



Profiles of body mass index and the nutritional status among children and adolescents categorized by waist-to-height ratio cut-offs



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ABSTRACT

Background: Waist-to-height ratio (WHtR) is proposed as a simple, valid and convenient measure of abdominal obesity and health risks in practice. The present study examined the distribution of nutritional status among children and adolescents categorized by WHtR cut-offs.

Methods: A total of 30,459 students (15,249 boys and 15,210 girls) aged 7–18 years participated in the study. Height, weight and waist circumference (WC) of all subjects were measured, body mass index (BMI) and WHtR were calculated. The grades of nutritional status (thinness, normal weight, overweight and obesity) was defined by the international BMI cut-offs. All subjects were divided into three groups (low, moderate and high) according to their WHtR, BMI level and the distribution of nutritional status among the three groups were compared.

Results: In both boys and girls, significant differences in BMI level and the nutritional status were observed among the three groups. Children and adolescents aged 7–18 years in the 'high WHtR group' (≥ 0.5) had higher BMI than those in the 'low WHtR group' (< 0.4) by 6.00–10.15 kg/m² for boys and 5.24–9.51 kg/m² for girls. 'low WHtR group' had higher prevalence of thinness, and 'high WHtR group' had higher prevalence of overweight and obesity. The optimal distribution of nutritional status is found in the 'moderate WHtR group' (between 0.4 and 0.5) with the highest proportion of normal weight and low prevalence of thinness and obesity.

Conclusion: WHtR is associated with nutritional status, which could be an indicator of nutritional status and early health risk. It is necessary to develop optimal boundary values in the future.

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1. Introduction

Nutritional status during childhood plays an important role in the human lifecycle. The importance of child growth as an indicator for tracking the nutrition and health status of populations is well recognized [1]. Obesity and thinness are two of the most common nutritional disorders and both are associated with health consequences. Childhood obesity increases the risk of obesity in adulthood and is associated with cardiovascular disease (CVD) risk factors such as hypertension, diabetes and dyslipidemia [2–4]. Thinness can also result in problems such as osteoporosis, pubertal delay, menstrual irregularity, increased susceptibility to infections, hypothermia, thinning hair and premature mortality [5, 6]. Body mass index (BMI) is perhaps the most commonly used measure for defining overweight and obesity in clinical practice and population surveys [7]. Recently, an extended international BMI cut-offs for

screening thinness, overweight and obesity among children and adolescents has been established [8], which provides a convenient for the assessment of nutritional status and comparison between countries.

It is well known that compared with general obesity, abdominal obesity is associated with greater health risks [9–13]. The waist-to-height ratio (WHtR) has been suggested as an alternative measure to identify abdominal obesity with a simple public health message 'keep your waist circumference to less than half your height' [14,15]. Furthermore, WHtR has also been shown to outperform BMI and waist circumference (WC) in discriminating risk of hypertension, diabetes, and CVD risk [16–18]. However, little is known about the distribution of nutritional status among children and adolescents with different WHtR. In this article, based on a large sample, we report the profiles of BMI and the distribution of different grades of nutritional status (thinness, normal weight, overweight and obesity) among children and adolescents categorized by WHtR cut-offs in Shandong, China.

2. Subjects and methods

The study was approved by the Ethical Committee of the Shandong Center for Disease Control and Prevention, Shandong, China.

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2.1. Study population

Data for this study were obtained from a large cross-sectional survey of schoolchildren. A total of 30,459 students (15,249 boys and 15,210 girls) from 17 districts in Shandong Province, students of Han nationality, aged 7–18 years, participated in the National Surveys on Chinese Students' Constitution and Health, which were carried out in September to October 2014. (The first author is the leader of the investigation team in Shandong.) All subjects voluntarily joined this study with informed consents. The sampling method was stratified multistage sampling based on selected primary and secondary schools. Six public schools (two primary schools, two junior high schools, and two senior high schools) from each of the 17 districts in Shandong were randomly selected and invited to participate in the study. From the selected schools, two classes in each grade were selected, and all students of the selected classes were invited to join the study. All subjects were primary and secondary students, ranging from 7 to 18 years of age, and all were of Han ancestry that accounts for ~99.32% of the total population in Shandong.

2.2. Measurements and definitions

All measurements were performed by a team of trained health professionals in each of the 17 districts. Each professional is required to pass a training course for anthropometric measurement organized by the investigation team in Shandong. All measurements were taken using the same type of apparatus and followed the same procedures. Height without shoes was measured using metal column height-measuring stands to the nearest 0.1 cm. Weight was measured using lever scales to the nearest 0.1 kg while the subjects wore their light clothes. BMI was calculated from their height and weight (kg/m^2), and the grades of nutritional status (thinness, normal weight, overweight and obesity) was defined by the international cut-offs [8]. WC was measured midway between the lowest rib and the superior border of the iliac crest with an inelastic measuring tape at the end of normal expiration to the nearest 0.1 cm. WHtR was calculated as WC divided by height, and abdominal obesity was defined as $\text{WHtR} \geq 0.5$ [14].

2.3. Statistical analyses

Considering the BMI values of children change with age, BMI-for-age Z-scores were calculated based on the distribution of the total sample. The grades of nutritional status (thinness, normal weight, overweight and obesity) within each WHtR category were determined. All subjects were divided into three groups (low WHtR group: $\text{WHtR} < 0.4$, moderate WHtR group: $0.4 \leq \text{WHtR} < 0.5$, high WHtR group: $\text{WHtR} \geq 0.5$) according to their WHtR and comparisons of BMI among the three groups were made by one-way ANOVA; comparisons on the distribution of nutritional status among different groups were made by chi-square test. All analyses were performed with the statistical package SPSS 11.5. Significance was defined at the 0.05 level.

3. Results

3.1. Comparison of BMI among different WHtR groups

Comparison of BMI among children and adolescents categorized by WHtR is presented in Table 1. Statistically significant differences were observed among the three groups ($P < 0.01$). Children and adolescents aged 7–18 years in the 'high WHtR group' had higher BMI compared with those in the 'low WHtR group' in all age groups, the range of differences being $6.00\text{--}10.15 \text{ kg}/\text{m}^2$ (representing 40.53–55.80%) for boys and $5.24\text{--}9.51 \text{ kg}/\text{m}^2$ (representing 36.49–55.50%) for girls. Children and adolescents aged 7–18 years in the 'high WHtR group' had higher BMI than their counterparts in the 'moderate WHtR group' by $4.35\text{--}6.99 \text{ kg}/\text{m}^2$ (representing 26.46–33.69%) for boys and $3.45\text{--}6.48 \text{ kg}/\text{m}^2$ (representing 21.38–32.12%) for girls. The comparison of BMI Z-score among the three groups is presented in Table 2. Statistically significant differences were observed between any two groups ($P < 0.01$), 'high WHtR group' had the highest and 'low WHtR group' had the lowest BMI level. Fig. 1 shows that the BMI Z-score increased with WHtR in both boys and girls, from -1.03 (boys) and -1.10 (girls) in the $\text{WHtR} < 0.34$ group to 2.61 (boys) and 2.99 (girls) in the $\text{WHtR} \geq 0.60$ group. We found that the BMI Z-score is positive associated with WHtR, the correlation coefficient were 0.804 for boys and 0.745 for girls ($P < 0.01$).

Table 1
Comparison of BMI among children and adolescents categorized by WHtR (kg/m^2).

Gender	Age/years	Total		WHtR < 0.4		0.4 ≤ WHtR < 0.5		WHtR ≥ 0.5		F	P	
		n	Mean ± SD	n	Mean ± SD	n	Mean ± SD	n	Mean ± SD			
Boys	7	1392	17.19 ± 2.96	141	14.81 ± 1.40	964	16.46 ± 1.98	287	20.81 ± 3.28	495.69	0.000	
	8	1403	17.70 ± 3.33	208	14.94 ± 1.59	879	16.88 ± 2.14	316	21.81 ± 3.32	657.35	0.000	
	9	1328	18.50 ± 3.54	203	15.70 ± 1.81	793	17.47 ± 2.22	332	22.65 ± 3.46	634.43	0.000	
	10	1342	19.01 ± 3.89	231	15.59 ± 1.80	783	18.11 ± 2.48	328	23.59 ± 3.71	681.28	0.000	
	11	1309	20.04 ± 4.13	217	16.03 ± 1.49	688	18.80 ± 2.34	404	24.32 ± 3.89	756.66	0.000	
	12	1309	20.10 ± 4.07	293	16.77 ± 1.89	721	19.37 ± 2.46	295	25.17 ± 4.13	702.77	0.000	
	13	1209	20.39 ± 4.17	384	17.35 ± 1.75	603	20.01 ± 2.45	222	26.72 ± 4.07	895.04	0.000	
	14	1176	21.05 ± 4.09	360	17.99 ± 1.62	623	20.74 ± 2.50	193	27.73 ± 3.79	929.69	0.000	
	15	1190	21.24 ± 3.99	397	18.19 ± 1.57	632	21.35 ± 2.46	161	28.34 ± 3.79	988.33	0.000	
	16	1282	21.45 ± 3.72	404	18.57 ± 1.43	716	21.67 ± 2.43	162	27.65 ± 4.37	758.74	0.000	
	17	1207	21.61 ± 3.63	345	18.59 ± 1.29	701	21.65 ± 2.21	161	27.91 ± 3.87	901.27	0.000	
	18	1102	21.91 ± 3.68	291	18.71 ± 1.54	663	21.86 ± 2.12	148	28.41 ± 3.73	890.42	0.000	
	Girls	7	1393	16.25 ± 2.45	268	14.35 ± 1.16	939	16.14 ± 1.70	186	19.59 ± 3.50	397.67	0.000
		8	1390	16.80 ± 2.81	304	14.70 ± 1.18	918	16.67 ± 2.12	168	21.30 ± 3.16	532.08	0.000
9		1345	17.43 ± 3.10	325	15.21 ± 1.98	841	17.40 ± 2.37	179	21.60 ± 3.51	387.23	0.000	
10		1351	18.08 ± 3.49	400	15.67 ± 1.58	769	18.28 ± 2.66	182	22.56 ± 4.71	388.02	0.000	
11		1327	18.82 ± 3.37	364	16.17 ± 1.58	785	18.92 ± 2.46	178	23.78 ± 3.73	564.62	0.000	
12		1322	19.27 ± 3.47	392	16.44 ± 1.69	779	19.65 ± 2.48	151	24.69 ± 3.95	615.07	0.000	
13		1200	19.73 ± 3.50	365	17.13 ± 1.76	743	20.16 ± 2.65	92	26.63 ± 3.92	541.85	0.000	
14		1186	20.25 ± 3.26	304	17.59 ± 1.52	770	20.47 ± 2.31	112	25.98 ± 4.16	514.27	0.000	
15		1199	20.78 ± 3.08	273	18.17 ± 1.52	829	20.98 ± 2.32	97	26.38 ± 3.66	462.42	0.000	
16		1224	20.83 ± 2.79	226	18.34 ± 1.35	893	20.93 ± 2.12	105	25.30 ± 3.96	354.21	0.000	
17		1183	21.15 ± 2.98	195	18.44 ± 1.52	880	21.12 ± 2.24	108	26.30 ± 3.53	410.31	0.000	
18		1090	21.03 ± 2.88	203	18.35 ± 1.38	786	21.06 ± 2.09	101	26.20 ± 3.24	465.45	0.000	

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