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Waist circumference and waist-to-height ratio in Han Chinese children living in Chongqing, south-west China

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Abstract

Objective: To derive age- and sex-specific reference values for waist circumference (WC) and waist-to-height ratio (WHtR) for Han Chinese children and adolescents and to establish the prevalence of excess central adiposity in our study population.
Design: Cross-sectional study of schoolchildren attending randomly selected primary and secondary schools in south-west China in October 2003 and April 2004. Anthropometry was measured using standard procedures. The LMS method was used to construct smoothed WC and WHtR percentile curves. Overweight and obesity were defined by the International Obesity Task Force (IOTF) criteria and the Working Group on Obesity in Children. Excess central adiposity fat was defined by previously published WC cut-points and a WHtR $\geq 0{\cdot}5$.
Setting: Primary and secondary schools in Chongqing, south-west China.
Subjects: A total of 7326 (49·2% boys) Han Chinese students at 5–17 years old.
Results: On the basis of the IOTF criteria, 26·4% of boys were overweight or obese compared with 16·4% of girls ($P < 0{\cdot}001$). WC cut-points identified 31% of boys and 28% of girls as having excess central adiposity, whereas using the WHtR criterion, 14·8% of boys and 5·6% of girls were identified. Young boys (5–12 years) had a significantly ($P < 0{\cdot}001$) higher WHtR than girls.
Conclusions: We have constructed WC and WHtR percentile curves for Han Chinese children and adolescents living in Chongqing. Our measurements were based on a student population with a relatively high rate of overweight and obesity. These data will provide a point of reference for future studies measuring the prevalence of overweight and obesity in China.

Keywords
Central adiposity
Han Chinese
Waist circumference percentiles
Waist-to-height ratio

Over the past two decades the prevalence of childhood overweight and obesity has increased dramatically in large Chinese cities[1]. In parallel, there has been an escalated incidence of the metabolic syndrome[2], a clustering of cardiovascular risk factors including dyslipidaemia, hypertension and insulin resistance[3]. Excessive accumulation of adipose tissue in both central subcutaneous and visceral regions of children and adolescents has been associated with these metabolic abnormalities[4]. The recommended anthropometric measures that reflect central adiposity distribution in children include waist circumference (WC) and waist-to-height ratio (WHtR). Both measures are highly sensitive to upper body fat accumulation and predict adverse cardiovascular risk factors[5,6].

Several studies have described ethnic differences in WC[7–10] and there are recognised cut-points for WC for both European and Asian adults[11]. For children and adolescents, WC cut-points tend to be based on age- and sex-specific reference values. Age- and sex-related WC percentile values have been established in several countries including the United States, the United Kingdom and Australia[7,10,12]. WC percentile charts have been developed for children living in Hong Kong[13] and Xinjiang Uygur Autonomous Region[14], in north-west China. However, both percentile charts have limitations. The percentile charts for Hong Kong children do not differentiate between ethnicities and the Xinjiang autonomous region charts are based on limited numbers of children in each age group (median: seventy-nine; (range: forty-seven to 131)).

The WHtR has also been proposed as a measure of central adiposity and studies in adults and children have suggested a cut-point of 0·5 as a simple means of indicating

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whether the amount of central fat is excessive[5,15]. The WHtR cut-point has several advantages over WC cut-points as it is easy to calculate and it is not age and sex specific. WHtR has not been previously described in Han Chinese children.

Establishing normative ethnic-specific data are essential for early detection of excess central adiposity. The aim of the present study was to derive age- and sex-specific reference values for WC and WHtR in Han Chinese children and adolescents and to establish the prevalence of excess central adiposity in our study population.

Materials and methods

Participants

This is a school based, cross-sectional study that was conducted in the city of Chongqing, south-west China in October 2003 (primary schools) and in April 2004 (secondary schools). The total city population is approximately thirty-two million of which 4·4 million are primary- and secondary-school students (National Chinese Census 2006, personal communication (F.X.) with the Office of Primary and Middle School Health of Chongqing Education Committee). For the present study, 7326 (49·2 % boys) Han Chinese students aged 5–17 years were recruited from fifteen primary schools and nine secondary schools from a potential of thirty-eight primary schools and eighteen secondary schools in Chongqing. School selection was undertaken by the Office of Primary and Middle School Health of Chongqing Education Committee and was based on randomly computer-generated numbering to represent both urban and city areas and to be representative of total school community. Two classes in each grade were selected in collaboration with the school principal based on timetables and operational needs. A written informed consent was obtained from ~99 % of the participants or from their parents and the research protocol was approved by the Primary and Secondary School Physical Health Division of the Chongqing Education Committee.

Measurements

Anthropometric measurements included height, weight and WC. Height was measured without shoes to the nearest 0·5 cm by a standard stadiometer. Weight was measured to the nearest 0·5 kg on calibrated scales, wearing light clothing. WC was measured midway between the lowest rib and the superior border of the iliac crest with a non-elastic flexible tape and was recorded to the nearest centimetre. All anthropometric measurements were performed by trained health technicians. BMI was calculated as weight/height^2 (kg/m^2) and WHtR by dividing the WC (cm) by height (cm). Overweight and obesity were defined by age- and sex-specific BMI cut-off points according to the International Obesity Task Force (IOTF) criteria[16] and Working Group on Obesity in Children (WGOC)[17] for children aged 7 years and older. Excess central fat was defined by previously published WC standards based on ethnic Chinese living in Hong Kong[18,19] and a WHtR $\geq 0{\cdot}5$[15].

Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences statistical software package version 15·0 for Windows (SPSS Inc., Chicago, IL, USA). After assessing the data distribution, sex differences in anthropometric data were assessed with the Student's *t* test. Association between age and WHtR was assessed using curve estimation. The χ^2 test was used as a measure of association between categorical variables. The LMS method[20] was used to construct smoothed percentile curves for WC using LMS ChartMaker Light[21]. The LMS method summarises the changing distribution by three curves representing the median (M), coefficient of variation (S) and skewness (L); the latter expressed as a Box–Cox power. Using penalised likelihood methods, the three curves are fitted as cubic splines by non-linear regression, and the extent of smoothing required is expressed in terms of smoothing parameters or equivalent degrees of freedom. Agreement between criteria for classifying overweight and obesity was assessed by the κ statistic.

Results

The anthropometric characteristics of the study population are shown in Table 1. Boys were generally taller than girls, except at 10 years of age when girls were on average 2·9 cm taller than boys ($P<0{\cdot}001$). Boys aged 6–10 years also had a significantly higher BMI ($P<0{\cdot}001$). However, after the age of 10 years sex difference in anthropometry were small. Overall, using IOTF criteria 26·4 % of boys were overweight or obese compared with 16·4 % of girls ($P<0{\cdot}001$) and using the WGOC criteria (for children ≥7 years) 29·7 % of boys and 19·4 % of girls ($P<0{\cdot}001$) were overweight or obese. The two classification criteria showed very good agreement ($\kappa = 0{\cdot}88$, $P<0{\cdot}001$); 99·6 % of children defined as overweight or obese using the IOTF criteria were also defined as overweight and obese using the WGOC criteria.

Smoothed WC and WHtR percentile curves for boys and girls are shown in Figs 1 and 2. The percentile values are shown in Tables 2 and 3 (WC and WHtR). WC increased with age in both sexes until 15 years and then plateaued. Boys had a higher WC than girls. The mean WHtR was also higher in boys than girls until the age of 12 years ($P<0{\cdot}001$). In adolescents, the only statistical difference that was observed between sexes was at 15 years when girls had a higher WHtR than boys, 0·43 compared with 0·42 ($P<0{\cdot}001$). In contrast to the association between age and WC, the association between age and WHtR was flatter. In boys this association was negative, age explaining 2·5 % of the variance ($R^2 = -0{\cdot}025$,

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Table 1 Anthropometric measures, prevalence of overweight and obesity, and excess central adiposity

		Height (cm)		Weight (kg)		BMI (kg/m^2)		Overweight		Obese		Excess central adiposity (WC)*		Excess central adiposity (WHtR ≥ 0·5)	
Age (years)†	*n*	Mean	SD	Mean	SD	Mean	SD	*n*	%	*n*	%	*n*	%	*n*	%
Boys															
5	96	122·1	5·2	25·7	4·5	17·1	2·1	17	17·7	10	10·4	–‡		13	13·5
6	217	125·7	5·6	27·7	4·1	17·4	2·2	61	28·1	21	9·7	92	42·4	42	19·4
7	231	130·1	6·7	30·2	6·3	17·7	2·6	59	25·5	21	9·1	104	45·0	39	16·9
8	311	132·2	8·9	31·2	7·6	17·6	2·6	65	20·9	21	6·8	102	32·8	49	15·8
9	342	136·2	10·2	34·3	9·7	18·1	3·1	70	20·5	28	8·2	113	33·0	59	17·3
10	328	141·3	10·0	38·1	10·5	18·8	3·1	76	23·2	23	7·0	107	32·6	60	18·3
11	347	149·3	10·9	43·3	11·0	19·2	3·0	73	21·0	14	4·0	103	29·7	49	14·1
12	353	155·3	11·9	48·9	14·0	19·9	3·8	71	20·1	22	6·2	105	29·7	56	15·9
13	352	160·4	11·3	52·2	13·6	20·0	3·6	54	15·3	16	4·5	79	22·4	35	9·9
14	274	166·7	8·5	60·1	13·4	21·5	3·9	53	19·3	25	9·1	88	32·1	46	16·8
15	295	170·6	6·0	63·1	11·6	21·6	3·6	54	18·3	14	4·7	91	30·9	31	10·5
16	319	170·7	5·9	63·4	11·7	21·7	3·6	39	12·2	15	4·7	90	28·2	35	11·0
17	136	172·1	5·8	64·7	11·2	21·8	3·5	23	16·9	6	4·4	37	27·2	17	12·5
Total	3603	150·0	18·5	45·6	17·0	19·51	3·6	715	19·9	236	6·6	1112	30·9	531	14·7
Girls															
5	147	120·4	4·8	24·4	3·5	16·8	1·9	35	23·8	11	7·5	–‡		10	6·8
6	226	123·4	5·3	25·3	3·4	16·5	1·5	47	20·8	5	2·2	55	24·3	9	4·0
7	254	128·3	7·5	28·0	5·7	16·9	2·2	41	16·1	10	3·9	68	26·8	15	5·9
8	296	131·1	9·2	29·6	7·0	17·0	2·3	40	13·5	13	4·4	64	21·6	16	5·4
9	312	136·1	9·9	32·5	8·5	17·3	2·8	40	12·8	9	2·9	67	21·5	17	5·5
10	299	144·2	9·9	37·6	9·2	17·9	2·8	42	14·0	7	2·3	74	42·7	7	2·3
11	359	149·2	9·1	42·3	9·7	18·8	2·8	55	15·3	4	1·1	78	21·7	14	3·9
12	351	152·0	8·4	45·7	10·0	19·6	3·1	58	16·5	6	1·7	94	26·8	26	7·4
13	433	156·0	7·4	49·8	10·0	20·4	3·4	59	13·6	12	2·8	116	26·8	25	5·8
14	336	158·2	6·1	52·9	8·1	21·1	2·7	42	12·5	4	1·2	137	40·8	26	7·7
15	313	158·7	5·9	53·1	7·5	21·1	2·5	32	10·2	2	0·6	121	38·7	23	7·3
16	284	159·9	5·2	53·4	7·3	20·9	2·5	25	8·8	1	0·4	104	36·6	15	5·3
17	113	159·7	5·2	54·4	7·1	21·3	5·3	12	10·6	0	0·0	35	31·0	5	4·4
Total	3723	145·9	15·1	41·6	13·2	19·0	3·2	528	14·2	84	2·3	1013	27·2	208	5·6

WC, waist circumference; WHtR, waist-to-height ratio.
*Age- and sex-specific cut-points based on ethnic Chinese children living in Hong Kong[18,19].
†Age is in whole years, e.g. 5 years = 5–5·99 years.
‡No cut-point available for 5-year-old children.

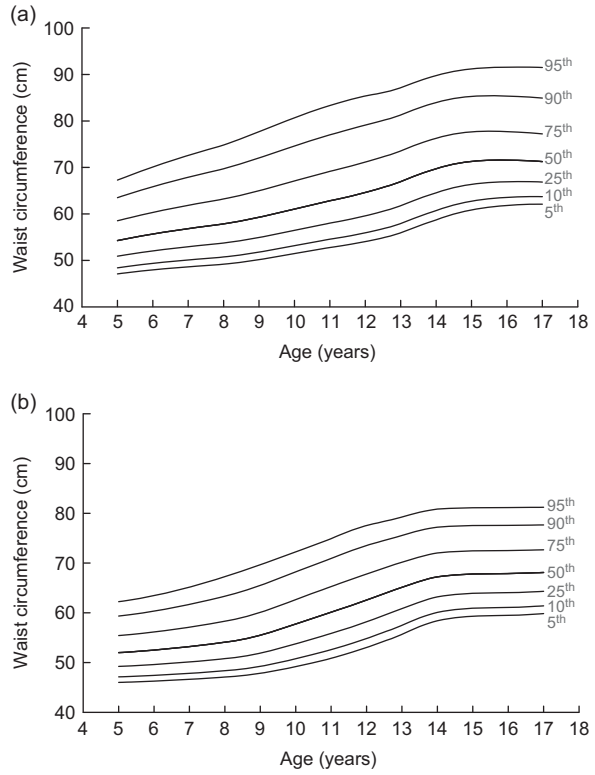

Fig. 1 Smoothed waist circumference curves for the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentile for (a) boys and (b) girls

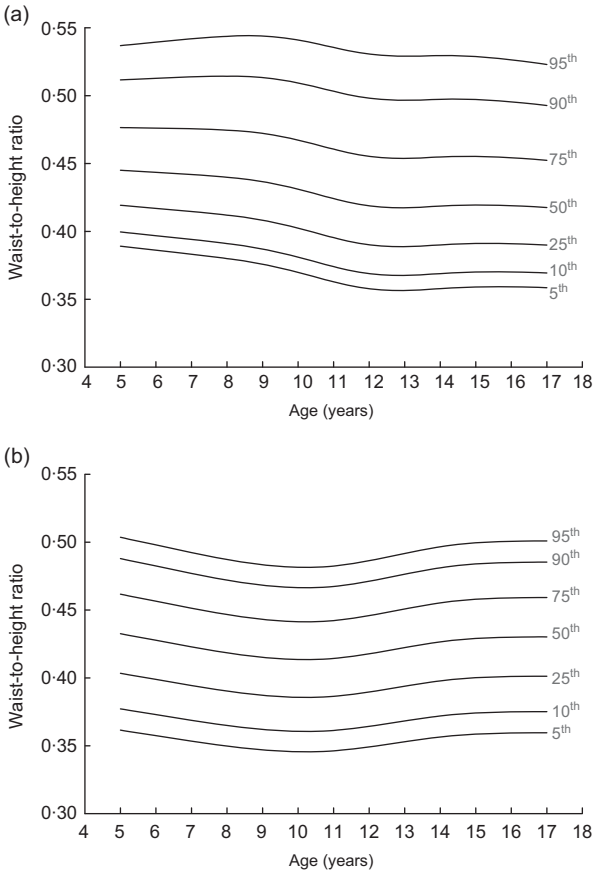

Fig. 2 Smoothed waist-to-height ratio curves for the 5th, 10th, 25th, 50th, 75th, 90th and 95th percentile for (a) boys and (b) girls

$P < 0{\cdot}001$). The relation between age and WHtR in girls was best described as quadratic ($R^2 = 0{\cdot}021$, $P < 0{\cdot}001$; Fig. 2).

The age- and sex-specific WC cut-points based on ethnic Chinese living in Hong Kong were approximately equivalent to the 70th percentile of our population; 31·7% of boys and 28·3% of girls were identified as having excess central adiposity (Table 1). Using these WC cut-points, excess central adiposity was particularly prevalent in 6- and 7-year-old boys (43·8%) and 14- to 17-year-old girls (36·8%). In comparison the WHtR cut-point of 0·5 identified 14·8% of boys and 10·8% of girls as having excess central adiposity (Table 1). The highest WHtR was observed (0·71) in a 14-year-old boy who had a BMI of 37·4 kg/m^2, 2·3% of children (3·1% boys, 1·1% girls) had a WHtR $> 0{\cdot}55$ and 0·7% (1·1% boys, 0·3% girls) had a WHtR $> 0{\cdot}6$.

Discussion

We constructed WC and WHtR percentiles for Han Chinese children, aged 5 to 17 years, living in the city of Chongqing in 2003 and 2004. Our WC percentiles are similar to those published on Han Chinese children living in Xingjiang Uyger Autonomous Region[14] but higher than those published on children living in Hong Kong in 2005 and 2006 (Table 4)[13]. At the 90th percentile the differences ranged from 2·4 to 7·2 cm in boys and from 1·8 to 6·9 cm in girls and were greater in both sexes during early adolescence (13–15 years) compared with younger children (6–9 years).

The difference in WC between Han Chinese living in China and children living in Hong Kong can be explained, in part, by the different rates of overweight and obesity as defined by the IOTF criteria. In our cohort, 26% of boys and 16% of girls were overweight or obese compared with 21% and 14% of boys and girls in the Hong Kong cohort. Similar rates of overweight and obesity to ours have been reported in Han adolescents (12–14 years old) living in Beijing; 24% of boys and 18% of girls were overweight or obese[2]. These rates are considerably higher than the 2002 Chinese national figures of 6% for children aged 7–17 years[22]. The disparity between different rates of overweight and obesity in rural China and large cities has been well documented[22]. The WC percentile data in our study population are likely to represent the current trend in overweight and obesity in Chinese cities.

Ethnicity is also a potential confounder in explaining the difference in WC and WHtR percentiles. It is estimated

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Table 2 Waist circumference (cm) percentiles for boys and girls

Age (years)*	*n*	5th	10th	25th	50th	75th	90th	95th
Boys								
5	96	47·1	48·4	50·9	54·3	58·5	63·5	67·3
6	217	48·0	49·4	52·0	55·7	60·3	65·8	70·1
7	231	48·7	50·1	53·0	56·9	61·9	67·9	72·6
8	311	49·2	50·8	53·8	57·9	63·2	69·7	74·8
9	342	50·2	51·8	54·9	59·3	65·0	72·0	77·7
10	328	51·5	53·2	56·5	61·0	67·1	74·6	80·7
11	347	52·8	54·6	58·0	62·8	69·2	77·0	83·3
12	353	54·1	56·0	59·6	64·6	71·2	79·1	85·4
13	352	55·9	57·9	61·7	66·9	73·5	81·2	87·1
14	274	58·7	60·7	64·5	69·7	76·3	84·0	89·8
15	295	60·9	62·8	66·4	71·3	77·7	85·3	91·2
16	319	61·8	63·6	66·9	71·6	77·7	85·4	91·6
17	136	62·1	63·7	66·9	71·3	77·2	84·9	91·5
Girls								
5	147	46·2	47·3	49·3	51·9	55·1	58·8	61·5
6	226	46·2	47·4	49·6	52·5	56·1	60·2	63·3
7	254	46·5	47·8	50·1	53·3	57·3	62·0	65·6
8	296	47·0	48·3	50·8	54·3	58·6	63·8	67·8
9	312	47·9	49·3	52·0	55·7	60·3	65·8	69·9
10	299	49·2	50·8	53·8	57·7	62·6	68·1	72·1
11	359	51·1	52·8	55·9	60·1	65·1	70·6	74·6
12	351	53·3	55·1	58·4	62·6	67·7	73·3	77·1
13	433	55·7	57·5	60·8	65·1	70·2	75·7	79·4
14	336	57·9	59·7	62·9	67·1	72·1	77·5	81·2
15	313	59·2	60·8	63·9	67·9	72·7	78·0	81·6
16	284	59·5	61·1	64·0	67·8	72·4	77·3	80·8
17	113	59·7	61·2	63·9	67·5	71·8	76·4	79·8

*Age is in whole years, e.g. 5 years = 5–5·99 years.

Table 3 Waist-to-height ratio percentiles for boys and girls

Age (years)*	*n*	5th	10th	25th	50th	75th	90th	95th
Boys								
5	96	0·39	0·40	0·42	0·45	0·48	0·51	0·54
6	217	0·39	0·40	0·42	0·44	0·48	0·51	0·54
7	231	0·38	0·39	0·41	0·44	0·48	0·51	0·54
8	311	0·38	0·39	0·41	0·44	0·47	0·51	0·54
9	342	0·38	0·39	0·41	0·44	0·47	0·51	0·54
10	328	0·37	0·38	0·40	0·43	0·47	0·51	0·54
11	347	0·36	0·37	0·40	0·42	0·46	0·50	0·54
12	353	0·36	0·37	0·39	0·42	0·46	0·50	0·53
13	352	0·36	0·37	0·39	0·42	0·45	0·50	0·53
14	274	0·36	0·37	0·39	0·42	0·45	0·50	0·53
15	295	0·36	0·37	0·39	0·42	0·46	0·50	0·53
16	319	0·36	0·37	0·39	0·42	0·45	0·50	0·53
17	136	0·36	0·37	0·39	0·42	0·45	0·49	0·52
Girls								
5	147	0·36	0·38	0·40	0·43	0·46	0·49	0·50
6	226	0·36	0·37	0·40	0·43	0·46	0·48	0·50
7	254	0·35	0·37	0·39	0·42	0·45	0·48	0·49
8	296	0·35	0·37	0·39	0·42	0·45	0·47	0·49
9	312	0·35	0·36	0·39	0·42	0·44	0·47	0·48
10	299	0·35	0·36	0·39	0·41	0·44	0·47	0·48
11	359	0·35	0·36	0·39	0·41	0·44	0·47	0·48
12	351	0·35	0·36	0·39	0·42	0·45	0·47	0·49
13	433	0·35	0·37	0·39	0·42	0·45	0·48	0·49
14	336	0·36	0·37	0·40	0·43	0·46	0·48	0·50
15	313	0·36	0·37	0·40	0·43	0·46	0·48	0·50
16	284	0·36	0·37	0·40	0·43	0·46	0·49	0·50
17	113	0·36	0·38	0·40	0·43	0·46	0·49	0·50

*Age is in whole years. e.g. 5 years = 5–5·99 years.

that ~95% of Hong Kong residents are ethnic Chinese, with no differentiation between Chinese ethnicities[23]. Anthropometric differences in children of different Chinese ethnicities have been demonstrated[14]. Measurement error or sample bias is unlikely; both studies used the same technique to measure WC and the participants in both studies are representative of the population studied.

Similar to findings in a study on Australian children[24], WC identified a greater number of children and adolescents as having excess central adiposity compared with being classified as overweight or obese using BMI criteria. These results are concerning and have public health implications. Excessive accumulation of central adipose tissue has been associated with cardiovascular risk factors[4,5]. Of particular concern was the high proportion (44%) of young boys with increased WC. While the explanation for the difference between younger and older children is not clear, we speculate that it may represent the advancing wave of the obesity epidemic for boys in China.

We also described the association between age and WHtR in Han children and adolescents. In some populations WHtR has been shown to more readily identify adolescents with adverse cardiovascular risk factors compared with WC and BMI[6,25–27]. The WHtR is also easy to calculate and is considered to be independent of age and sex. However, in our study population we observed a clinical and statistically significant sex difference in WHtR in young children (5–11 years). A similar trend was observed in children living in Hong Kong[28].

Table 4 Waist circumference (cm) corresponding to the 90th percentile from three different populations

Age (years)	Han living in Chongqing	Han living in Xingjiang Uyger Autonomous Region[14]	Ethnic Chinese living in Hong Kong[13]
Boys			
5	63·5		
6	65·8		63·4
7	67·9	65·5	65·0
8	69·7	67·4	66·6
9	72·0	70·2	68·5
10	74·6	73·1	70·6
11	77·0	75·8	72·5
12	79·1	78·3	74·0
13	81·2	80·4	75·3
14	84·0	82·3	76·8
15	85·3	83·9	78·3
16	85·4	85·5	79·6
17	84·9	87·0	80·7
Girls			
5	58·8		
6	60·2		58·4
7	62·0	60·7	60·0
8	63·8	62·1	61·6
9	65·8	63·8	63·4
10	68·1	66·0	65·1
11	70·6	68·5	66·9
12	73·3	71·4	68·4
13	75·7	74·4	69·7
14	77·5	76·7	70·6
15	78·0	77·9	71·3
16	77·3	78·0	71·8
17	76·4	77·3	72·2

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WHtR sex differences are likely to be a result of the differences in overall adiposity; 30% of boys aged 5–11 years were overweight or obese compared with 19% for girls.

To date, no cut-points for WHtR have been validated against metabolic outcomes for Han Chinese children and adolescents. In the absence of metabolic markers we defined excess central adiposity as a WHtR ≥ 0·5. Fewer children were identified as having excess central adiposity using a WHtR ≥ 0·5 compared with WC cut-points, 10·2% and 30·0%, respectively. Almost all students (99·5%) with a WHtR ≥ 0·5 were identified as having excess central adiposity defined by WC cut-points. We speculate that a WHtR cut-point of 0·5 may identify those children at greatest metabolic risk. However, a limitation of our study is that metabolic markers were not measured and further studies are required to further investigate the use of both the WC cut-points and WHtR in predicting cardiovascular risk in Han Chinese children.

In conclusion, we have constructed WC and WHtR percentile curves for Han Chinese children and adolescents aged 5–17 years living in Chongqing. Our measurements were based on a student population with a relatively high rate of overweight and obesity. Using IOTF criteria ~ 1 in 4 boys and 1 in 6 girls were overweight or obese. These data will provide a point of reference for future studies measuring the prevalence of overweight and obesity in China.

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