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GROWTH STATUS AND INDICES OF ADIPOSITY AND FAT PATTERNING AMONG ADOLESCENT RAJPUT BOYS OF CHAMBA

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ABSTRACT

The present study hasbeen undertaken with an aim to study thegrowth pattern and indices of adiposity and fat patterningamong adolescent Rajput boys of District Chamba. The cross-sectional sample is based on 217 Rajput boys ranging in age from 11 to 18 years, belonging to village Haripur and Chamba town. Rajput boys witnessed their adolescent spurt for stature, weight, waist circumference and hip circumference between 13 and 14 years. ANOVA revealed significant differences in the anthropometric traits between various age groups. Body mass index after showing an initial decrease till 12 years, witnessed rapid increase between 13 and 17 years with maximum increase of 1.22 kg/m2 during 16 to 17 years. Waist/hip ratio (WHR) indicated more thickening of their hip region as compared to waist region as the mean values demonstrated a general decrease with the advancing age. Waist height ratio among sample boys fluctuated between a very narrow rangeof 0.39 to 0.41. Mean values for A body shape index (ABSI) increasedgradually from 11 to 13 years, showed a fluctuating trend thereafter and recorded the minimum value of 0.74 at 16 years. The percent fat as depicted by Body adiposity index decreased from 24.99% to 21.26 % during 11 to 18 years.Rajput boys of Chamba exhibited poor growth performance compared to affluent Indiansand WHO standards which may be attributed to their poor socio-economic status and inadequate diet. However, when compared with Rajput Chamba boys studied three decades ago, the boys of the present study showedconsiderably greater mean values for weight and height particularly during 14 to 17 years pointing towards secular trends after 14 years.

Key Words: Adolescence, Fat patterning, Body mass index,Body Adiposity Index,A body shape index

INTRODUCTION

Growth status of an individual is the attained size or level of maturity at a given point of time. It is obtained by measuring infants, children and adolescents and comparing the values with appropriate referencedata to reflect their health status.

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Human growth is the outcome of interaction between genes and environment. There is considerable individual variability in size attained and rate of growth atdifferent ages. The pattern of growth during infancy differs from those in childhood and adolescence. During infancy, childhood and early adolescence growth is not a continuous process, it occurs in so called salutatory growth spurts,which differ in growth velocity (Wales, 1998). Adolescence is the period of maximum transition when all body dimensions growwith a rapid pace along with profound sexual, skeletal, physiological and psychological changes. Puberty is a highly dynamic biological process associated with size, proportions and body composition,preceded by a sharp increase in body weight which is reflected in an increase in BMI (de Leonibus *et al.* 2013).Differences in males and females during puberty are also well documented. Body size at birth is very important because of its relationship to morbidity and mortality during early infancy and health implications in adulthood.The amount of total fat and its regional distribution are independent and important markers in anthropological and epidemiological studies of nutrition and chronic diseases (Baumgartner and Roche, 1988; Bouchard, 1988; Muller *et al.*, 1991; Bjorntorp, 1997; Daniels *et al.* 2000, Rodriguez *et al.*, 2004). The adultpattern of regional fat distribution emerges during adolescence and individuals exhibit considerable differences in the timing and tempo of adolescent growth spurt as well as in sexual maturation (Malina *et al.* 2004).Body mass Index is the most widely used index of adiposity among adolescents,however it does not reflect the contributions of body fatness and muscle mass towards body mass index. There are different ways to studybody fat distribution. i.e. by waist circumference alone (Daniels *et al.*, 2000); byusing trunk/extremity ratio; by combining waist-hip ratio and skinfold ratios (Flori *et al.* 2000). However, in recent years, measures of central obesity, principally waist circumference and the waist: hip ratio and to a lesser extent the waist: height ratio, which more accurately describe the distribution of body fat compared with BMI, have been suggested to be more closely associated with subsequent morbidity and mortality. (Despres, 2012; Huxley *et al.* 2010).

A body shape index (ABSI) expresses the excess risk from high WC in a convenient form thatis complementary to BMI and to other known risk factors (Krakauer & Krakauer, 2012). Recently, the Body Adiposity Index (BAI), which is based on the measurements of hip circumference and height, has been suggested as a new index of adiposity (Bergman *et al.* 2011). Data on abdominal visceral fat for children and adolescents are relatively limited (Malina 1996, 2005).There are numerous studies on growth status of Indian children and adolescents but studies on fat patterning are limited (Kapoor *et al.*, 1998; Mercedes *et al.*, 2001; Sinha and Kapoor, 2005, 2009; Singh *et al.*, 2007; Singh, 2008;Talwar *et al.*, 2005, 2010, 2011; Talwar and Singh, 2014). Koziel and Malina (2005) published that that early maturing adolescents accumulate more subcutaneous adipose tissue on the lower trunk compared with later maturing peers of the same age and sex.

The nutritional transition and modernization has affected the growth characteristics during the recent years therefore, it calls for regular monitoring of growth status

and fat distribution pattern of populations in view of secular trends.The present study has been undertaken with a view to understanding growth status and fat patterning among adolescent Rajput boys of District Chamba.

MATERIAL AND METHODS

Chamba is an ancient town in the Chamba district in the state of Himachal Pradesh, in northern India. Chamba is bounded on north-west by Jammu and Kashmir, on the north-east and east by Ladakh area of Jammu and Kashmir state and Lahaul and Bara-Bangal area of Himachal Pradesh, on the south-east and south by the District Kangra of Himachal Pradesh and Gurdaspur District of the Punjab.The temperatures in summer vary between 38 °C and 15 °C and in winter: 15 °C and 0 °C .The maximum temperature recorded in summer is 39 °C (102 °F) and the minimum temperature in winter is "1 °C (30 °F). The average annual rainfall in the town is 785.84 millimeters (30.939 in).The Gujjars and the Gaddis are two main groups of tribal people in Chamba. The Brahmans, Rajputs, Thakurs, Rathis and the Khatris all form the majority in Gaddis. Hinduism is the main religion followed by the people of Chamba.

The present cross-sectional study was carried out on the sample of 217 adolescent Rajput boys of Chamba ranging from the age of 11 to 18 years. The data were collected from two schools namely Government senior secondary school, Haripur in District Chamba and Govt. senior secondary school, Chamba town.Precautions were taken in the selection of subjects. Only those children who were physically and mentally normal were included in the sample. Age is an extremely important characteristic in growth studies so proper care was taken while noting down the dates of birth which were recorded from the school registers.The decimal age of each subject was calculated from the date of birth and date of examination using the 'Decimal Age Calendar' of Tanner *et al.* (1966). Subjects ranging in age from 11-18 years were divided into age group of one year each using age mid points.Thus, each age group included individuals not more than 6 months younger or older than the age group. The general information about subjects' families like education status andoccupation was calculated through interview schedule.To assess the growth status and fat distribution pattern stature, weight, waist circumference and hip circumference were taken on each subject using standard techniques given by Weiner & Lourie (1981). One- way analysis of variance (ANOVA) was performed for each variable to study age trends.To study total adiposity body mass index (Wt/ht (m^2) was calculated for each subject. A body shapeindex (ABSI) expresses the excess risk from high WC in a convenient form

that is complementary to BMI and to other known risk factors(Krakauer &. Krakauer, 2012). It is calculated as ABSI=WC/BMI2/3height1/2. Recently, the body Adiposity Index (BAI)which is based on the measurements of hip circumference and height has been suggested as a new index of obesity (Bergman *et al.* 2011). Waist /hip ratio is also a useful index to study fat patterning.

Waist /height ratio is also considered to be a strong predictor of obesity. In the present study, BMI, ABSI index BAI, waist/hip ratio and waist height ratio have calculated to study adiposity and fat distribution.The whole year mean annual increments were calculated by subtracting themean of the preceding age group from that of the succeeding group (Tanner, 1962).

Majority of the subjects were vegetarian. The staple diet of the subjects included rice, wheat, pulses and seasonal vegetables, however their staple food also included cakes made out of maize and wheat which they take it with Mah ki dal and Rajmah madrah. The most favorite item consumed in Chamba is Rajmah Madrah which is made using Rajmah mixed with lots ofspices, yogurt and Ghee. Majority of boys consumed milk daily but fruit consumption wasminimum among the subject.

RESULTS

It is evident from table 1 that all the measurements of Rajput boys of Chamba increased with the advancing age. They attained a stature of 137.87 cm. at 11 years which increased to 168.03 cm. at 18 years, thereby showing a net increase of 30.16 cmor 21.87 % over a period of eight years. Themaximum gain in stature is witnessed between 13 and 14 years (12.36 cm). The minimum value of mean weight of Rajput boyswas 30.70 kg observed at age 11 years and maximum value of 52.74 kgwas observed at age 17 years. Theyadded 22.04 kg from 11 to 17 years. However, they exhibited maximum gain of 7.96 kg between 13 and 14 years.The minimummean value of 56.89 cm for waist circumferencewas observed at age 11 years and it reached to a maximum of 68.17 cm at age 18 years. The boys of the present study added 11.28 cm in their waist circumference during eight years.The maximum gain (3.99 cm) in this parameter is witnessed between 13 to 14 years.Hip circumference among boys gained a total of 15.87cm from an initial value of 69.51 cm to the maximum value of 85.38 cm. attained at 18 years and maximum annual gain of 6.94 cm. was obtained between 13 and 14 years. Body mass index after showing an initial decrease till 12 years witnessed rapid increase between 13 and 17 years with maximum increase of 1.22 kg/m2 during 16 to 17 years and .81 kg/m2 between 13 and 14 years. Waist /hip ratio demonstrated an overall decreasing trend with increasing age. Waist height ratio among sample boys fluctuated between a very narrow range of 0.39 to 0.41.ABSI exhibited steady increase in the mean values till 13 years followed by a minor decrease to pick up again at 15 years where after the values show a decreasing trend till 17 years. Body adiposity index shows a general trend of decrease among Rajput boys of Chamba with the advancing age.

DISCUSSION

Our findings demonstrate that there is an increasing trend in both height and weight of adolescent Rajput boys of Chamba with the advancing age. Nearly all skeletal and muscular dimensions take part in the spurt, though not to an equal degree.More of the spurt in height comes from acceleration in trunk height than from acceleration

in growth of the legs (Tanner, 1989).Previous studies have shown that boys attain a peak height velocity of 10.3 cm/year, on average two years later than girls and gain 28 cm. in height (Marshall & Tanner, 1970;Kelch et.al.1994). The mean body height of the sample boysincreased by 30.17 cmor 21.87 % and body weight increased by 22.04 kg or71.79% from 30.70 kg at 11 years to 52.74 kg at 17 years. The peak height and weight velocities as seen through annual gain have been observed between 13 to 14 years where sample boys gained 12.36 cm in height and 7.96 kg in weight. Similarly, Rajput boys from kullu showed an increase of 27.6 cm (20.20%) in stature and 20.6kg (73.6%) in weight from 11 to 17 years with maximum gain of 8.66 cm in height and 7.09 kg in weight between 14 and 15 years (Talwar et. al., 2011).Rajput boys of Chamba showed greater annual gain in height as compared to Kullu Rajput boys but there was not much difference in annual gain in weight.Rajput boys of the present study had their annual gain in height and weight one year earlier than Rajput boys of Kullu.Adolescence is a period of rapid weight gain because of overall development in all bodily dimensions. Nearly fifty percent of adult body weight is gained during adolescence. In boys peak weight velocity occurs at about the same time as peak height velocity (age 14) and averages9kg/ year (Barnes, 1975; Tanner, 1965).Our study reports similar findings.

Body mass index is a measure of heaviness that reflects both lean and fat tissue and is influenced by the various factors including age, sex, socio-economic condition, diet, exercise and metabolic function (Garn *et al.*, 1986; Bouchard and Perusse, 1988; Reddy,1998). The mean values of body mass index among adolescent Rajput boys increase regularly with the age but the magnitude is much larger between 13 to 17 years with its maximum gain of 1.22 kg/m^2 from 16 to 17 years. A rapid increase in the mean values of BMI during 16 to 17 years reveals an accelerated growth of boys of the present study during this period. Many earlier studies witness a similar trend of accelerated growth in BMI among boys during adolescence and muscle mass contributes maximum towards it.

Body circumferences play a vital role in determining body size and body proportion in adolescents andreflect fat mass and fat free mass and the skeletal size is associated with fat free mass (Wagner and Heyward, 1999). Waist circumference and waist–hip ratio (WHR) have been used as most frequent and indirect measures of intra-abdominal fat mass(Han et.al.1997).According to a report of world health organization waist circumference could be used as an alternative to BMI whenexamining the relationship between weight status and disease risk as well as fat percentage and fat distribution (WHO, 2011).

Waist and hip circumferences among the sample of adolescent Rajput boys of Chamba register faster growth between 13 to 14 years showing maximum gain of 3.99 cm in waist circumference and 6.94 cm in hip circumference during this period.Rajput boys show a total gain of 16.77 cm on their hips as compared to waist where only 11.28 cm are added during a span of eight years.It is also evident from the mean values of their waist/hip ratios.Waist-hip ratio of the sample boys was found to have a decreasing trend with fluctuation at 14 and 16 years which

indicates relatively more thickening of hip region as compared to waist region. Waist-hip ratio decreases from childhood to 18 years in boys and increases later on as the age proceeds up to 30 years. (Ashwell *et al.*, 1985; Casey *et al.* 1994). Similar results have been reported by many studies (Mukhopadhyay *et al.* 2005; Talwar *et al.* 2011 and Talwar and Singh, 2014). The findings of the present study are in consensus with these earlier studies.Moreover, a large hip circumference as compared with waist circumference is known to have a protective effect towards cardiovascular diseases and, is also suggested by its use in the denominator of the waist to hip ratio. (Molarius & Seidell, 1998; Canoy, 2010).

Waist-height ratio ranges between 0.39 to 0.41 (less than 0.5) shows that adolescent boys of Chamba are not obese.Matsha *et al.* (2013) proposed that waist-to-height ratio (WHtR) cut-off of 0.5 is less optimal for cardio metabolic risk screening in children in many settings especially among South African children and this optimal value is likely to be sensitive to gender, ethnicity and urbanization. The newly developed and applied ABSI (A Body shape index) is based on WC, weight and height, where high ABSI indicates that WC is higher than expected for given height and weight and corresponds to a more central concentration of body volume. Applying ABSI along with BMI as a predictor variable separates the influence of the component of body shape measured by WC from that of body size. (Krakauer and Krakauer, 2012). In sample boys ABSI showed an overall gradual increase with decreasing trend at 16 and 17 years. Their Mean values fluctuate within a very narrow range showing an appropriate waist circumference for their height and weight. Krakauer & krakauer, (2012) published that Individuals showing higher values of ABSI have a smaller fraction of mass as limb muscle with a corresponding increase in the fraction of mass around the trunk which has been highlighted as a marker of mortality and morbidity. ABSI was also found to predict resting blood pressure in adolescents more precisely than BMI (Duncan *et al.* 2013).

Body adiposity index (BAI) is a newly developed index which measures the body fat but unlike BMI, it uses hip circumference instead of weight. BAI could directly estimate body fatness without the need for further adjustment for characteristics such as sex and age.Because of the increasing importance of childhood obesity, it is critical to examine the behavior of the BAI in pre-pubertal and post pubertal children of both sexes, and different ethnicities. It has been suggested that hip circumference captures male–female differences in adiposity better than the BMI (Bergman *et al.* 2011). In present study BAI depicts a decreasing trend like waist hip ratio except for the values of 12 and 13 years, which shows decrease of percent fat among adolescent boys with the advancing age. This decline during male adolescence is a function of the adolescent spurt in fat-free mass, more specifically muscle mass. (Malina, 2000).

Studies on growth status and fat distribution of children and adolescents are extremely significant in view of achieving early diagnosis in public health and promoting health and nutrition. Thus, to measure the growth status of a particular

population, it is pertinent to make a cross comparison with the existing international and national standards to point out the differences in growth patterns. Height, Weight and Body mass index (BMI) have been compared with WHO (2007) percentiles and with the mean values of growth standards by ICMR (1989), Affluent Indians (Agarwal *et al.* 1992), Rajputs of Bharmour (Singh, 1980); Rajputs of Chamba (Singh and singh, 1987); Rajput of Kullu; (Talwar *et al.* (2011); Kanets of Kinnaur (Malhotra, 1975); Affluent Indians (Khadilkar *et al.* (2009) and Nationwide school children (Marwaha *et al.* (2011).

Adolescent boys of present study when compared with nationwide data of boys (ICMR, 1989), for height reveal greater mean values at all ages except for 13 years.Boys of the present study when compared with Affluent Indian boys (Agarwal, 1992), Affluent Indians (Khadilkar *et al.* 2009) and Nationwide school children (Marwaha *et al.* 2011), were found to be considerably shorter and lighter at all ages. However, boys of the Present study have maximum annual gain between 13 and 14 years as in the case of affluent Indian boys (Khadilkar *et al.*, 2009). Nationwide school children (Marwaha *et al.* 2011) are considerably taller at all ages than sample boys. Rajput boys of Chamba are taller than Rajputs of Bharmour, Kanets of Kinnaur, Rajputs of Chamba and Rajputs of Kullu except for 13 years when Kullu Rajput boys stand taller.

Mean values of weight of Adolescent boys of the present study are considerably lowerwhen compared with mean values of weight of Affluent Indian boys (Agarwal, 1992); Affluent Indians (Khadilkar *et al.* 2009) and Nationwide school children (Marwaha *et al.* 2011). The Rajputs of Bharmour are considerably lighter than all other boys. These differences in height and weight may be attributed to differences in socio-economic status and dietary habits along withenergy expenditure. To examine secular changes in height and weight of Chamba Rajput boys, comparison has been made with a study, conducted about three decades ago on Rajput boys of Chamba by Singh and Singh (1987). Rajput boys of the present study showed greater mean height and weight as compared to Chamba Rajput boys studied in 1987, after 14 years. This gives a clear evidence of secular trends in height as well as in weight after adolescence. Rajput boys of present study are taller by 2.84 cm at 14 years; 4.82 cm at 15 years; 4.15 cm. at 16 years and 4.94 cm. at 17 years. However, in weight they are heavier than them by 4.16 kg at 14 years; 2.48 kg at 16 years and 5.08 kg at 17 years. Improved environmental quality and nutritional circumstances are most often offered as the major contributors to larger body size (Malina *et al.*, 2004).

BMI of Rajput boys of Chamba when compared to BMI of the affluent Indian studies, shows lower values than them at all ages except for 11 years when the mean the value is more than affluent Indians (Agarwal *et al.* 1992). The maximum body mass index (BMI) values have been recorded in affluent Indians (Khadilkar *et al.* 2009) and Nationwide school children. (Marwaha *et al.* 2011).

The height of the present sample When compared for height with WHO (2007)

percentiles, the mean values of present sample lied between 15th and 25th percentile at age 11, fluctuated between 5th and 15th percentiles at 12 years to attain 3rd centile at 13 years and fluctuated further between 5th and 15th percentiles till 15 years, where after these coincide with 15th centile till 18 years.

Their mean values for BMI fluctuated between 25th and 50th percentiles of WHO at 11 years, there after, the values were consistent at 15th centile till 14 years to dip down between 5th and 15th percentiles at 15 and 16 years, which increased to 15th centile at 17 years, where after the values fluctuated between 5th and 15th percentiles at 18 years. The sample boys were found to be substantially shorter and lighter than their western counterparts at all ages. . These differences in height and weight with their western counterparts may be attributed to their lower nutritional status, besides genetic endowment.Inadequate and poor nutrient intake along with high energy expenditures result in smaller body size.

Table 1: Mean, Standard deviations (SD) and ANOVA of anthropometric measurements and indices in adolescent Rajput boys of District Chamba

Age in years variables	*11 N=30*	*12 N=28*	*13 N=23*	*14 N=30*	*15 N=33*	*16 N=26*	*17 N=27*	*18 N=20*	*ANOVAF-VALUE (p-value)*
Stature									
Mean	137.87	139.53	141.48	153.84	160.12	163.65	167.54	168.03	83.22
SD	7.58	6.67	6.08	7.31	8.55	6.03	6.72	3.92	(0.00)
Weight									
Mean	30.70	31.24	32.25	40.21	43.66	46.87	52.74	52.16	40.50
SD	4.44	6.67	7.21	7.34	7.74	6.13	9.08	8.99	(0.00)
Waist Circ									
Mean	56.89	57.24	58.10	62.09	63.94	64.02	67.69	68.17	12.10
SD	6.10	6.58	4.26	6.28	4.61	7.88	5.41	10.59	(0.00)
Hip Circ									
Mean	69.51	70.27	72.60	79.54	80.90	82.60	85.28	85.38	27.60
SD	7.28	7.45	3.41	6.41	4.88	5.53	7.21	7.87	(0.00)
BMI									
Mean	16.15	15.88	16.01	16.92	17.04	17.49	18.71	18.46	5.00
SD	1.99	1.62	2.91	2.45	2.93	1.98	2.34	3.05	(0.00)
Waist-Hip ratio									
Mean	0.82	0.82	0.80	0.78	0.79	0.77	0.80	0.80	2.10
SD	0.06	0.06	0.04	0.05	0.05	0.07	0.05	0.08	(0.04)
Waist-Height Ratio									
Mean	0.41	0.41	0.41	0.40	0.40	0.39	0.40	0.41	0.73
SD	0.05	0.04	0.02	0.04	0.03	0.05	0.03	0.06	(0.64)
ABSI									
Mean	0.76	0.77	0.78	0.76	0.77	0.74	0.75	0.76	0.66
SD	0.08	0.07	0.07	0.04	0.05	0.08	0.06	0.11	(0.70)
BAI									
Mean	24.99	24.65	25.212	23.79	22.04	21.52	21.33	21.26	7.00
SD	3.98	3.39	3.79	3.80	2.92	3.03	2.73	4.05	(0.00)

Table 2: Comparison of Stature (cm) of Rajput Boys of Chamba with Stature of Affluent Indians, Rajputs of Bharmour, Rajputs of Chamba, Rajputs of Kullu and Kanets of Kinnaur

Age (years)	*ICMR 1989*	*Affluent Indians*	*Rajput Bharmour*	*Rajput Chamba*	*Rajput Kullu*	*Kanet Kinnaur*	*Khadilkar et al. 2009*	*Marwaha et.al. 2011*	*Present study*
11	133.4	139.60	129.0	135.8	136.5	129.4	142.40	144.25	137.87
12	138.3	145.80	135.8	141.2	138.77	133.7	148.30	150.15	139.53
13	144.6	152.00	139.8	149.3	146.14	138.8	154.80	156.07	141.48
14	150.1	157.60	142.4	151.0	151.19	142.9	161.40	161.47	153.84
15	155.5	162.50	147.8	155.3	159.85	150.8	166.10	165.91	160.12
16	159.5	166.30	154.6	159.5	161.56	152.7	168.50	169.29	163.65
17	161.4	168.70	157.8	162.6	164.10	157.3	169.70	171.96	167.54
18	163.1	169.80	-	-	-	-	170.40	174.39	168.03

Table 3 : Comparison of weight (kg) of Rajput Boys of Chamba with weight of Affluent Indians, Rajputs of Bharmour, Rajputs of Chamba, Rajputs of Kullu and Kanets of Kinnaur

Age (years)	*ICMR (1989)*	*Affluent Indians*	*Rajput Bharmour*	*Rajput Chamba*	*Rajput Kullu*	*Kanets Kinnaur*	*Khadilkar et al. 2009*	*Marwaha et al. 2011*	*Present study*
11	25.9	30.60	24.33	29.75	28.09	26.78	35.60	36.86	30.70
12	28.5	34.80	26.75	31.75	31.10	29.22	40.50	41.03	31.24
13	32.1	39.40	28.90	37.84	34.27	31.35	45.60	45.45	32.25
14	35.7	44.10	30.79	36.05	37.23	33.49	50.60	49.98	40.21
15	39.6	48.50	35.11	47.18	44.32	38.52	54.70	54.37	43.66
16	43.2	52.40	40.49	44.39	47.00	41.98	57.70	58.51	46.87
17	45.7	55.50	42.73	47.66	48.77	45.28	59.80	62.42	52.74
18	47.4	58.60	-	-	-	-	61.50	66.25	52.16

Table 4: Comparison of BMI (kg/m²) of Rajput boys of Chamba with BMI of Affluent Indians

Age (years)	*Affluent Indians*	*Khadilkar et al. 2009*	*Marwaha et al. 2011*	*Present study*
11	15.80	17.50	17.61	16.15
12	16.40	18.20	18.10	15.88
13	17.10	18.80	18.61	16.01
14	17.70	19.30	19.16	16.92
15	18.40	19.80	19.75	17.04
16	19.10	20.30	20.34	17.49
17	19.70	20.70	20.91	18.71
18	20.00	21.10	21.46	18.46

REFERENCES

Agarwal, D.K., Agarwal, K.N., Upadhyay, S.K., Mittal, R., Prakash, R. and S. Rai., 1992. Physical and sexual growth pattern of affluent children from 5 to 18 years of age. *Indian Paediatr.*, 29: 1203–1283.

Ashwell, M., Cole, T.J. and A.K. Dixon., 1985. Obesity: New insight into anthropometric classification of fat distribution shown by computed tomography. *BrMedJ.*, 290: 1692.

Barnes, H.V., 1975. Physical growth and development during puberty. *Med Clin North Am* 59(6): 1305-17.

Baumgartner, R.N. and A.F. Roche., 1988. Tracking of fat pattern indices in childhood: The Melbourne Growth Study. *Hum Biol*., 60: 549-567.

Bergman, R. N., Stefanovski, D., Buchanan, T. A., Sumner, A. E., Reynolds, J. C., Sebring, N. G. and R. M. Watanabe., 2011. A better index of Body Adiposity. *Obesity (Silver Spring, Md.).,* 19(5): 1083-1089.

Bjorntorp, P., 1997. Body fat distribution, insulin resistance and metabolic diseases. *Nutrition*., 13: 795- 803.

Bouchard, C., 1988. Inheritance of human fat distribution. *In Fat distribution during growth and later health outcomes, edited by C. Bouchard and F. E. Johnston (New York: Alan R. Liss)*., 103-125.

Bouchard, C., Perusse, L., Leblanc, C., Trebley, A. and G. Theriault., 1988. Inheritance of amount and distribution of human body fat. *Int. J. Obesity*., 12: 205-215.

Canoy, D., 2010. Coronary heart disease and body fat distribution. *Curr. Atheroscler.Rep*., 12:125–133.

Casey, V.A., Dwyer, J.H., Berkey, C.S., Bailey, S.M., Coleman, K.A. and I. Valadian., 1994. The distribution of body –fat from childhood in a longitudinal –study population . *Annal of Human Biology.,* 21: 39-55.

Daniels, S.R., Khoury, P.R. and J.A. Morrison., 2000. Utility of different measures of body fat distribution in children and adolescents. *American Journal of Epidemiology*., 152:1179-1184.

De Leonibus, C., Marcovecchio, M.L., Chiavaroli., De Giorgis,T., Chiarelli,F. and A. Mohn., 2013. Timing of puberty and physical growth in obese children: A longitudinal study in boys and girls. *Pediatric Obesity.,* 9: 292-299.

de Onis, M., Dasgupta, P., Saha,S., Sengupta, D. and M. Bloossner., 2001. The National Centre for Health Statistics reference and the growth of Indian adolescent boys. *Am. J. of Clinical nutrition*., 74:248-253.

de Onis, M., Onyango, A.W., Borghi, E., Siyam, A., Nishida, C. and J. Siekmann., 2007. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* **85**(9): 649- 732.

Despres, Jean-Pierre., 2012. Body Fat Distribution and Risk of Cardiovascular Disease. *American Heart Association.,* 126: 1301-1313.

Duncan, M.J., Mota, J., Vale, S., Santos, M.P. and J.C. Ribeiro., 2013. Associations between body mass index, waist circumference and body shape index with resting blood pressure in Portuguese adolescents. *Am J Hum Biol*., 40:163–7.

Flori, G., Facchini, F., Pettener, D., Rimondi, A., Battistini, N. and G. Bedogni., 2000. Relationships between blood pressure, anthropometric characteristics and blood lipids in high and low altitude populations from central Asia. *Annals of human Biology*., 27: 19-28.

Garn, S.M., Leonard, W.R. and V.M. Hawthorne., 1986. Three limitations of the body mass index. *Am. J. Clin. Nutr.,* 44: 996-997.

Han, T.S., McNeill, G., Seidell, J.C. and M.E. Lean., 1997. Predicting intra-abdominal fatness from anthropometric measures: the influence of stature. *Int J Obes Relat Metab Disord*., 21: 587–93.

Huxley, R., Mendis, S., Zheleznyakov, E., Reddy, S. and J. Chan., 2010. Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk. *European Journal Clinical Nutrition.*, 64:16-22.

ICMR., 1989.*Growth and Physical Development of Indian Infants and Children*. ICMR Tech. Rep.Ser.18. New Delhi.

Kapoor, S., Patra, V. S., Sandhu and A.K. Kapoor., 1998. Fatness and its distribution pattern among JatSikhs. *J. Indian Anthrop. Soc.,* 33: 223-228.

Kelch, R.P. and I.Z. Beitins., 1994. Adolescent sexual development. In: Kappy MS, Blizzard RM, Migeon CJ, eds. The diagnosis and treatment of endocrine disorders in childhood and adolescence. *4th ed. Springfield, IL: Charles C Thomas*., 193–234.

Khadilkar, V.V., Khadilkar, A.V., Cole T.J. and M.G. Sayyad., 2009. Cross-sectional growth curves for height, weight and body mass index for Affluent Indian Children. *Indian Pediatrics.*, 46: 477-489.

Koziel, S. andR.M. Malina., 2005. Variation in relative fat distribution associated with maturational timing: The Wroclaw Growth study. *Annals of Human Biology*., 32: 691–701.

Krakauer, N.Y. and J.C. Krakauer., 2012. A new body shape index predicts mortality hazards independently of body mass index.*PLoS ONE* 7(7):395-04.

Malhotra, R., 1975. A study of physical growth and development status of a high altitude population in the Himalayas (A cross-sectional study of Kinnaura male Rajputs). Unpublished Ph. D. thesis, Punjab University, Chandigarh, India.

Malina, R.M., 1996. Regional body composition: Age, sex, and ethnic variation. In: Roche AF, Heymsfield SB, Lohman TG, editors. *Human body composition. Champaign, IL: Human Kinetics*., 217–255.

Malina, R.M., 2000. In Exercise and sport science. *Garrett WE, Kirkendall DT, editors. Philadelphia, PA: Lippincott Williams & Wilkins*., 425–445. (Growth, maturation, and performance).

Malina, R.M., 2005. Variation in body composition associated with sex and ethnicity. In: Heymsfield SD, Lohman TG, Wang ZM, Going S, editors. *Human body composition, 2nd edn. Champaign, IL: Human Kinetics*., 271–298.

Malina, R.M., Bouchard, C. and Oded Bar-Or., 2004. *Growth, maturation and physical actiEdition. Human Kinetics. United States.*

Marshall, W.A. and J.M. Tanner., 1970. Variation in the pattern of pubertal changes in boys.*Arch Dis Child.*, 45: 13-23.

Marwaha, R.K., Tandon, N., Ganie, M. A., Kanwar, R.,Shivaprasad, C., Sabharwal,A., Bhadra,K. and A. Narang., 2011. Nationwide reference data for height, weight and body mass index of Indian school children. *Natl Med J India*., 24:269–77.

Matsha, T.E., Hassan, M.S., Hon, G.M., Soita, D.J., Kengne, A.P. and R.T. Erasmus., 2013. Derivation and validation of a waist circumference optimal cutoff for diagnosing metabolic syndrome in a South African mixed ancestry population. *Int J Cardiol.*, 168 (3): 2954-5.

Molarius, A. and J.C. Seidell., 1998. Selection of anthropometric indicators for classification of abdominal fatness—a critical review. *Int. J. Obes. Relat. Metab. Disord*., 22:719–727.

Mukhopadhyay, A., Bhadra, M. and K. Bose., 2005. Regional Adiposity, Body composition and Central body fat distribution of 10 to 16 years old Bengalee Boys of Nimta, North 24 Parganas, West Bengal, *India. Coll. Anthropol*., 29(2): 487-492.

Muller, W.H., Wear, M.L., Harris, C.L., Emerson, J.B., Barton,S.A., Hewett, D.H. and W.J. Schull., 1991. Which measure of body fat distribution is best for epidemiological research. *Am J Epidem.,* 133: 858-869.

Reddy, B.N., 1998. *Human Biology*., 70(5): 901-917.

Rodrigues, G., Monero, L.A., Blay, M.G., Blay, V.A., Garagorri, J.M., Sarria, A. and M. Bueno., 2004. Body composition in adolescents: measurements and metabolic aspects. *International J of Obesity.,* 28:S54-S58.

Singh, L. and S.P. Singh., 1987. Physical growth of Rajput and Brahmin boys of Chamba (ms.).

Singh, R., 2008. Trends and perspectives of anthropometrical research: Some methodological illustrations. In Prasad A, Mukherjee R, Ekka BA, editors. *Social research methodologies in action*. *Conceptual andTheoretical Concerns in Social Research*. Ranchi: Xavier Institute of Social Service., 1: 207–227.

Singh, S.P., 1980. Physical growth of Dhaula Dhar Gaddi Rajput males of Dhaula Dhar Range of the Himalayas. *Zeitschrift fur Morphologie und Anthropologie*., 70: 295-301.

Singh, S.P., Malhotra, P., Sidhu, L.S. and P.P. Singh., 2007. Skeletal Frame size of Spitian Children. *J. Hum. Ecol*. 21(3): 227-230.

Sinha, R. and S. Kapoor., 2005. Fat patterning among Indian adolescent boys and girls. *Indian J Phys Anthropol Hum Genet*., 24:135-141.

Sinha, R. and S. Kapoor., 2009. Gender difference in fat indices as evident in two generations.*Anthropol Anz*., 67(2): 153-63.

Talwar, I. and B. Singh., 2014. Body Composition and fat patterning among adolescent boys of district Yamunanagar, Haryana. *Indian Journal Physical Anthropology & Human Genetics*., 33.(1): 31-42.

Talwar, I., Kaur, B. and V. Negi., 2011. Growth trends in bodily dimensions and fat distribution pattern during adolescence among Rajput boys of Kullu valley. *Indian Journal of Physical Anthropology and Human Genetics.,* 30(1-2):183-200

Talwar, I., Sharma, K. and S. Kapur., 2010. Growth trends in body, fat, circumferential and physiologicaltraits during adolescence among Rajput females of Theog, Shimla District (Himachal Pradesh), India. *Ann Hum Biol.,* 37(4): 536 – 553.

Talwar, I., Vasudha. and P. Bajwa., 2005. Fatness and regional distribution of body fat among adolescent Brahmin girls. *Indian J Phys Anthrop Hum Genet.*, 24:143–151.

Tanner, J. M., 1965. The relationship of puberty to other maturity indicators and bodycomposition in man. *Symp Soc Stud Hum Biol*., 6: 211.

Tanner, J. M., Whitehouse, R. H. and M. Takaishi., 1966. Standards from birth to maturity for height, weight, height velocity in British Children. *Archive Dis. Child.*, 41:454-613.

Tanner, J.M., 1962. *Growth at Adolescence*, Blackwell Scientific Publications: Oxford.

Tanner, J.M., 1989. *Fetus into man: physical growth from conception to maturity*. Cambridge, MA: Harvard University Press.

Wagner, D.R. and V.H. Heyward., 1999. Techniques of body composition assessment: A review of laboratory and field methods. *Research Quarterly for Exercise and Sport.,70* (2), 135–9.

Wales, J.K.H., 1998. A brief history of the study of human growth dynamics. *Ann. Hum.Biol*., 25:175-184.

Weiner, J. S. and J. A. Lourie., 1981. *Practical Human Biology.* New York; Academic Press.

World Health Organization., 2011. Waist circumference and Waist- hip ratio: Report *of WHOexpert committee*. Geneva: World Health Organization.