

## Waist Circumference, Waist for Height and Skinfold Thickness, Percentile Curves in School-Going Children of Age 5 to 15 Years

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### Abstract

**Background:** It is indeed ironic that a problem of “plenty”, which is childhood obesity has emerged while we are still fighting under-nutrition and infectious diseases. Hence it becomes important to “target” populations who are most in need of it [1].

**Objectives:** To develop age and gender-specific percentile curves in school-going children between the age group of 5 to 15 years, for the three parameters- waist circumference, triceps skinfold thickness, and waist for height ratio. Also, to find the prevalence of overweight and obesity in this age group of 5-15 years.

**Study-design:** Cross-sectional study over duration of two years.

**Participants:** 1070 children from the schools of Davangere, between the age group of 5 to 15 years, class UKG to 10.

**Intervention:** Height, weight, waist circumference, triceps skin-fold thickness has been measured using standard anthropometric methodology BMI and waist to height ratio has been calculated.

**Outcomes:** Percentile charts and centile curves have been obtained based on the above data, age-wise, and gender-wise. They have been compared with each other and prevalence from each parameter is obtained.

**Results:** The prevalence of overweight is 12.4% and obesity is 9.5%. It is much more according to newly obtained centile charts. Girls tend to be more obese than their counterparts. The centiles are of lesser values when compared to age and sex-matched centiles from studies done at metropolitan cities.

**Conclusion:** On comparison of detecting overweight and obese children based on WHO and IAP definitions of overweight or obesity, the above-mentioned parameters certainly provide us with false high or false positive results. But they serve us of particular help in understanding different aspects of obesity and its complications.

**Keywords:** Pediatric obesity; Percentile curves; Waist circumference; Waist to Height ratio; Skinfold thickness; Pediatric metabolic syndrome; Overweight; School children

### Introduction

The non-communicable diseases are increasing in number rapidly over the last few decades. Pediatric obesity and overweight are said to be foremost among them. It is not any more a problem of only the developed countries. WHO has reported that they are increasing rapidly in the low and middle income countries as well. WHO states in a 2016 report that, 340 million children between 5-19 years, all over the world, are estimated to be obese or overweight and most astonishingly, 3 quarters of them are from Asia and Africa [2].

Pediatricians across our country are well versed with under-nutrition and its management. While the depths of Pediatric obesity need to be tackled urgently. The consequences of Pediatric obesity range from being a major risk factor for all cardiovascular diseases on a long term, to being a hassle in the child's social and psychological development [3,4]. Also, abdominal obesity is being largely talked about. The International Diabetes Federation states that, “for children age 10 years or older, metabolic syndrome can be diagnosed with abdominal obesity (using waist circumference percentiles) and the presence of two or more other clinical features including elevated triglycerides, low HDL-cholesterol, high blood pressure, increased plasma glucose.” Abdominal fat seems to be the central factor because most patients with the syndrome have excess abdominal fat [5].

The WHO and CDC define obesity and overweight based on age-

specific BMI percentile cut-offs. The revised IAP 2015 uses BMI cut-off percentiles equivalent to adult BMI of 23 and 27 kg/m<sup>2</sup> to define overweight and obesity respectively [6,7]. Though BMI is a good predictor of fat mass, it is only a surrogate measure of body fatness. Monitoring the changes in fat-free mass cannot always be readily distinguished from that in fat mass. Hence greater attention should be paid on the development of databases and standards based on direct measurement of body fat [8]. DEXA, CT, MRI, ultrasound are means of measuring body fat. But simple anthropometric tools are handy and serve the purpose in clinical practice [9].

Waist circumference is a perimeter used to assess abdominal fat. It is recognized as the most metabolically active intra-abdominal fat in both children and adults. Many studies including the Bogalusa Heart study have established a strong association between waist circumference and risk for coronary heart disease in children between 5 to 17 years [10]. Waist to height ratio is calculated by dividing waist circumference and

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height of the individual Ashwell [11] in her unique study states that this ratio is more sensitive than BMI as an early warning of health risk when monitored on a regular basis. This ratio is not age or sex dependent. Hence 0.5 is said to be a cut-off, and keeping waist circumference to less than half of the height can serve as the goal.

Skinfold thickness is said to be a measure for subcutaneous fat, based on a hypothesis that body fat is equally distributed all over the body. There are seven sites in which skinfold thickness can be measured. In our study we have used triceps as the site Reilly JJ et al. [4] in their study state that SFT can be a good predictor of body fat when it has population-specific, age-specific, gender-specific standards. He also points at the difference of fat deposition in pubertal and pre-pubertal age groups, and how it attributes to risk assessment on precise measurements [12]. In our study we have explored these facts and aimed at developing percentile curves for the above-mentioned anthropometric parameters, hence easily detecting more and more children in our locality who are at risk, especially when used collectively.

## Methods

Our data is cross-sectionally studied over a duration of 2 years, between November 2016 and August 2018 School going children of age 5 to 15, standard UKG to 10 in the government and private schools of Davangere have been included in our study. Children with major health issues have been excluded. There are 45 schools in the city of Davangere, South Zone, including government and private-aided and unaided schools. Based on the review of literature on Indian children and the prevalence of overweight and obesity, an average of 7.8% and 2.5% for overweight and obesity respectively, the sample size is estimated to be 1150 school children. Sample size calculated from the formula [13].

$$\therefore \lambda = 1135 \sim 1150$$

The minimum sample size at each age group has been fixed at 100 children, as this is the minimum recommended sample size at each age group. The schools have been selected by randomized sampling, 10 schools which included 5 private-unaided, 2 private-aided and 3 government schools, to reach a sample of 1070. Informed consent has been taken from the head of the institutions. Information regarding the study along with the consent sheet was sent to all parents through the school; along with a questionnaire to collect data on age, date of birth, sex, and history of any medical illness of the child Class UKG to 10<sup>th</sup> students are the participants in the study. They have been divided into classes of socioeconomic status based on the annual fee of the school. The study has been given ethical clearance by our institutional committee.

Height was measured using a stadiometer, with the child standing in an erect posture so that the back of the head, shoulder blades, heels, buttocks were brought in contact with the vertical surface of the stadiometer. The head was placed such that, the child looked directly in the Frankfurt's plane, which is the line joining the floor of the external auditory meatus to the lower margin of the orbit, and the bi-auricular plane being horizontal. The headpiece was kept firmly over the vertex just enough to compress the hair. Measured to the nearest 0.5cm.

Weight measured using a standard calibrated electronic scale, in kilograms with nearest 0.1 kg with the child standing quiet on the center of the scale, in erect posture without any support, without shoes. BMI was calculated (weight in kg/ height in m<sup>2</sup>). As per IAP recommendations, children from 5 to 15 years are classified as overweight and obese based on adult-equivalent of 23 and 27 cut-off

lines respectively [7]. Waist circumference measured with the child standing erect, using a stretch resistant, non-elastic tape. The tape was applied horizontally just above the upper lateral border of the right iliac crest, just at the level of the umbilicus. Taken at the end of normal expiration, recorded to the nearest 0.1cm [14].

Triceps skin fold thickness measured using Harpenden calipers. The folds of skin and underlying subcutaneous adipose tissues are grasped with the left thumb and forefinger, just enough to separate from the underlying muscle. The jaws of the calipers are placed at the marked level, perpendicular to the length of the folds. The skinfold is measured to nearest of 0.1mm.

Waist circumference by height ratio was calculated.

Number of overweight and obese children identified based on BMI centiles of age and sex, from the IAP growth charts, using 23 and 27 adult-equivalent of BMI. Children are also being classified as overweight or obese based on the 75<sup>th</sup> and 90<sup>th</sup> centiles respectively from all the parameters, waist circumference, triceps skinfold thickness and waist by height ratio. Hence the prevalence of overweight and obesity in school children of Davangere has been calculated according to each parameter and compared. Data are presented as mean and centiles calculated to 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> using Microsoft Excel software and presented in tables. These values are then plotted on graphs to obtain centile curves for each parameter gender-wise.

## Results

Among the total 1070 school children studied, 622 which is 58.13% are males, and 448 are females which is 41.87% (Tables 1-3 and Figures 1-3).

After plotting these percentile curves, using the 75<sup>th</sup> centile for overweight and 90<sup>th</sup> for obesity, prevalence of each have been calculated in all three parameters and compared with BMI [6].

It is found that 12.4% of the children were overweight and 9.5% of children were found to be obese in our study according to the IAP definition of 23 and 27 adult equivalent. According to waist circumference 14.7% of the children were overweight and 8% obese. Also boys and girls had similar prevalence. The triceps skinfold thickness seemed to detect more obese and overweight girls. 12.7% of boys and 14.1% of girls, hence total 13.3% were overweight 9.6% of boys and 11.7% girls, total of 10.8% were obese. Waist by height ratio, showed 13.9% overweight and 7.4% obese children.

## Discussion

Obesity in Davangere is on the rising trend in tune with the rest of the world Fast food, junk foods and mobile phones are the beloved companions of children nowadays. The three parameters waist circumference, skinfold thickness and waist to height ratio have identified many more children at risk, who fall short of the standard overweight and obesity definition. It is also observed that girls are at greater risk than boys, over all parameters.

The waist circumference percentile curves are said to claim the patterns of central adiposity, inherent in the city. It differs according to the race, region, ethnicity and socioeconomic status. When compared to the studies done in India, in Bangalore and the 5 major cities in India, in the studies done by Kuriyan R, et al. [15] and Anuradha Khadilkar A, et al. [16] respectively, the waist circumference overall percentiles are comparatively of lesser values. The centiles were lesser even when compared with a similar study done on British children

**Table 1:** The waist circumference percentiles age and sex-wise.

Boys Age (y)	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>
5	45 35	46 70	48 00	49 00	52 00	54 95	56 30	64 25
6	45 70	48 00	49 00	51 00	54 75	58 00	61 30	65 45
7	49 00	50 00	53 00	55 00	58 50	62 10	64 40	69 40
8	49 75	51 50	54 00	57 50	61 00	63 00	65 00	67 00
9	49 00	49 00	53 00	55 00	62 00	64 00	69 00	78 00
10	50 00	51 00	53 00	57 00	68 00	72 35	77 80	85 25
11	53 10	56 00	59 00	63 00	73 50	77 70	79 00	84 60
12	53 80	54 00	58 00	61 00	74 50	80 00	84 00	85 20
13	54 00	55 90	58 50	65 50	74 25	77 00	86 20	90 00
14	57 05	59 70	66 00	69 50	74 25	75 00	77 30	87 10
15	54 10	56 10	60 25	64 50	72 00	79 80	84 60	87 85
Girls Age (y)	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>
5	44 55	45 00	47 00	50 00	52 75	57 90	59 30	60 75
6	45 00	47 00	48 75	51 00	55 00	57 00	58 00	59 30
7	48 50	49 00	52 00	54 00	56 00	59 75	65 50	69 50
8	47 15	48 30	51 75	55 50	58 00	61 55	62 00	64 55
9	47 00	49 20	52 00	57 00	64 00	66 00	67 90	69 00
10	51 20	53 00	55 00	59 00	66 00	70 60	75 20	78 60
11	51 40	55 00	57 00	62 00	69 00	75 50	77 20	81 30
12	52 95	55 90	60 00	64 00	70 00	73 30	76 00	78 10
13	56 00	58 00	63 00	70 00	77 00	80 00	83 00	85 00
14	55 00	56 20	62 00	69 00	76 00	76 60	77 80	
15	61 05	62 20	65 25	71 00	76 75	78 70	79 90	87 60

**Table 2:** Percentile charts for triceps skinfold thickness, age and sex-wise.

Boys Age (y)	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>
5	6 61	6 97	8 10	9 65	11 25	12 59	15 06	15 59
6	6 28	7 48	8 25	10 45	12 88	16 00	16 00	17 00
7	7 00	7 16	8 40	10 00	11 05	13 12	16 32	19 07
8	7 20	7 60	8 60	10 60	12 85	15 00	16 90	17 43
9	7 00	8 00	9 40	12 00	14 60	15 50	16 50	17 00
10	6 78	7 40	9 00	11 40	15 10	17 67	18 18	18 34
11	8 80	9 44	11 35	14 60	17 60	18 14	18 92	20 31
12	7 89	8 74	11 35	13 80	16 70	18 20	18 50	18 52
13	8 56	9 77	10 85	13 10	17 15	19 47	22 04	24 72
14	8 57	10 56	12 00	15 70	20 28	21 00	21 77	22 79
15	10 03	10 50	13 58	15 60	16 68	19 88	20 00	25 70
Girls Age (y)	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>
5	7 17	7 80	9 00	10 90	13 28	15 67	17 06	17 58
6	7 79	8 00	9 00	11 00	12 90	15 01	15 84	16 59
7	7 18	7 30	8 88	11 10	14 83	16 15	17 20	17 88
8	7 03	7 59	9 75	11 85	14 13	15 62	16 29	19 02
9	8 46	8 92	10 20	12 30	16 00	17 00	17 72	21 08
10	7 80	8 48	10 40	12 00	15 00	16 76	17 32	17 80
11	9 36	10 20	10 60	11 80	14 40	16 18	17 38	18 19
12	9 80	10 56	11 75	14 00	16 45	17 25	17 51	18 01
13	10 80	11 50	13 80	15 80	17 50	20 30	21 00	24 00
14	11 50	11 68	13 60	16 80	20 40	23 28	24 08	
15	12 90	14 87	16 00	17 80	19 08	22 85	23 18	26 34

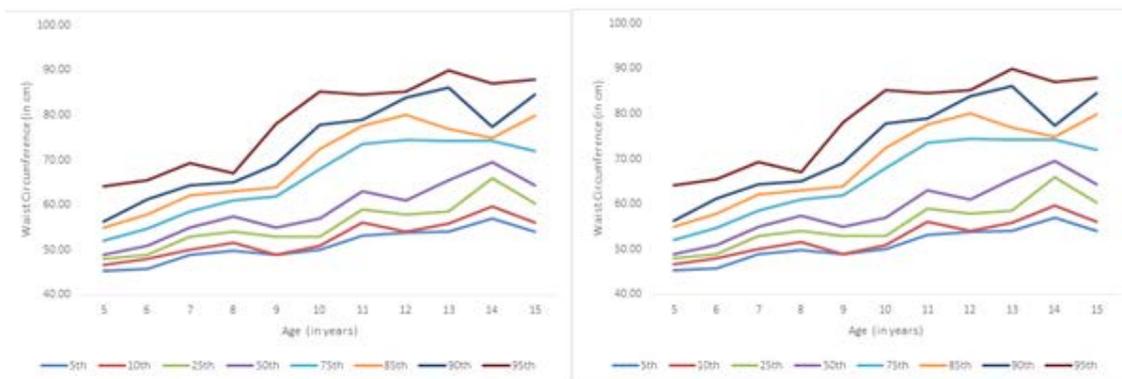
[17]. One probable reason could be, as our study has included children of all socioeconomic statuses, that is from both private and government schools. Another reason could be, our children of Davangere city are less exposed to obesogenic factors when compared to those children in the metropolitan cities which have been studied.

Despite which, the overall prevalence of overweight and obesity in

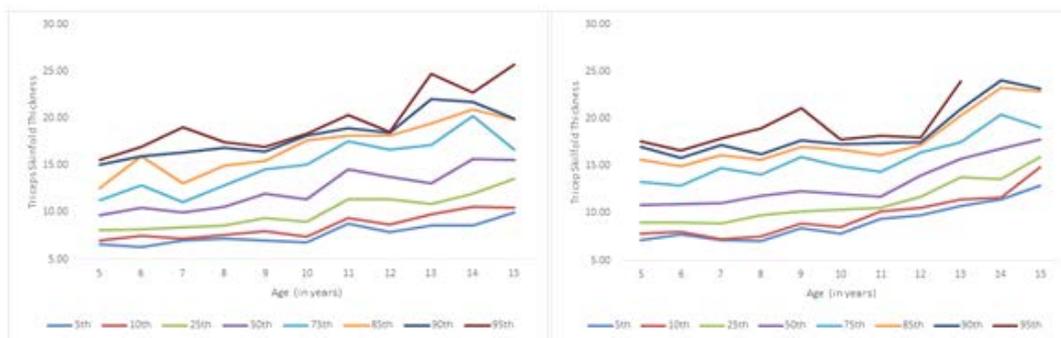
on the rise in Davangere school-going pediatric population, especially considering the susceptibility of risk of Metabolic Syndrome, which is predicted by the central adiposity. The prevalence of overweight and obesity as indicated by waist circumference percentiles 75<sup>th</sup> and 90<sup>th</sup> is 14.7% and 8% respectively, which is definitely high. Also, it is noted that girls have higher values when compared to centile values of boys, as established in most of the similar studies done all over the world.

**Table 3:** Waist circumference to height ratio percentile charts in boys and girls of age 5 to 15 years.

Boys Age (y)	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>
5	0.41	0.41	0.42	0.43	0.46	0.48	0.49	0.56
6	0.38	0.38	0.42	0.44	0.46	0.48	0.50	0.52
7	0.41	0.42	0.44	0.46	0.48	0.52	0.53	0.55
8	0.40	0.41	0.43	0.46	0.48	0.49	0.51	0.52
9	0.39	0.39	0.41	0.43	0.46	0.49	0.51	0.56
10	0.37	0.38	0.40	0.42	0.49	0.52	0.53	0.57
11	0.38	0.39	0.41	0.46	0.51	0.53	0.56	0.58
12	0.36	0.37	0.40	0.44	0.48	0.53	0.57	0.58
13	0.36	0.37	0.40	0.43	0.49	0.53	0.54	0.57
14	0.36	0.39	0.42	0.44	0.46	0.47	0.49	0.55
15	0.35	0.36	0.38	0.40	0.44	0.48	0.49	0.50
Girls Age (y)	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>
5	0.39	0.41	0.42	0.44	0.47	0.50	0.51	0.54
6	0.40	0.41	0.43	0.45	0.47	0.49	0.51	0.52
7	0.41	0.41	0.43	0.45	0.47	0.49	0.50	0.54
8	0.39	0.41	0.43	0.45	0.47	0.49	0.50	0.52
9	0.37	0.39	0.41	0.44	0.47	0.51	0.52	0.52
10	0.39	0.40	0.41	0.44	0.47	0.52	0.52	0.54
11	0.36	0.39	0.42	0.43	0.47	0.52	0.54	0.56
12	0.36	0.37	0.39	0.43	0.47	0.48	0.49	0.51
13	0.38	0.39	0.40	0.46	0.50	0.52	0.53	0.55
14	0.37	0.38	0.41	0.45	0.48	0.49	0.49	0.51
15	0.38	0.39	0.42	0.45	0.47	0.50	0.50	0.57



**Figure 1:** The percentile curves of waist circumference for boys and girls 5-15 years.



**Figure 2:** Shows triceps skinfold thickness percentile curves of boys and girls, 5-15 years.

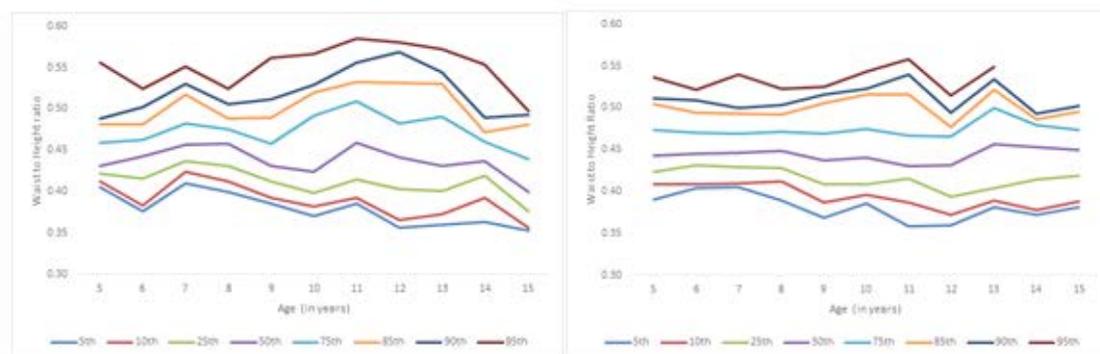


Figure 3: Shows the percentile curves of waist circumference by height ratio in boys and girls.

Hence, it can be concluded that though waist circumference is good indicator of obesity, and in predicting the cardiovascular risks, it cannot be used in uniformity worldwide in the definition of obesity, as it is highly variable according to the trends in the particular ethnic groups. Also, those children with waist circumference above 75<sup>th</sup> centile can be considered under risk, and can be advised regarding the prevention strategies. This action point has been taken into reference from the study done by Kuriyan R, et al. in Bangalore [15].

The waist by height ratio percentile tables and curves when compared to similar studies, have remained same with insignificant differences. Also, it is similar among different age groups and among boys and girls. This indicates that the waist circumference could be monitored on an individual basis, with respect to their heights in agreement with the study done by Lemieux, et al. [18]. The prevention strategies as simple as exercise and diet can be easily adopted on their own. Also, our study substantiates the following points quoted by Ashwell [11] and Motswagle, et al. [8] that, waist by height ratio is more sensitive than BMI as an early warning of health risks. Also, the value obtained between is 75<sup>th</sup> and 85<sup>th</sup> centile in each age group stands close to 0.5 in our study, similar to what they state, for 0.5 being the boundary value for risk detection [19].

The prevalence of overweight and obesity obtained from waist circumference and waist height ratio are similar. Hence it can be said waist to height ratio also indicates central adiposity and a good indicator as an action point for Pediatric metabolic syndrome. The triceps skinfold thickness percentile charts and curves have been plotted, and the values obtained are similar to the values obtained by Khadiolkar, et al. [20], from school children in the five Metropolitan cities. It is also been noted that the values in the pubertal age group, >12 years, differ, when compared to the studies done all over the world, where centile charts are proposed [21]. This again substantiates the point that the fat deposition is a highly variable entity especially in the pubertal age group and requires region specific, ethnicity specific charts [12].

Also these have to be modified on a regular basis with respect to the secular trends of obesity [22]. One of the limitations with respect to skinfold thickness in our study is the number of sites it is measured. Better results are obtained with 3 or 7 sites [23]. Also, the prevalence obtained from BMI is far more than what has been obtained in the recent studies done at Bangalore and the 5 metropolitan cities, though we have included children from all socioeconomic statuses [15, 16]. This could be explained by the fact that children are definitely being exposed to more obesogenic factors in the form of parental life style and behavior modifications in trend with the technology [24]. We conclude from our present study that, it is necessary to develop our

own percentile charts for waist circumference, waist by height ratio and skinfold thickness which varies among different races and ethnic groups. They can be simple bedside clinical tools to detect more children at risk [25].

What we already know?

BMI is used to detect and define obesity worldwide.

What this study adds?

BMI when added on with waist circumference, waist to height ratio and skinfold thickness plotted on population-specific charts, specifies the target of different aspects of obesity, hence better counseling can be carried out by a pediatrician.

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