

**Original article:**

**Waist circumference and Waist height ratio percentiles for assessing childhood obesity: Cross-Sectional Survey in rural Indian child population.**

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**Abstract:**

**Introduction:** This research work proposed the age-gender specific percentile charts for waist circumference (WC) and Waist height ratio (WHtR) with determination of its validity in comparison to international criteria of 0.5 as cut off value. In addition the prevalence of obesity among the rural child population was estimated.

**Methodology:** A cross sectional school based study was carried out at Loni, Ahmednagar-Maharashtra, during May 2008 to December 2010. Two stage sampling method was applied for selection of schools. The eligible population accounted at 2642 from the total study population after meeting the inclusion criteria. Age-gender specific waist circumference percentile charts were tabulated and categorization of obesity was done as per the International Diabetic Federation criteria of 90<sup>th</sup> percentile. WHtR percentile charts were formulated and ninety fifth percentile was taken as the cut off limit to comment on obesity.

**Observations and Results:** The mean WHtR ( $\geq 95^{\text{th}}$  percentile) cut off, for male and female children of rural area in Maharashtra is proposed at 0.43 and 0.44 respectively. The sensitivity and specificity of WHtR was 1.00 (95% CI 0.92-1.00) and 0.82 (95% CI 0.79-0.84) with statistical significant association ( $\chi^2=351.06$ ,  $p<0.0001$ ) in comparison to international criteria of 0.5. The prevalence of obesity with the criteria of  $WC>90^{\text{th}}$  percentile,  $WHtR >0.5$  and  $WHtR>95^{\text{th}}$  percentile was estimated at 12.87%, 3.4%, and 20.74% respectively.

**Conclusion:** child hood obesity is best screened with use of WHtR of lower cut off limit in comparison to international criteria, especially for rural children in India.

**Key words:** Child obesity, height, Waist circumference

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**Introduction**

Obesity has been described as one of today's most neglected public health problems (WHO). The rise in its prevalence among children is a cause of concern, due to its persistency into adulthood and association with morbidity [1][2]. Globally, an estimated 10 per cent of school-aged children, between 5 to 17yr of age, are overweight or obese [3]. Developing countries are faced with this "New World Syndrome" accounting to enormous socioeconomic and public health burden [4]. Even the accurate measurement of this condition in India is not without quandary.

Anthropometric indices which can predict childhood central obesity include mainly Body Mass Index, waist circumference (WC), and waist-height ratio (WHtR). [5-9]. Body Mass Index, most commonly used as a tool for measuring obesity, with the cut off limits for adults and percentile charts for children [10-12], is not without limitations. Central fat adiposity, which is not measured by this Index, has been associated with the risk of cardiovascular and metabolic disease in children. Though Waist circumference cut off values for Indian adults are being laid, but for assessment of child hood obesity,

only percentile charts have been developed for countries like Canada, Cuba, Italy, Spain, United Kingdom and United States by various researchers.[13-18]. Even the International Diabetic Federation has recommended the 90<sup>th</sup> percentile as a limit but without a cut off value.[19] Similarly, relatively new concept of waist height ratio, has proposed a cut off limit of 0.5 by Ashwell MA et al [20]. Other researchers like Weili Y et al has proposed the threshold limit value as 0.485 in boys and 0.475 in girls among Chinese school children [21]. This has created a dilemma in the researchers for selection of appropriate tool among Indian child population. These varied percentile charts and cut off values, made us inquisitive to propose the Age gender specific percentile charts for waist circumference, WHtR and determine the validity of 0.5 WHtR as cut off value to determine the prevalence of obesity among the Rural child population of Maharashtra in age group of 6-16 years.

### **Methodology**

A cross sectional school based study was carried out in Ahmednagar district of Western Maharashtra. It has 80.34% rural population and 19.66% urban population. This District has fourteen Talukas, of which Taluka Rahata was the point of focus for the present study. Taluka Rahata has many villages of which the major educational hub is at Loni. This place provides education from primary classes to super specialization in almost all fields. The study was conducted out over a period of two year from May 2008 to December 2010. The research design got the clearance from Institutional Ethical Committee of Rural Medical College, Loni

**Selection of participants:** List of the schools under the Pravara Rural Education Society (PRES) was

sought which comprised of both affluent and non affluent schools. One school each from both the affluent and non affluent schools was chosen for this study by Random sampling (lottery method). This resulted in two schools eligible for study named as Pravara public school (affluent) and Ahilyabai Holkar school (non affluent). The said selection was done in order to get the generalized data, so as to neutralize the effect of economic status. Pravara Public school is an affluent school with a fee structure of Rs 1600 per month is situated in Pravaranagar and has facilities for both boarders and day scholar children. Ahilyabai Holkar school is a non affluent school with fee of Rs 200 per month situated in Loni. This school is Marathi medium which enrolls only day scholar. Written permission was sought from the respective schools to conduct the study. All the children, in the age group of 6-16 years, for which the consents were available, constituted the study population. The eligible populations (2642) among these two schools were enrolled for the study. Those participants who did not meet the inclusion criteria were detained from the present study.

An inclusion criterion was framed on the basis of age between six to sixteen years only. This age group was in accordance to International Diabetic Federation classification of metabolic syndrome for identifying obese children[19]. Anthropometric measures like waist circumference and height was recorded for this eligible population. Inelastic Measuring tape of 15 meters (Freeman tape) was used to measure the Waist Circumference in accordance to the WHO criteria[22-23]. Stadiometer measured the Height with the subject barefooted, standing in an erect position against a vertical scale of it and the position of subjects was kept in a way so that top of external

auditory meatus was in level with the inferior margin of the bony orbit. Both the measurements were to the nearest of 0.1 cm. Age-gender specific waist circumference percentile charts were tabulated as per the IDF criteria of 90<sup>th</sup> percentile. The children having more than or equal to 90<sup>th</sup> percentile of waist circumference were labeled as obese. With the use of height and waist measurements, Waist height ratio percentile charts were formulated ranging from third percentile to ninety seventh percentile. The cut off limit at ninety fifth percentile was chosen to comment on obesity. The sensitivity and specificity were calculated for the said percentile and was compared with the standard international criteria of WHtR more than 0.5 proposed by Ashwell M A et al [20]. The mean of 95<sup>th</sup> percentile values of WHtR were taken to suggest the cut off values for male and female children of rural area in Maharashtra to classify them as obese. The prevalence of obesity was calculated with all the said criterias.

**Statistical analysis:** Data Coding and Entry was done in Microsoft Excel spread sheets. Subsequent analysis was done by inferential statistical methods. Mean and standard deviation of the parameters used in study were calculated. Percentiles charts were calculated for Waist Circumference and waist height ratio. The tables were analyzed manually for calculation of Ratio, Percentages, and Proportion. Chi-square was applied to evaluate association between the study variables. Pearson's Correlation coefficient was calculated using SYSTAT version 12 (Craine software Bangalore) to see correlation between waist circumference and height.

### Results

The analysis of demographic composition of the study population revealed that children aged 9 years

had the maximum presentation at 362 (13.70%) and at 16 years of age had the minimum presentation at 30 (1.14%). Males 1986 (75.17%) outnumbered the females 656 (24.83%). (Table 1). The strength of children in affluent school 1886 (71.38%) was more as compared to Non affluent school 756 (28.62%).

Mean and standard deviation of age, height, waist circumference and waist height ratio for both males and females were analyzed. It was observed that males had slightly more mean values of waist circumference 56.28 cm and waist height ratio 0.40 compared to females (Table 2).

Considering the total population of 2642, age and gender specific percentile charts from third to ninety seventh percentile were tabulated. Age specific waist circumference percentile charts for males (Table3) and females (Table 4) were drafted. The 90<sup>th</sup> percentile values (IDF criteria for MS), for males ranged from the minimum of 45.72 cm to 81.28 cm and for females as 46.99 to 64.77. Age specific waist height ratio percentile charts for males (Table5) and females (Table 6) considered the 95<sup>th</sup> percentile as a cut off limit to identify the obese children. Mean values of this said percentile were 0.43 and 0.44 for males and females respectively.

Validation of Waist height ratio (>95<sup>th</sup> percentile) against Waist height ratio (0.5 cutoff) as a screening criteria in rural population was analyzed. The sensitivity and specificity calculated are shown in Table 7. A significant statistical association ( $p < 0.0001$ ) was observed between the two indices. The prevalence of obesity with the criterias of WC>90<sup>th</sup> percentile, WHtR >0.5 and WHtR>95<sup>th</sup> percentile was estimated at 12.87%, 3.4%, and 20.74% respectively. (Table 8)

Table 1: Age and gender specific profile of children in affluent and non affluent schools

Age (years)	Male (%)	Female (%)	Total (%)
6 to <7	32 (1.21%)	10 (0.38%)	42 (1.59%)
7 to <8	236 (8.93%)	66 (2.50%)	302(11.43%)
8 to <9	172 (6.51%)	54 (2.04%)	226 (8.55%)
9 to <10	262 (9.91%)	100 (3.79%)	362 (13.70%)
10 to <11	256 (9.69%)	44 (1.67%)	300 (11.36%)
11 to <12	250 (9.46%)	54 (2.04%)	304 (11.50%)
12 to <13	246 (9.31%)	80 (3.03%)	326 (12.34%)
13 to <14	232 (8.78%)	100 (3.79%)	332 (12.57%)
14 to <15	172 (6.51%)	96 (3.62%)	268 (10.13%)
15 to <16	106 (4.02%)	44 (1.67%)	150 (5.69%)
16 to <17	22 (0.84%)	8 (0.30%)	30 (1.14%)
<b>Total</b>	1986(75.17%)	656 (24.83%)	2642(100%)
<b>School</b>			
<b>Affluent</b>	1568(59.35%)	318 (12.04%)	1886 (71.38%)
<b>NonAffluent</b>	418 (15.82%)	338 (12.79)	756 (28.62%)
<b>Total</b>	1986(75.17%)	656 (24.83%)	2642(100%)

Table 2 : Gender specific profile of study variables among school children

Variables	Male (n=1986)			Female (n=656)		
	Mean	SD	95% CL	Mean	SD	95% CL
<b>Age (years)</b>	10.67	2.47	10.52±10.83	11.09	2.61	10.81±11.38
<b>Height (cm)</b>	137.87	15.22	136.92±138.82	139.70	15.38	138.04±141.37
<b>Waistcircumference (cm)</b>	56.28	8.26	55.77±56.79	55.74	8.14	54.86±56.62
<b>Waist height ratio</b>	0.40	0.04	0.40±0.41	0.39	0.03	0.39±0.40

Table 3 : Age specific Waist percentiles of male children of 6-16 years.

Percentile	3 <sup>rd</sup>	5 <sup>th</sup>	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	97 <sup>th</sup>
Age (Years)										
6	43.18	43.18	43.43	45.72	46.99	50.80	50.80	<b>53.09</b>	53.34	53.34
7	43.18	43.18	43.18	44.15	44.45	45.72	45.72	<b>45.72</b>	45.72	45.72
8	43.18	43.18	43.18	43.18	45.72	45.72	45.72	<b>46.86</b>	47.57	48.26
9	45.36	45.72	45.72	47.96	48.26	48.26	48.26	<b>48.26</b>	49.53	49.53
10	40.64	42.04	45.72	48.26	48.26	50.80	50.80	<b>50.80</b>	50.80	50.80
11	45.64	45.72	45.72	48.26	48.26	50.80	50.80	<b>50.80</b>	51.38	52.07
12	45.72	45.72	45.97	48.26	50.80	50.80	50.80	<b>50.80</b>	50.80	50.80
13	45.72	47.12	48.39	50.80	50.80	52.07	53.34	<b>53.34</b>	53.34	53.34
14	50.80	52.20	53.34	53.34	54.61	55.88	55.88	<b>55.88</b>	55.88	55.88
15	53.34	53.34	53.34	54.61	55.88	57.15	58.42	<b>58.42</b>	58.42	58.42
16	48.26	49.02	55.88	58.42	63.50	78.74	81.28	<b>81.28</b>	97.28	99.06

All Units in centi-meters

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Table 4 : Age specific Waist circumference percentiles of female children of 6-16 years.

Percentiles	3 <sup>rd</sup>	5 <sup>th</sup>	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	97 <sup>th</sup>
Age (years)										
6	40.64	40.64	40.64	40.64	40.64	45.09	46.99	<b>46.99</b>	46.99	46.99
7	38.10	39.50	40.64	42.88	44.45	46.99	46.99	<b>46.99</b>	47.57	48.26
8	40.64	42.04	43.18	44.15	45.72	48.26	48.26	<b>50.55</b>	50.80	50.80
9	40.64	41.35	42.04	44.45	45.72	48.26	48.26	<b>48.26</b>	48.26	48.26
10	45.72	45.72	45.85	47.96	49.53	54.61	55.88	<b>58.17</b>	58.42	58.42
11	45.72	45.72	45.85	48.26	51.44	54.61	54.61	<b>54.61</b>	55.19	55.88
12	43.18	44.58	45.97	50.50	50.80	53.67	55.88	<b>55.88</b>	55.88	55.88
13	45.72	47.12	48.39	50.80	52.07	53.67	54.61	<b>54.61</b>	55.19	55.88
14	49.53	51.64	53.47	55.58	55.88	58.42	58.42	<b>58.42</b>	59.00	59.69
15	58.42	58.42	58.42	59.69	63.50	63.75	64.77	<b>64.77</b>	65.91	67.31
16	58.42	58.42	58.42	58.42	60.96	64.77	64.77	<b>64.77</b>	64.77	64.77

All Units in centi-meters

Table 5 : Age specific Waist height ratio of male children of 6-16 years

Percentiles	3 <sup>rd</sup>	5 <sup>th</sup>	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	97 <sup>th</sup>
Age (years)										
6	0.37	0.38	0.38	0.39	0.43	0.45	0.45	0.45	<b>0.46</b>	0.46
7	0.37	0.37	0.37	0.38	0.39	0.40	0.41	0.41	<b>0.42</b>	0.42
8	0.36	0.37	0.37	0.38	0.39	0.40	0.41	0.41	<b>0.43</b>	0.43
9	0.35	0.35	0.36	0.37	0.38	0.39	0.40	0.40	<b>0.40</b>	0.40
10	0.34	0.34	0.34	0.37	0.38	0.39	0.40	0.40	<b>0.41</b>	0.41
11	0.34	0.34	0.34	0.35	0.36	0.37	0.38	0.39	<b>0.40</b>	0.40
12	0.33	0.34	0.34	0.36	0.37	0.38	0.39	0.39	<b>0.40</b>	0.41
13	0.34	0.35	0.35	0.36	0.37	0.38	0.38	0.39	<b>0.40</b>	0.40

<b>14</b>	0.34	0.34	0.35	0.36	0.37	0.38	0.39	0.39	<b>0.40</b>	0.41
<b>15</b>	0.32	0.32	0.33	0.34	0.37	0.38	0.38	0.39	<b>0.39</b>	0.39
<b>16</b>	0.32	0.32	0.34	0.35	0.38	0.45	0.48	0.48	<b>0.59</b>	0.60

All Units in centi-meters

Table 6 : Age specific Waist height ratio of female children of 6-16 years

Percentiles	3 <sup>rd</sup>	5 <sup>th</sup>	10 <sup>th</sup>	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	85 <sup>th</sup>	90 <sup>th</sup>	95 <sup>th</sup>	97 <sup>th</sup>
Age (years)										
<b>6</b>	0.35	0.35	0.35	0.36	0.37	0.41	0.42	0.42	<b>0.42</b>	0.42
<b>7</b>	0.35	0.35	0.35	0.38	0.40	0.42	0.43	0.43	<b>0.45</b>	0.45
<b>8</b>	0.33	0.35	0.36	0.36	0.40	0.42	0.44	0.44	<b>0.45</b>	0.46
<b>9</b>	0.34	0.35	0.36	0.37	0.39	0.40	0.40	0.41	<b>0.41</b>	0.41
<b>10</b>	0.33	0.34	0.34	0.36	0.40	0.41	0.44	0.46	<b>0.50</b>	0.53
<b>11</b>	0.32	0.34	0.35	0.37	0.38	0.43	0.44	0.44	<b>0.46</b>	0.48
<b>12</b>	0.33	0.33	0.34	0.36	0.38	0.39	0.41	0.41	<b>0.43</b>	0.43
<b>13</b>	0.34	0.34	0.34	0.35	0.37	0.38	0.38	0.39	<b>0.40</b>	0.40
<b>14</b>	0.35	0.35	0.35	0.37	0.38	0.40	0.40	0.41	<b>0.41</b>	0.42
<b>15</b>	0.35	0.36	0.36	0.38	0.41	0.43	0.44	0.46	<b>0.47</b>	0.48
<b>16</b>	0.38	0.38	0.38	0.38	0.38	0.39	0.40	0.40	<b>0.40</b>	0.40

All Units in centi-meters

Table 7 : Validation of Waist height ratio (>95<sup>th</sup> percentile) against Waist height ratio (0.5 cutoff)

Variables	WHtR >0.5 (%)	WHtR <0.5 (%)	Total	P value	Sensitivity (95% CI)	Specificity (95% CI)
<b>WHtR (&gt;95<sup>th</sup> percentile)</b>	90 (3.41%)	458 (17.33%)	548 (20.74%)	P<0.0001	1.00 (0.92-1.00)	0.82 (0.79-0.84)
<b>WHtR (&lt;95<sup>th</sup> percentile)</b>	0	2094 (19.26%)	2094 (19.26%)			
	90 (3.41%)	2552 (96.59%)	2642			

$\chi^2=351.06$  (p<0.001)

Table 8 : Gender -wise prevalence of obesity with criteria's used in the study. (n=2642)

Gender	WC>90 <sup>th</sup> (%)	WHtr>95 <sup>th</sup> (%)	WHtr>0.5 (%)
<b>Male</b>	254 (9.61%)	422 (15.97%)	72 (2.72%)
<b>Female</b>	86 (3.26%)	126 (4.77%)	18 (0.68%)
<b>Total</b>	340 (12.87%)	548 (20.74%)	90 (3.40%)

**Discussion**

The state of dilemma over a specific cut off limit to screen obese children in rural areas, sample of 2642 was sought. The group of 6 to 16 years school children was in accordance to the IDF criteria. Mean age for the study population was 10.88 years, which is similar to as reported by weili yan study et al[21] at 10.7 ±3.2. The composition of study participants on the basis of gender showed the boys to girls' ratio at 3:1. Male dominance of study subjects were more

acute in affluent school 1568 (83.14%) than non affluent school 418 (55.3%).(Table 1). This was because the affluent school was a predominant male boarding school which however also had extended the facilities to include female day scholars. A study on similar age group was conducted, by D.R Bharati et al[4] (2555 children) and Anand N.K, Tandon L et all [24] (5000 school children in age group of 5 to 17 years in Amritsar city, Punjab.

The anthropometric indices like waist circumference and waist height ratio were calculated for both the



genders. Waist circumference mean had the lower limits for females compared to males as also reported by chaoulang li [25] among American population (NHANES 1999-2004) and Ian jansen[26] analysis of Bogulsia heart study. Waist height ratio mean had no gender specific difference in the present study (Table 2).

In view of known limitations of BMI as an epidemiological tool for surveillance of obesity [27-28], WC and WHtR were adopted to comment on obesity in children. Criteria of IDF (WC>90<sup>th</sup> percentile) was adopted to comment on obesity for rural Maharashtra children population. Similar WC percentile charts for children have been developed in different countries [13-18]. Specific percentile charts are formulated to exactly comment on the obesity in this rural area which may differ from others, because of phenotype variation in the population. This variation may be explained on the predisposition of the central obesity among Asian population as compared to other regions.

There is a strong positive correlation between height and WC throughout growth, i.e from childhood to adulthood, as also evidenced in the present study( $r=0.59$ ,  $0.55\pm 0.63$ ; 95%CL,  $p<0.0001$ ), so the inclusion of WC in combination with height may partly correct for the effect of height on WC. Thus, WHtR was also included. Though the cut off limit of 0.5 WHtR has been suggested by Ashwell et al 1996[20] internationally, but considering the rural children population of Maharashtra, an attempt was made to formulate these age and gender specific percentile charts. The criterion of 0.5 cut off limit was compared with the 95<sup>th</sup> percentile charts. An attempt for the validation of WHtR percentile more than 95<sup>th</sup> percentile revealed the sensitivity and specificity as

1.00 (95% CI 0.92-1.00) and 0.82 (95% CI 0.79-0.84) with statistical significant association ( $\chi^2=351.06$   $p<0.0001$ ) in comparison to international criteria. High obesity prevalence of 20.74% (WHtR>95<sup>th</sup> percentile) as compared to only 3.4% (WHtR >0.5) may be due to the high sensitivity of the earlier criteria at the cost of specificity, but it is recommended as the prevalence of childhood obesity is on rise globally. This criterion may serve as a simple tool to track the obese individuals from childhood to adult hood for effective health education. The only disadvantage will be that health awareness will have to be disseminated to some false positive also, which in fact is the advantage for the community as a whole, as these individuals also become aware and sensitized. Using mean WHtR cut off 0.43(males) and 0.44 (females) in age group of 6-16, the gender specific prevalence of obesity is estimated at 422 (15.97%) and 126 (4.77%). Children, who are classified as obese, on basis of high waist height ratio, should be encouraged to eat healthy diets and be more physically active.

#### **Conclusion:**

These findings provide useful information that further strengthens our understanding of the obesity epidemic among children and adolescents of rural area of Maharashtra. It even sheds light on the importance of using Waist Height ratio as a simple easy index with ratio of 0.43 and 0.44 as cut off values to screen obese males and females respectively. Its simplicity lies in, using only a standardized measuring tape instead of portable weighing machines (problem of zero correction), to screen obese individuals. Efforts are needed to promote the measurement of this important anthropometric parameter as a “vital sign” in schools and pediatric primary care practice.

**Abbreviations used:**

WC	: Waist Circumference
WHtR	: Waist Height Ratio
X <sup>2</sup>	: Chi-square
RSSDI	: Research Society for the Study of Diabetes in India
PRES	: Pravara Rural Education Society
WHO	: World Health Organisation
IDF	: International Diabetic Federation
MS	: Metabolic Syndrome

**References :**

1. Must A, Jacques PF, Dallal GE, Bajema CJ & Dietz WH. Long term morbidity and mortality of overweight adolescents. A follow up of the Harvard Growth Study of 1922 to 1935. *New Engl. J. Med.* 1992; 327:1350 –1355.
2. Troiano RP & Flegal KM: Overweight children and adolescents: description, epidemiology and demographics. *Pediatrics* 1998;101: 497 – 504.
3. Childhood obesity-The global picture. [Online] [Cited January12, 2012]; Available from URL: <http://www.who.org/childhoodobesity.asp>
4. D.R. Bharati, P.R. Deshmukh & B.S. Garg. Correlates of overweight & obesity among school going children of Wardha city, Central India. *Indian J Med Res*, June 2008; 539-543.
5. Freedman DS, Dietz WH, Srinivasan SR, Berenson GS: The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatr* 1999;103:1175-82.
6. Kahn HS, Valdez R. Metabolic risks identified by the combination of enlarged waist and elevated triacylglycerol concentration. *Am J Clin Nutr* 2003;78:928-934.
7. Katzmarzyk PT, Srinivasan SR, Chen W, Malina RM, Bouchard C, Berenson GS. Body mass index, waist circumference, and clustering of cardiovascular disease risk factors in a biracial sample of children and adolescents. *Pediatrics* 2004;114(2):198-205.
8. Gower BA, Nagy TR, Goran MI. Visceral fat, insulin sensitivity, and lipids in prepubertal children. *Diabetes* 1999;48:1515-21.
9. Kelishadi R, Gheiratmand R, Ardalan G, et al. Association of anthropometric indices with cardiovascular disease risk factors among children and adolescents: CASPIAN Study. *Int J Cardiol* 2007;117:340-48.
10. Cole T J, Freeman J V & Preece M A. Body Mass Index reference curves for the UK, 1990. *Archives of Disease in Childhood* 1995;73: 25–29.
11. Dietz WH & Bellizzi MC. Introduction: the use of body mass index to assess obesity in children. *American Journal of Clinical Nutrition* 1999;70: 123–125.
12. National Center for Health Statistics (2000) Pediatric growth charts. [www.cdc.gov/growthcharts](http://www.cdc.gov/growthcharts)
13. Katzmarzyk P T. Waist circumference percentiles for Canadian youth 11–18 y of age. *Eur J Clin Nutr.* 2004;58: 1011–1015.
14. Martinez E, Devesa M, Bacallao J, Amador M. Percentiles of the waist-hip ratio in Cuban scholars aged 4.5 to 20.5 years. *Int J Obes Relat Metab Disord.* 1994;18: 557–560.

15. Zannolli R, Morgese G. Waist percentiles: a simple test for atherogenic disease? *Acta Paediatr.* 1996;85: 1368–1369.
16. Moreno LA, Fleta J, Mur L, Rodriguez G, Sarria A, Bueno M. Waist circumference values in Spanish children: gender related differences. *Eur J Clin Nutr.* 1999;53: 429–433.
17. McCarthy H D, Jarrett K V, Crawley H F. The development of waist circumference percentiles in British children aged 5.0–16.9 y. *Eur J Clin Nutr.* 2001;55: 902–907.
18. Fernandez J R, Redden D T, Pietrobelli A, Allison DB. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. *J Pediatr.* 2004;145: 439–444.
19. Paul Zimmet, George Alberti, Francine Kaufman, Naoko Tajima, Martin Silink, Silva Arslanian, et al on behalf of the International Diabetes Federation Task Force on Epidemiology and Prevention of Diabetes. The metabolic syndrome in children and adolescents: the IDF consensus. *Diabetic voice.* December 2007; 52(4).
20. Ashwell MA, LeJeune SRE & McPherson B. Ratio of waist circumference to height may be better indicator of need for weight management. *British Medical Journal* 1996;312-377.
21. Weili Y, He B, Yao H, Dai J, Cui J, Ge D, et al. Waist-to-height ratio is an accurate and easier index for evaluating obesity in children and adolescents. *Obesity (Silver Spring).* Mar 2007;15(3):748-52.
22. World Health Organization (WHO). Waist circumference and waist-hip ratio: report of a WHO expert consultation. Geneva, 8-11 December 2008. Geneva, Switzerland: WHO; 2011.
23. World Health Organization (WHO): WHO STEPwise approach to surveillance (STEPS). Geneva, Switzerland: WHO; 2008
24. Anand N. K. and Tandon L. Prevalence of hypertension in school going children *Indian pediatrics* 1996; 33(5): 377-381.
25. Chaoyang Li, Earl S. Ford, Ali H. Mokdad, Stephen Cook. Recent Trends in Waist Circumference and Waist Height Ratio Among US Children and Adolescents. *Pediatrics* 2006; 118: 1390 .
26. Ian Janssen, Peter T Katzmarzyk, Sathanur R, Srinivasan, Wei Chen, Robert M et al. Combined Influence of Body Mass Index and Waist Circumference on Coronary Artery Disease Risk Factors Among Children and Adolescents. *Paediatrics* 2005;115:1623-1630
27. Ellis KJ, Abrams SA & Wong WW. Monitoring childhood obesity: Assessment of the weight/height<sup>2</sup> index. *American Journal of Epidemiology* 1999;150: 939–946.
28. Moreno LA, Sarria A, Fleta J, Rodriguez G & Bueno M. Trends in body mass index and overweight prevalence among children and adolescents in the region of Aragon (Spain) from 1985 to 1995. *International Journal of Obesity* 2000;24: 925–93.

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