ORIGINAL ARTICLE

Study of Physical Growth Standards of Adolescents in the Age Group of 10 to 15 Years from Satara District of Maharashtra,India

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Abstract:

Background: Adolescence is a significant period of human growth and maturation. The reference values are central to the growth monitoring. *Aims and Objectives:* This study was carried out to develop the mean, standard deviation and percentile curves for height, weight, and BMI of studied population and to compare them with the national and international studies. *Material and Methods:* A cross-sectional, High School based study was conducted. A total 2025 adolescents (1222 boys and 803 girls) from 8 Tahsils of Satara districts were included in the study. *Results:* When compared with 1977 NCHS and 2007 WHO reference standards, boys and girls 50th percentile values of height of present study were comparable. Mean and 50th percentile values of our study were considerably greater than ICMR values at all ages and for both the sexes. In the present study 85th and 95th percentile values for boys were comparable with WHO 2007 reference values. For girls 85th percentile values were comparable with this reference values up to 13.5 years of age. *Conclusions:* The present physical growth standards can be recommended for monitoring of growth of High School going children from Satara district.

Keywords: Height, Weight, BMI, Physical Growth

Introduction:

Adolescence is a significant period of human growth and maturation; unique changes occur during this period and many adult patterns are established. Individuals in the age group of 10-19 years are placed in the adolescent age group. The importance of health of adolescence has started to receive increasing recognition particularly in developing countries where four out of five world's young population live and where more than half the population is under the age of 25 years [1]. The measures to be used for assessment of growth should be economical to perform, easy to standardize, reliable, and capable of execution by especially trained non professional individuals. Anthropometric measures are best suited to fulfill these criteria [2].

Simple measurement of height and weight serve as reliable means to evaluate the growth of a child and also to detect gross abnormalities even when no other clinical sign of illness is manifested [3]. Therefore, the use of the growth charts in schools, public health clinics, supplemental feeding programmes, community health and nutrition surveys and physician's offices can assist identification of adolescents with growth or nutritional abnormalities [4].

The pattern of growth of a population changes over time and hence growth references should be updated regularly, particularly for countries in nutrition transition [5]. In a country like India with wide variation in the growth determinants, it is essential that the normal values are developed region-wise and are redefined from time to time [6, 7]. Non availability of an anthropometric

profile for adolescents of Satara District in western Maharashtra prompted us to undertake this study. This study was carried out to develop the mean, standard deviation and percentile curves for height, weight, and BMI of studied population and to compare them with the national (ICMR) [8] and international NCHS, USA [4] and WHO 2007 studies [9].

Materials and Methods:

The study was carried out in the Satara district which is situated in the western part of state of Maharashtra, India. Adolescents were classified into eleven half- yearly age groups (10, 10.5,….15). Children's height is a sensitive indicator of their physical well-being, and has been recommended as a measure of their nutritional state [10-12]. As body height can be assumed to be normally distributed, for each half year the sample size was calculated on the basis of mean and standard deviation of height from various studies. These minimum sample sizes were computed with 95 % confidence level and allowable error of 1.5 % of the respective mean height [8, 13]. The maximum of minimum total sample size calculated was 575 for boys and 446 for girls. A total 2025 adolescents (1222 boys and 803 girls) from 8 Tahsils were included in the study. As per the guidelines given by International Union of Nutrition Sciences [2] the English Medium schools were selected on the grounds that they catered to the elite population.

An updated list of all English Medium Schools (5^{th} -10^{th} standard) obtained from Zilla Parishad, Satara was used as the sampling frame. From each of eleven Tahsils in Satara district, one school was selected by random sampling technique using lottery method and all the adolescents in the age group of 10-15 years of selected schools were included in the study. Children suffering from any major systemic diseases or with any major surgical operation likely to affect their growth and with limb deformities were excluded from the study. There were no English medium schools catering to 10-15years age group in Khatav and Patan Tahsils. From Mahabaleshwar Tahsil schools catering to 10-15 years age group were residential schools and maximum adolescents in those schools were from all over India. As they do not represent the Satara District, they were not included. Hence no schools from Khatav, Patan and Mahabaleshwar Tahsils were included in the study.

The purpose and the process of the study were explained to the school authorities and teachers. Informed consent was obtained. Data was collected in pre-tested proforma from February 2009-March 2011. For all study subjects same measuring equipments were used, which were calibrated daily for standardization to reduce bias/error. Weights, heights, were recorded using the methods described in anthropometric standardization reference manual [14].The study was approved by the Institutional Ethics Committee of the Krishna Institute of Medical Sciences Deemed University, Karad, Maharashtra, India.

Data were analyzed using SPSS-20 software for windows. In order to test the significance of the difference, statistical tests such as unpaired t test, ANOVA were used wherever necessary. Height, weight and BMI percentile curves were generated by using the Lambda –Mu–Sigma (LMS) method, which is currently the recommended method for generating centiles [15]. The LMS regression was done using the LMS Light software (The institute of child health, London).

Results:

The present study was done in the schools for 5th to 10th standard; therefore, the age variation observed in the studied children was between 10-15years.A total 2025 adolescents from Satara district constituted the study sample. Out of 2025 study subjects 1222 (60.3%) were boys and 803 (39.7%) were girls. Overall sex ratio was 657.1/1000. The girls per 1000 boys ratio was 564.9/1000 boys at 10 years and 507.7/1000 boys at 15 years. Significantly higher numbers of boys than girls were included in the study. ($\chi 2 = 20.229$; df =10; $p<0.05$).

The difference in mean height, weight and BMI between Tahsils in various age groups and both the sexes were not significant ($p > 0.05$). Thus apparently it appears that the affluent children from all Tahsils of Satara district are following same growth pattern. Therefore the pooled observations for height, weight and BMI were presented for affluent children from Satara district.

Height (in cms)

The height correlated positively with age and increased with the increase in age. Median (50th percentile) values largely coincided with the mean values in various age groups and both the sexes. Total gain in height during 10-15 years was 26.45 and 19.52 cms in boys and girls respectively. The Peak Height Velocity (PHV) in boys was at 13-14 years as compared to 10-11 years in girls. (Table 1A and 1B, Fig.1A and 1B)

Table 1A: Anthropometric Profile of Study Population –Height in Centimeters (Boys)

Age (years)	N	Mean	S.D.	Percentile values						
				3rd	5th	10th	25th	50th	75th	97th
10	154	139.26	6.27	127.00	128.75	131.00	135.00	139.00	143.00	151.70
10.5	121	140.57	7.22	127.66	130.00	131.20	136.50	140.00	145.50	155.34
11	126	143.38	6.45	132.43	134.00	135.00	140.00	143.00	148.00	157.00
11.5	99	145.35	6.11	135.00	135.00	136.00	141.00	145.00	149.00	158.00
12	160	147.23	7.05	134.00	135.00	138.00	143.00	147.50	152.00	161.00
12.5	84	150.76	8.89	131.65	135.25	139.50	146.00	150.00	157.00	166.90
13	127	153.22	8.33	135.00	142.00	144.00	148.00	153.00	158.00	169.16
13.5	122	157.82	8.66	141.76	145.00	148.00	152.00	157.50	163.25	174.31
14	104	163.15	8.32	150.00	150.00	151.00	156.25	163.00	169.00	177.85
14.5	60	162.42	7.54	144.00	145.20	152.00	159.00	163.00	168.00	176.51
15	65	165.71	7.37	149.98	150.00	154.00	161.50	167.00	170.50	180.00

**For all tables- N= No of subjects; S. D = Standard deviation*

Table 1B: Anthropometric Profile of Study Population –Height in Centimeters (Girls)

Age (years)	N	Mean	S.D	Percentile values						
				3rd	5th	10th	25th	50th	75th	97th
10	87	139.22	6.85	125.64	128.20	130.00	135.00	139.00	145.00	153.36
10.5	70	141.89	6.71	128.13	129.00	134.00	139.00	142.00	145.50	159.35
11	76	145.11	7.53	132.46	133.92	135.00	139.00	145.00	151.75	159.69
11.5	82	146.41	6.65	131.47	134.30	139.00	143.75	146.00	151.00	159.00
12	100	149.24	7.37	134.03	135.00	138.10	145.00	150.00	154.00	161.00
12.5	80	150.78	7.79	135.86	138.05	140.00	145.00	150.00	156.75	163.00
13	96	153.29	7.20	139.73	140.85	145.00	148.00	153.00	158.75	168.18
13.5	55	155.72	6.34	141.72	145.40	148.60	151.00	155.00	160.00	169.00
14	82	156.89	6.55	144.22	147.00	149.00	152.00	157.00	160.00	172.06
14.5	42	156.23	6.03	144.87	147.30	149.00	152.00	156.00	159.00	171.13
15	33	158.74	7.28	144.10	147.50	152.80	154.75	156.00	163.00	178.00

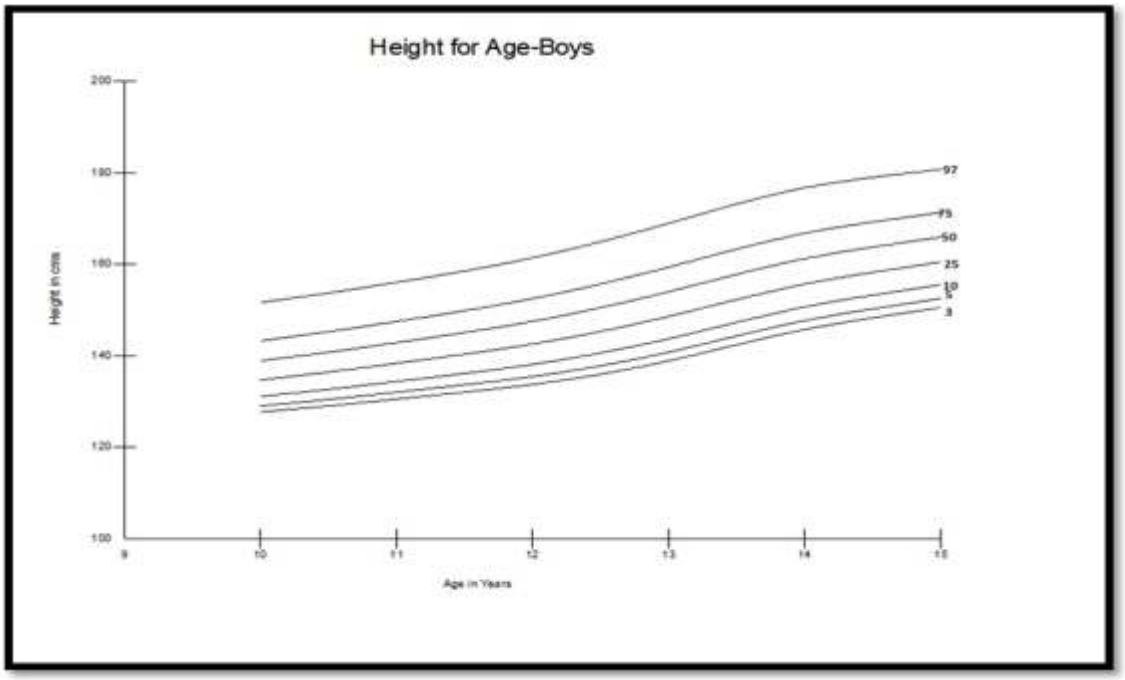

Fig. 1A: Reference Curves for Height Percentiles for Boys Using the 3rd, 5th, 10th, 25th, 50th, 75th And 97th Percentiles.

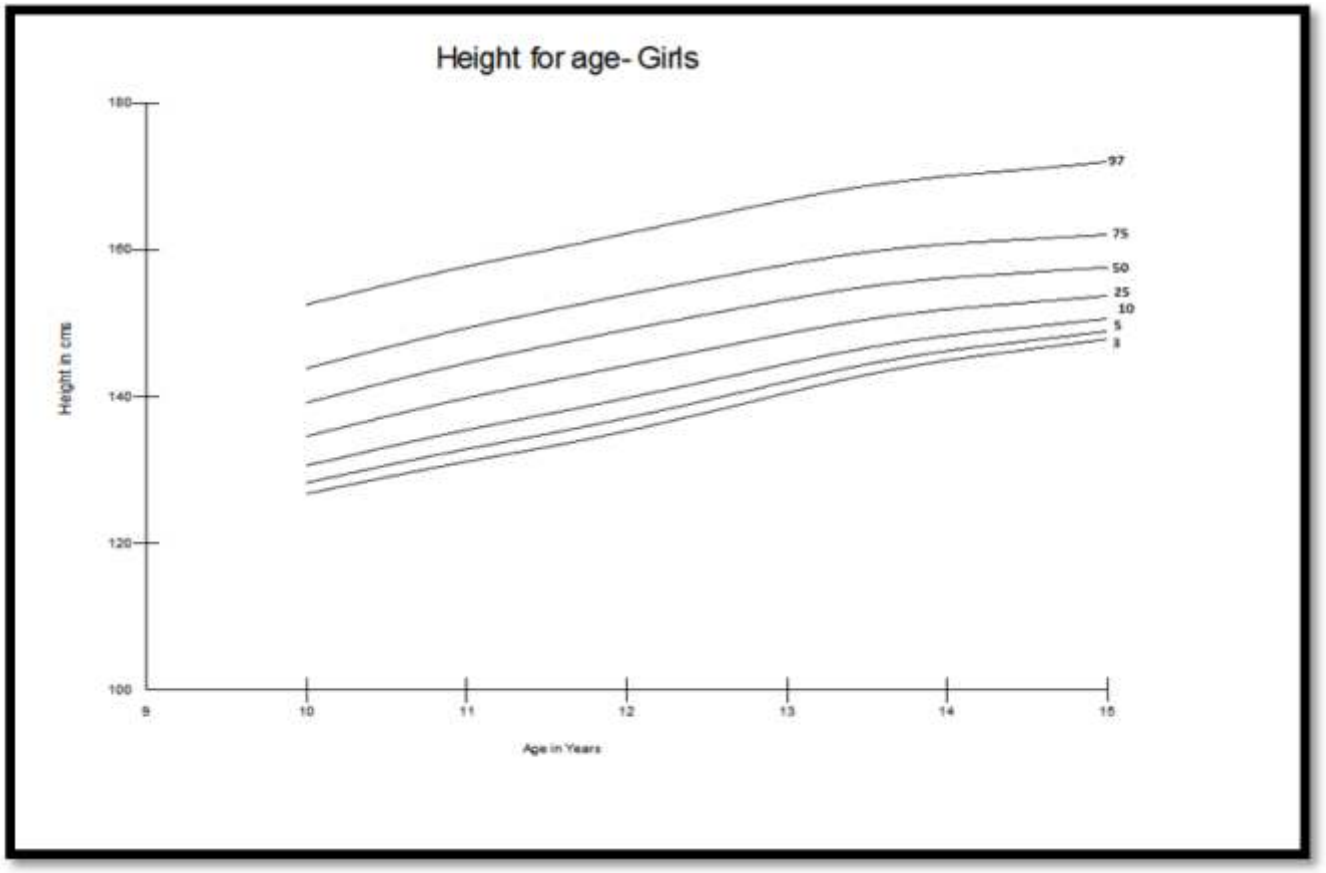

Fig. 1B: Reference Curves for Height Percentiles for Girls Using the 3rd, 5th, 10th, 25th, 50th, 75th And 97th Percentiles.

From 10.5-13 years of age girls had higher mean height than boys, however the difference everywhere was statistically not significant. But from 13.5 years onwards boys were taller than girls. The difference was statistically significant at 15years ($t=4.439$; $df=96$; $p<0.05$).

Weight (in Kg)

Body weight increased in both the sexes with increase in age. Median values largely coincided with the mean values in various age groups and both the sexes. The gain in weight for boys between 10 and 15 years was 19.60 kg and for girls 12.52 kg. The peak weight velocity in boys was at 13-14 years and in girls at 11-12 years. (Table 2A and 2B, Fig. 2A and 2B) From 10-12 years of age mean weight in girls was higher than boys but the difference was statistically not significant. From 13.5 years onwards mean weight in boys was higher than girls. The difference was statistically significant at 15 years ($t = 3.069$; $df=96$; $p < 0.05$) age.

Table 2-A: Anthropometric Profile of Study Population –Weight in Kgs (Boys)

Age (years)	N	Mean	S.D	Percentile values						
				3rd	5th	10th	25th	50th	75th	97th
10	154	30.60	6.76	20.65	22.75	24.00	25.00	29.00	35.00	47.70
10.5	121	32.05	6.88	22.66	23.10	24.20	26.00	30.00	36.00	48.68
11	126	33.99	8.04	23.90	24.00	25.00	27.00	32.50	38.62	54.00
11.5	99	34.85	6.88	24.00	25.00	26.00	30.00	35.00	40.00	52.00
12	160	36.60	7.31	26.00	26.05	27.10	31.00	35.00	40.00	54.17
12.5	84	39.26	7.97	27.10	28.25	30.00	32.50	38.00	45.00	56.90
13	127	40.55	7.88	26.00	29.00	31.00	35.00	40.00	45.00	59.16
13.5	122	45.17	10.09	29.69	31.15	34.00	38.00	43.50	50.00	75.00
14	104	48.40	10.35	35.00	36.25	39.00	41.00	45.00	53.00	74.80
14.5	60	47.62	9.50	31.00	31.00	36.00	40.25	48.00	53.75	73.00
15	65	50.20	10.21	31.00	34.00	40.00	42.50	49.00	55.00	73.00

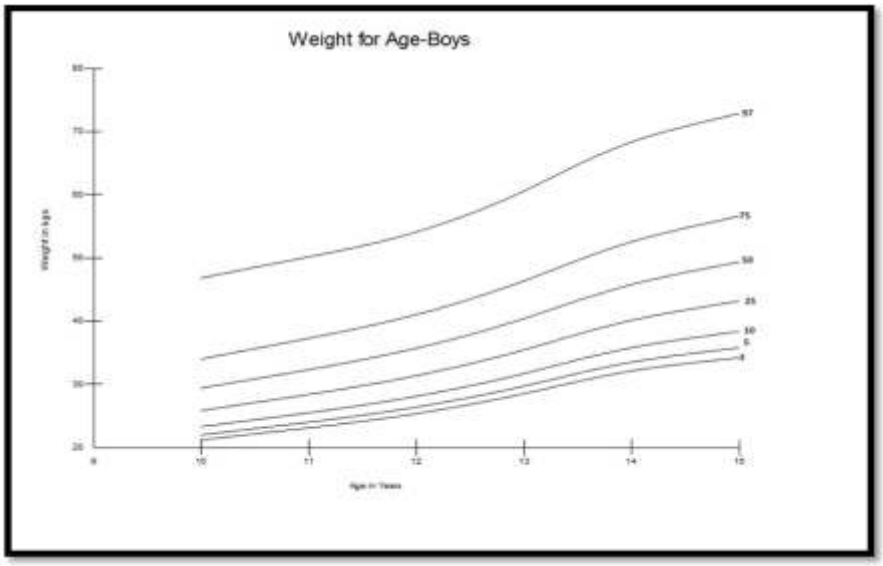

Fig. 2A: Reference Curves for Weight Percentiles for Boys Using the 3rd, 5th, 10th 25th, 50th, 75th And 97th Percentiles

Table 2-B: Anthropometric Profile of Study Population –Weight in Kgs (Girls)

Age (years)	N	Mean	S.D	Percentile values						
				3rd	5th	10th	25th	50th	75th	97th
10	87	31.86	7.54	21.00	22.00	24.00	25.00	30.00	38.00	49.00
10.5	70	33.14	6.68	21.39	24.00	25.00	28.00	31.00	40.00	45.87
11	76	34.80	7.84	22.62	24.85	25.70	30.00	34.00	39.00	54.00
11.5	82	37.11	8.07	26.00	28.58	30.00	31.00	35.00	41.25	59.51
12	100	38.44	8.90	24.00	25.00	28.05	32.00	37.00	43.00	60.00
12.5	80	38.93	9.14	24.43	25.05	27.10	32.00	38.00	45.00	60.70
13	96	41.36	7.07	27.00	28.70	33.00	36.00	41.00	46.00	54.36
13.5	55	43.04	7.65	32.00	32.80	33.60	35.00	42.00	46.00	60.64
14	82	44.41	7.54	32.47	34.15	36.00	40.00	44.00	47.25	66.53
14.5	42	44.87	7.41	32.58	34.15	35.30	40.00	45.00	50.00	62.13
15	33	44.38	5.28	35.05	36.75	38.40	40.00	44.00	47.75	60.84

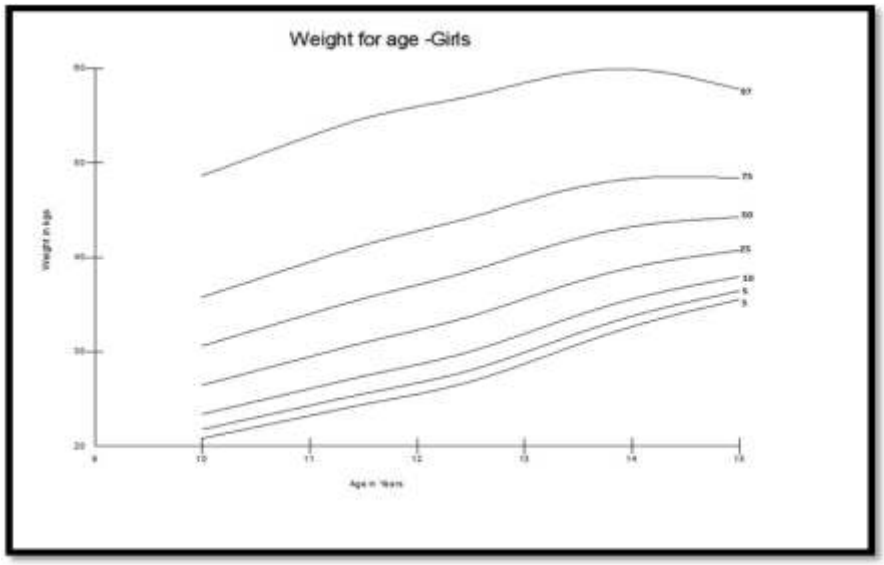

Fig. 2B: Reference Curves for Weight Percentiles for Girls Using the 3rd, 5th, 10th, 25th, 50th, 75th And 97th Percentiles

BMI (in kg/m^2)

Median values for BMI, like height and weight coincided with corresponding mean values of BMI in various age groups and both sexes. Mean values of BMI from 10-12 years were higher in girls than boys. From age 12.5 to 15 years mean values of BMI were higher in boys than girls but difference everywhere was statistically not significant. (Table 3A and 3B, Fig. 3 A and 3B).

Table 3A: Anthropometric Profile of Study Population –BMI in kg/m^2 (Boys)

Age (years)	N	Mean	S D	Percentile values							
				3rd	5th	10th	25th	50th	75th	85th	95th
10	154	15.72	2.57	11.90	12.18	13.08	13.92	15.31	17.12	18.47	21.02
10.5	121	16.11	2.66	12.70	12.81	13.27	13.92	15.73	17.84	19.01	20.44
11	126	16.40	3.03	12.21	12.47	13.05	13.78	15.82	18.60	20.22	22.01
11.5	99	16.41	2.66	12.62	12.76	13.50	14.27	16.10	18.05	19.17	21.40
12	160	16.71	2.48	13.23	13.33	13.99	14.79	16.33	18.02	19.26	22.07
12.5	84	17.19	2.68	13.06	13.33	13.85	15.36	16.89	18.69	20.00	22.63
13	127	17.17	2.39	13.50	13.99	14.57	15.52	16.90	18.42	19.80	22.35
13.5	122	18.08	3.59	13.37	14.08	14.52	15.85	17.27	19.61	21.08	24.05
14	104	18.09	3.00	14.01	14.19	14.79	15.97	17.39	20.15	21.32	24.01
14.5	60	18.00	3.24	13.54	14.26	14.76	15.62	17.36	19.34	21.46	24.59
15	65	18.24	3.39	13.76	13.96	14.62	15.65	17.67	20.14	22.76	24.88

Table 3B: Anthropometric Profile of Study Population–BMI in kg/m^2 (Girls)

Age (years)	N	Mean	S.D	Percentile values							
				3rd	5th	10th	25th	50th	75th	85th	95th
10	87	16.30	2.93	12.23	12.32	12.69	13.77	15.45	18.90	19.88	21.72
10.5	70	16.39	2.75	11.91	12.65	13.28	14.49	15.65	18.15	20.08	21.19
11	76	16.40	2.77	11.11	12.56	13.00	14.58	16.25	17.33	18.56	22.32
11.5	82	17.28	3.36	12.03	13.30	13.91	15.07	16.64	18.52	20.77	25.69
12	100	17.14	3.15	12.23	12.35	13.55	14.86	16.60	18.73	20.90	23.11
12.5	80	16.97	2.98	12.67	13.33	13.46	14.40	16.65	18.30	20.52	22.48
13	96	17.57	2.63	13.43	13.64	14.10	15.66	17.05	19.45	20.91	21.96
13.5	55	17.76	3.12	13.81	13.99	14.40	15.56	16.87	18.66	21.62	24.82
14	82	18.03	2.66	13.50	13.97	14.78	16.21	17.83	19.40	19.98	23.48
14.5	42	18.35	2.69	14.65	15.45	15.56	16.23	17.86	19.55	20.87	24.90
15	33	17.64	2.03	14.22	14.93	15.54	16.13	17.53	18.31	19.63	22.43

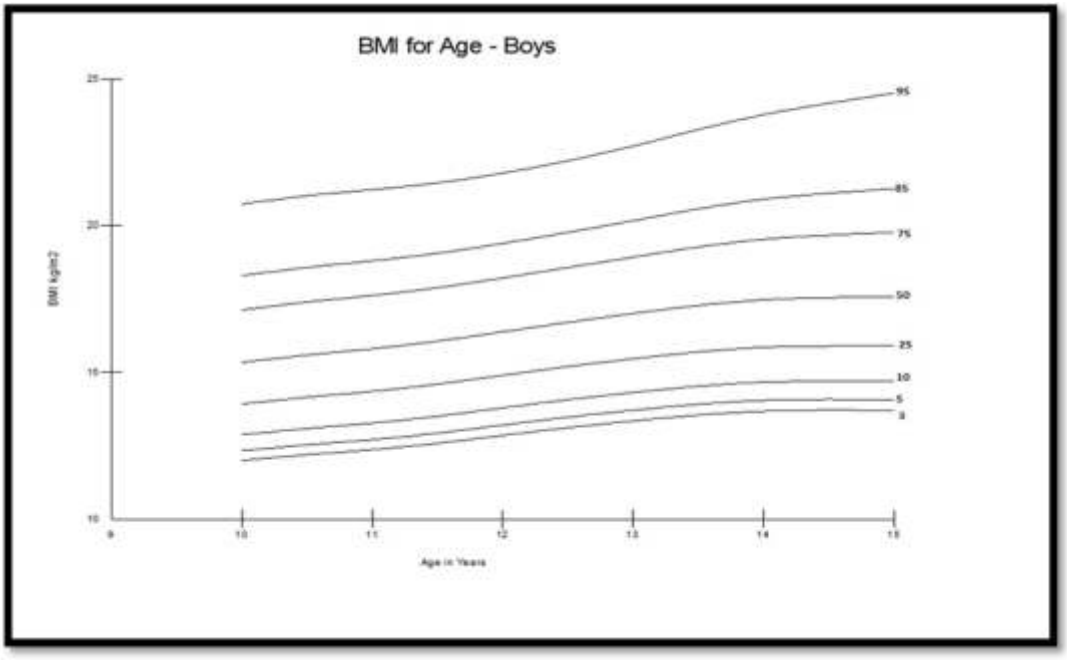

Fig. 3A: Reference Curves for BMI Percentiles for Boys Using the 3rd, 5th, 10th, 25th, 50th, 75th, 85th And 95th Percentiles

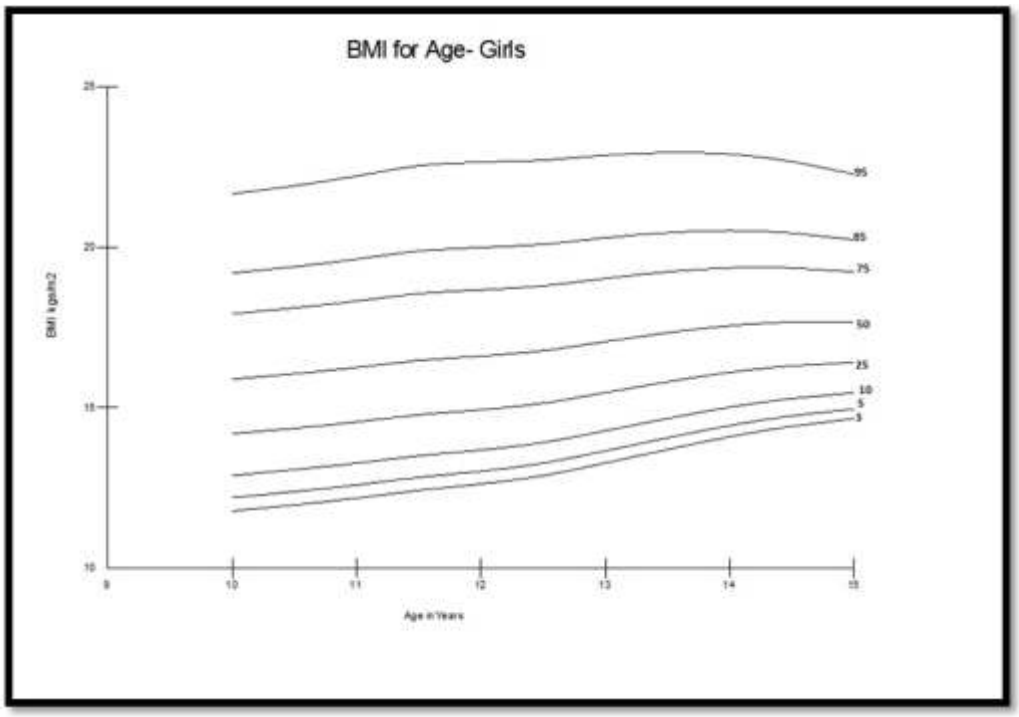

Fig. 3B: Reference Curves for BMI Percentiles for Girls Using the 3rd, 5th, 10th, 25th, 50th, 75th, 85th And 95th Percentiles

Discussion:

A total 2025 adolescents from Satara district constituted the study sample. The sex ratio was 564.9/1000 boys at 10years and 507/1000 boys at 15years; signifies the increasing drop out of female from their schools. This trend has been also observed in Surat study [16] and in ICMR study [8].

Height (in cms):

Similar to present study height percentiles in other studies have shown increments both for boys and girls with age [17-19]. From Varanasi Pereira *et al* have reported that girls in their study gained 17.5 cm during the age interval of 10-15 years [18] and Thakor *et al* from southern Gujarat have reported that boys gained 19.9 cms and girls 17.2 cms during the age interval of 10-15 years [16].

A nationwide study from India has reported peak height velocity in boys at 13-14 years as compared to 10-11 years in girls [20]. The pubertal growth spurt has been seen earlier in girls than in boys, which has given girls a significant height advantage at age 10.5-11.5 years. Starting at age 11.5 years, boys had a greater increase in height [21]. Similar results have been reported by a recent cross-sectional study by Zivienjak *et al* in Croatia [22] and that of the Japanese national survey [23]. Sex differences in height gains have been significant from age of 7.5 years to 14.5

years ($p < 0.0001$) [20].

When compared with 1977 NCHS and 2007 WHO reference; for boys 50th percentile values of present study have been comparable, except at the age of 15 years values have been lesser by 2 cms. In girls also the values for all ages have been comparable, except at the age of 15 years where present study values have been lesser by 5.8 and 5.7 cms than these studies [4, 9].

Mean and 50th percentile values of our study have been greater than ICMR [8] values at all ages. At 15 years boys and girls in our study have been taller by 10.4 and 6 cms respectively. Since ICMR study has been carried out five decades back and lots of improvement in the standard of living and nutritional status of the Indian population has taken place in recent decade, the present study mirrors those improvements by increase in mean height.

The 50th percentile values of height of boys and girls in the present study have been consistently higher than that of Agarwal *et al* study for all age groups except for girls at 15 years of age. At 15 years the boys have been 4.50 cms taller and the girls at 15 years have equal height [20]. The 50th percentile values of height for boys and girls in present study are comparable to Khadilkar *et al* study at all ages [24].

Weight (in Kg)

The mean and 50th centile values have been similar for all ages in boys as well as girls [20]. In Surat study weight gain has been 11.9 kg for boys and 11.2 kg for girls during 10-15 years age [16]. The girls from Varanasi have gained 15.1 kg during 10-15 years [18]. Boys have been significantly heavier and taller than girls within each age group in Vietnam study [25]. The peak weight velocity recorded in Piereria *et al* study has been at the age of 11 years while at the age of 12.9 years in British girls [18, 26]. When compared to 1977 NCHS reference [4] the 50th percentile values of weight for both boys and girls have been consistently lower for all age groups. The maximum difference was at the age of 15 years in both boys (7.70 kg) and girls (9.70 kg).

In the present study the 50th percentile values for both sexes have been considerably higher as compared to ICMR standard ranging from 6.10-9.80 kg in boys and 6.80-14.90 kg in girls. The present study 50th percentile value for boys have been higher as compared to Agarwal study and among girls present study values have been higher for all ages except at the age of 15years [20].The 50th percentile value for boys and girls have been lesser for all age groups in the present study as compared to Khadilkar study [24] (Fig. 4 A and B). The 50th percentile value for boys and girls are lesser for all age groups in present study as compared to Marwaha *et al* study and revised IAP growth charts [27, 28].

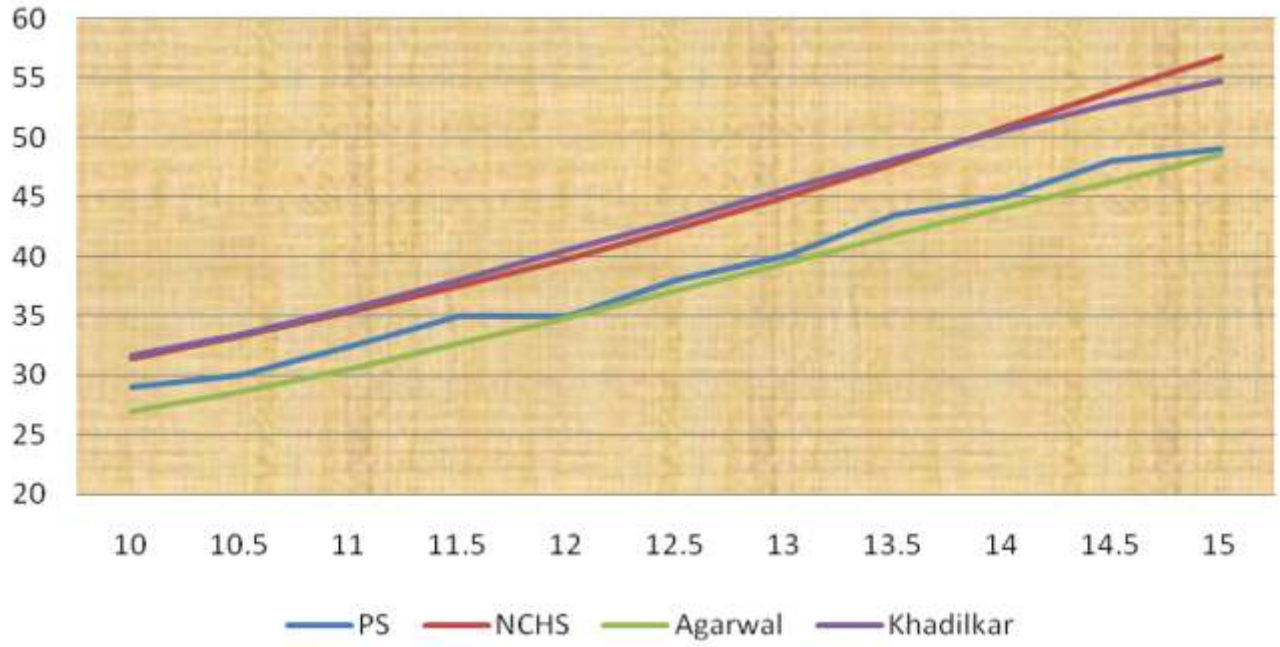

Fig. 4A : Comparison of Weight (Kgs) of Present Study Boys and Other Studies

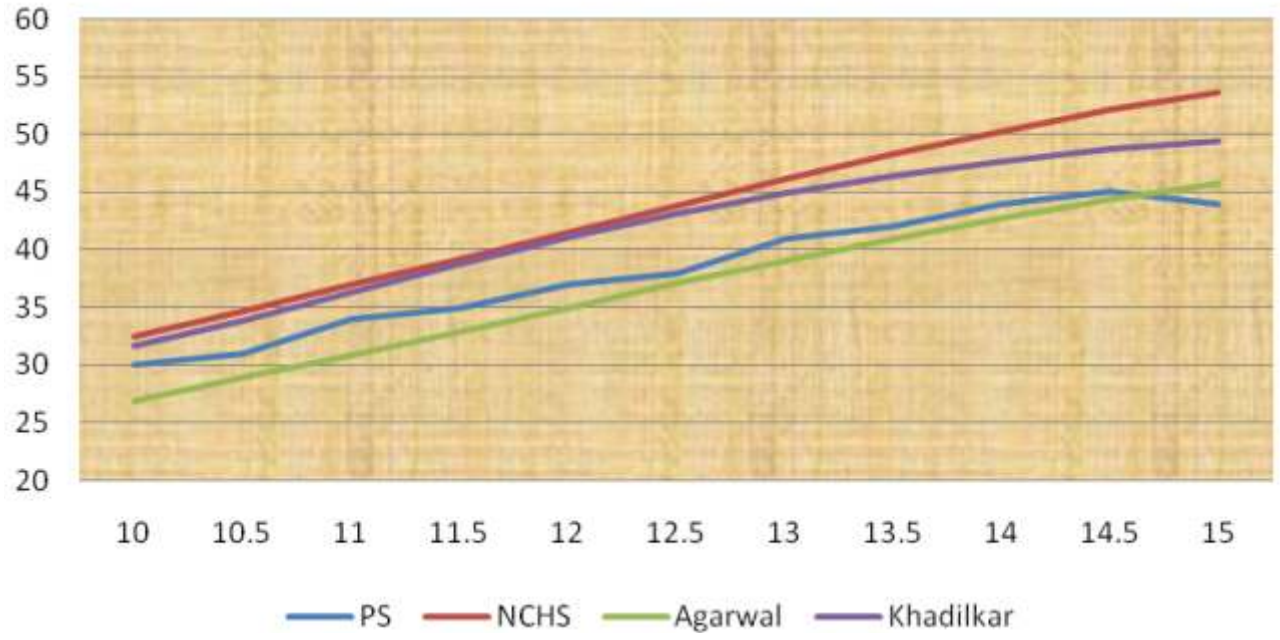

Fig. 4A : Comparison of Weight (Kgs) of Present Study Girls and Other Studies

BMI (kg/m^2)

Median values for BMI, like height and weight have coincided with corresponding mean values of BMI in various age groups and both sexes in Surat study [16].

The population and race specific 85th and 95th percentiles for people aged 6-74 years in the first National Health and Nutrition Examination survey (NHANES – I) have been presented by Must *et al* [29].In the present study 85th and 95th percentile values for both boys and girls are lesser than Must *et al* study. In the present study 85th and 95th percentile values for boys are comparable with WHO 2007 reference values. For girls 85th percentile values are comparable with these reference values up to 13.5 years age and 14 years onwards present study values are lesser while 95th percentile values are comparable with these values till 12 years; from 12.5 years onwards values are lesser than this reference [9].

In the present study 85th percentile values for boys are almost equal to Agarwal *et al* study values and 95th percentile values for Agarwal *et al* study are more at all ages. Both 85th and 95th percentile values for girls in present study; are lesser than Agarwal *et al* study [30].

In Khadilkar *et al* study [24] both 85th and 95th percentile values for BMI are higher than the present study and their values are even higher when compared with the 2007 WHO reference values [9] and Must *et al* study [29]. If we use 85th and95th percentiles as cut-offs for defining overweight and obese using these data, we are accepting higher BMI (overweight children) as normal at all ages. Thus there is variation within our country and children can be wrongly categorized as underweight or overweight as normal. Thus local references are helpful in directing the limited resources more efficiently to the needed ones.

Conclusion:

The present study provides the physical growth standard for school based population (10-15years) of District Satara from Western Maharashtra, India. It can be recommended for monitoring of growth at a glance in the field. Present study 50th percentile values for height and weight for both sexes have been considerably higher as compared to ICMR standard. In both sexes 50th percentile height values have been comparable to 1977 NCHS and 2007 WHO reference upto 15years age. Thus there is secular trend in height and weight of Indian children which is good indicators of improvements in socio-economic and socio-hygienic conditions and in state of health of population. The time is now ripe to conduct a nationwide study to re-evaluate our standards for adolescents.

This study has some limitations. It was a cross sectional study and so provides no information on longitudinal growth. Study has not included whole range of adolescent age group years.

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