a means of identifying people at risk of morbidity associated with central adiposity. However, no universally accepted WC cut-off point is defined to determine an increased risk of morbidity in young people.[10] It has also been suggested that waist-to-height ratio (WHtR) is a better measure to indicate increased risks of obesity and cardiovascular disease.

During the past 10 to 20 yrs, the value of WHtR has increased significantly, confirming that central fatness in

Table 2. Frequencies of Elevated FPG and Dyslipidemia

Variable	Control group n=1340	Obesity group n=325	OR (95% CI)	P
Elevated FPG	68 (5.1*)	31 (9.5*)	1.954 (1.250~3.054)	0.003
Dyslipidemia	98 (7.3*)	89 (27.4*)	2.012 (1.204~3.362)	0.008

*Unit: abnormal subjects (%). FPG = fasting plasma glucose; OR = Odds ratio; CI = Confidence Interval.

Table 3. Aggregation of the Cardiovascular Risk Factors

Group	0	1	2
Control group n=1340	1179(88.0*)	156(11.6*)	5(0.4*)
Obesity group n=325	215(66.2*)	100(30.8*)	10(3.1*)
OR (95%CI)	1	1.615(1.015~2.571)	6.659(1.337~33.159)
P		0.043	0.001

*Unit: abnormal subjects (%). 0= without metabolic dysfunction; 1= with one metabolic dysfunction; 2= with two metabolic dysfunctions. Results were adjusted for age, gender and BMI. OR = Odds ratio; CI = Confidence Interval.

children has risen dramatically during this time. WHtR was recently used as a surrogate of body fat centralisation (central obesity) and was shown to be linked more closely to childhood morbidity than BMI.[5] WHtR has several key advantages: it is easy to calculate, does not require sex- and age-specific percentiles, and is a simple measure that can be easily understood by clinicians and families alike.[10] WHtR could therefore be a very useful and rapid tool for screening overweight and obese children and adolescents.[11] Furthermore, WHtR as a measure of abdominal fat accumulation is regarded as a better predictor of cardiovascular risk than BMI.[12,13] Statistical evidence supports the superiority of measures of centralised obesity, especially WHtR, over BMI for detecting cardiovascular risk factors in both men and women.[14,15,16] Kahn *et al* (2005) recently found that WHtR is a simpler anthropometric index than sex- and age-specific BMI percentiles and a better method for identification of youth with adverse cardiovascular risk factors.[17] A study[6] with a stratified cluster representative sample of 23 422 chinese children, aged 0-18 yrs, showed that waist-to-height ratio that is equal to 0.46, could be taken as the optimal thresholds and there were significant differences for the average levels of systolic and diastolic blood pressure, serum triglyceride, high density lipoprotein cholesterol and their abnormal rates between the groups divided by the cut off points. Here, we show that an abdominal obesity group with WHtRe ≥0.46 had significantly elevated levels of FPG and TG, and a lower level of HDL compared with the control group with WHtR<0.46. Furthermore, the frequencies of elevated FPG and dyslipidemia were increased in adolescents with WHtRe ≥0.46. A recent paper suggested, a significant race and gender differential in the abdominal adipose tissue distribution, for a given BMI, WC, WHR (waist-to-hip ratio) and WHtR.[18] We suggest that similar future studies should consider these variables, when developing race- and gender-specific anthropometric cut-off points, for obesity and obesity-related health risks in youth.

Prospective epidemiological studies have shown that increased abdominal fat accumulation is associated with hyperinsulinemia and dyslipidemia.[11] Epidemiological studies have also shown that central, rather than general, adiposity is more strongly associated with the development of insulin resistance.[19] A recent study has validated the suitability of WHtR, to predict cardiovascular risk factors, over direct body fat measures, such as using dual-energy X-ray absorptiometry scanning and bioelectrical impedance analysis.[20] Here we show that 3.1% of an abdominal obesity group with a WHtRe≥0.46 had two metabolic dysfunctions compared to 0.4% of the control group (WHtR<0.46). Therefore, after adjusting for age, sex and BMI, the risk of having two metabolic dysfunctions in the abdominal obesity group was 6.659 times higher than the control group.

Collectively, this data suggests that WHtR may be a simpler and more effective index of abdominal obesity than other measures, with a ratio of WHtRe ≥0.46 being significantly associated with altered glucose and lipid metabolism in adolescents. We suggest that, this WHtR cut-off point should be adopted worldwide, as an early screening method in adolescents, in order to help attenuate the predicted increase in obesity and associated dyslipidemic-diabetic.

Contributions: QL designed the study, collected, analysed and interpreted the data. TJI helped with study design, interpretation of the data and revision of the manuscript. FZY was involved with designing the study, revision of the manuscript and took the decision to submit the paper for publication. CMM helped with analysis and interpretation of the data. He helped in writing the report. BWL, DHL and XLL helped with collection analysis and interpretation of data.

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REFERENCES

1. Ji CY, Sun JL, Chen TJ. Dynamic analysis on the prevalence of obesity and overweight school-age children and adolescents in recent 15 years in China. *Chin J Epidemiol* 2004;25:103-108.
2. Flegal, KM, Carroll, MD, Ogden, CL, Johnson, CL. Prevalence and trends in obesity among US adults, 1999–2000. *JAMA* 2002; 288: 1723-1727.
3. Gidding, SS, Bao, W, Srinivasan, SR, Berenson, GS. Effects of secular trends in obesity on coronary risk factors in children: the Bogalusa Heart Study. *J Pediatr* 1995;127: 868-874.
4. Weili Y, He B, Yao H *et al*. Waist-to-height ratio is an accurate and easier index for evaluating obesity in children and adolescents. *Obesity* (Silver Spring) 2007; 15: 748-752.
5. McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message—'keep your waist circumference to less than half your height'. *Int J Obes (Lond)* 2006; 30: 988-992.
6. Meng LH, MI J, Cheng H *et al*. Using waist circumference and waist to height ratio to access central obesity in children and adolescents. *Chin J Evid Based Pediatr* 2007; 2: 245-252.
7. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. *JAMA* 2002; 288: 1723-1727.
8. Levine JA. Obesity in China: causes and solutions. *Chin Med J* 2008; 121: 1043-1050.
9. Schneider HJ, Glaesmer H, Klotsche J *et al.* Accuracy of anthropometric indicators of obesity to predict cardiovascular risk. *J Clin Endocrinol Metab* 2007; 92: 589-594.
10. Garnett SP, Baur LA, Cowell CT. Waist-to-height ratio: a simple option for determining excess central adiposity in young people. *Int J Obes* 2008; 32: 1028-1030.
11. Carr MC, Brunzell JD. Abdominal obesity and dyslipidemia in the metabolic syndrome: importance of type 2 diabetes and familial combined hyperlipidemia in coronary artery disease risk. *J Clin Endocrinol Metab* 2004; 89: 2601-2607.
12. Aekplakorn W, Kosulwat V, Suriyawongpaisal P. Obesity indices and cardiovascular risk factors in Thai adults. *Int J Obes* 2006; 30: 1782-1790.
13. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr* 2005; 56: 303-307.
14. Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. *J Clin Epidemiol* 2008; 61: 646-653.
15. Esmaillzadeh A, Mirmiran P, Azizi F. Waist-to-hip ratio is a better screening measure for cardiovascular risk factors than other anthropometric indicators in Tehranian adult men. *Int J Obes Relat Metab Disord* 2004; 28: 1325-1332.
16. Esmaillzadeh A, Mirmiran P, Azizi F. Comparative evaluation of anthropometric measures to predict cardiovascular risk factors in Tehranian adult women. *Public Health Nutr* 2006; 9: 61-69.
17. Kahn HS, Imperatore G, Cheng YJ. A population-based comparison of BMI percentiles and waist-to-height ratio for identifying cardiovascular risk in youth. *J Pediatr* 2005; 146: 482-488.
18. Lee S, Kuk JL, Hannon TS, Arslanian SA. Race and gender differences in the relationships between anthropometrics and abdominal fat in youth. *Obesity (Silver Spring)* 2008; 16: 1066-1071.
19. Thomas GN, Zhao HL, Ma YQ *et al.* Relationship between obesity and cardiovascular risk factors in elderly Chinese subjects. *Chin Med J* 2002; 115: 897-899.
20. Lee K, Song YM, Sung J. Which obesity indicators are better predictors of metabolic risk?: healthy twin study. *Obesity (Silver Spring)* 2008; 16: 834-840.