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Age changes in the body physique and its association with BMI: a cross-sectional study among school going boys of Rajasthan, India

S. Kaur and S. Chandel

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Sukhmani Kaur and Shivani Chandel, Department of Anthropology, University of Delhi, Delhi-110007. E-mail ID(s): Sukhmani kaur- mani25sukh@gmail.com
Shivani Chandel- vs.shivani@gmail.com

Corresponding author: Shivani Chandel, Department of Anthropology, University of Delhi, Delhi-110007.

ABSTRACT:

Aim: The aim of this study was to assess the body physique and its association with BMI among school going boys of Rajasthan.

Methods: A cross-sectional sample of 240 boys of Dangi community of Udaipur belonging to the age group 10 to 17 years were studied for their body physique. All the anthropometric measurements were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK). The Heath-Carter method of somatotyping was used to study body physique and IOTF recommended cut-off points were used to assess BMI in children. Data was analyzed using MS-Excel and Statistical Package SPSS (IBM) version 20. Somatotype dispersion distances, Mean somatotype dispersion, Standard deviation of somatotype dispersion distance have been calculated. Somatochart was also plotted for the body physique of the population.

Results: The result of the study revealed that the body physique varied from mesomorphic-ectomorph to balanced ectomorph across the various age groups. Majority of the population falls into the underweight category. Positive correlations were observed between BMI and the endomorphic and mesomorphic components whereas negative correlation was observed with the ectomorphic component.

Conclusion: The findings indicate that the school going boys of Rajasthan are predominantly ectomorphic. The tendency towards higher ectomorphic component and prevalence of underweight among the boys could be the result of caloric inadequacy in their diets. Follow-up studies on larger sample size should be conducted and relation of body physique with body composition can be a further target of intervention among growing boys.

Key words: Body physique, Age changes, Body mass index, Dangi, Rajasthan

INTRODUCTION:

Somatotyping is one of the most valuable methods of evaluating body physique. It is the quantification of the present shape and composition of the human body in terms of endomorphy (relative fatness), mesomorphy (relative muscularity) and ectomorphy (relative linearity or thinness) (Carter and Heath 1990). Because of its exclusivity somatotyping has been used for studying population variation and/or age and sex variations. The differences in physique between populations in different regions were of importance, especially to underlie the cultural differences between populations (Handa *et al.* 1995). Somatotypes vary between population groups as well as during growth in the same population (Singh and Sidhu 1980; Malik *et al.* 1986; Kaul *et al.* 1996).

The start of biological growth and development during adolescence is signified by the onset of puberty, which is often defined as the physical transformation of a child into an adult. A great number of biological changes occur during puberty including sexual maturation, increase in stature and weight, completion of skeletal growth along with a marked increase in skeletal mass, and changes in body composition. In growth studies, somatotyping allows one to characterize changes in physique during growth in order to monitor growth patterns and to better understand variations in adult physique (Norton and Olds 1996; Malina *et al.* 2004). Changes in somatotype components during the growth period can also provide useful information about the growth status and the timing and rate of sexual maturation (Beunen *et al.* 1987; Hebbelinck *et al.* 1995; Toselli and Gruppioni 1999).

Number of studies has summarized the information related to somatotype changes during growth, but not much work has been done on this aspect among Dangi community residing in Udaipur district of Rajasthan, India. The present study, thus, aims to assess the changes in body physique with age and the association between its three components, viz., endomorphy, mesomorphy and ectomorphy and body mass index (BMI) among the boys of Dangi community of Udaipur in the age range of 10 to 17 years.

MATERIALS AND METHODS:

This study was approved by the Institutional Ethical Committee of the Department of Anthropology, University of Delhi, Delhi, India.

Study Population and Setting

The study was carried out on the boys belonging to Dangi community living in the villages of Girwa Tehsil, district Udaipur, Rajasthan, India. The Dangi are primarily located in the states of Rajasthan, Haryana, Gujarat and Uttarakhand. Dangi is principally a cultivating caste. The origin and actual meaning of term Dangi cannot be stated exactly as there are different interpretations of this name. Some claim that it is probably associated with the geological nature of the region where they might have lived. In Sanskrit language, Dang refers to highlands. Thus, it is quite possible that the

Dangi people might be the inhabitants of Dang region. It is also said that these people are probably called by this name due to their work of high land region. Some also say that the name Dangi has originated on linguistic basis. It refers to certain dialects mainly spoken in hilly region known as the Dangis. Dangi is spoken as sub-dialect of *Braj Bhasha* in the northern parts of former state of Jaipur. In the states of Rajasthan and Gujarat, the Dangi are also referred as Patels. Here, people are found to be practicing caste endogamy and sub-caste exogamy.

The community is purely vegetarian. Their staple food includes wheat (*gehu*), maize (*macca*), rice (*chawal*), pulses (*dal*), and available leafy and green vegetables. Occasionally, they eat the seasonal fruits. Adult men and women take tea regularly. Children take milk but it is not a regular habit. Besides milk, they take butter milk (*chaach*) and buttermilk with crushed dry corn (*raabri*) regularly. Alcohol in any form is not permitted in the society.

The data was mainly collected from the boys of the villages: Shobhagpura, Manwakhera, Pula, Eklingpura and also from some the schools there. The data for this study were obtained from a cross-sectional survey conducted in February 2016. Two hundred and forty (240) boys belonging to Dangi community in age group ranging from 10-17 years were evaluated for their somatotype characteristics. For the purpose of analysis, the subjects were classified into yearly intervals. Those subjects who had completed 10 years of age but were less than 11 years even by one day were grouped under 10+ age group. Similar pattern was followed for other age groups as well. Most of the boys were from middle and lower middle socio-economic class.

Data Collection

An informed consent was obtained from the parents or the guardians of the participants. After taking the consent, general information regarding educational level, occupation and income of the parents, family size and dietary preference was collected using an interview schedule.

Somatometric measurements namely stature, body weight, two bone diameters (biepicondylar humerus and biepicondylar femur), two muscle girths (mid-upper arm and calf), and four skinfolds (triceps, sub-scapular, supra-spinale and medial calf) were taken with standard equipments and procedure. Stature was measured in centimeters (cm) using an Anthropometric rod and body weight was measured in kilograms (kg) using a weighing machine. Sliding caliper and flexible steel tape were used to measure bone diameters and circumferences in centimeters respectively. Skinfold thickness was measured in millimeters (mm) using a Harpenden skinfold caliper. Body mass index (BMI) was calculated using the formula weight (kg) divided by height in square meters (m^2). The distribution into different BMI categories was done based on the ICMR International Obesity Taskforce (IOTF) age-specific BMI cut-off points for children. All the measurements were taken on the right side of the subjects, barefooted and in light clothes.

Anthropometric Somatotyping

Heath-Carter method (Heath and Carter 1967; Carter 1980) was followed for evaluating somatotype characteristics. The following equations were used for calculating somatotype:

Endomorphy = – 0.7182 + 0.1451 (X) – 0.00068 (X^2) + 0.0000014 (X^3)

Where, X = (sum of triceps, subscapular and supraspinale skinfolds) multiplied by (170.18/height in cm). This is called height-corrected endomorphy and is the preferred method for calculating endomorphy.

Mesomorphy = 0.858 × biepicondylar humerus + 0.601 × biepicondylar femur + 0.188 × corrected arm girth + 0.161 × corrected calf girth – height × 0.131 + 4.50

Where, Corrected arm girth = Upper arm circumference (in cm) – Triceps skinfold (in mm)/10 and Corrected calf girth = Calf circumference (in cm) – Calf skinfold (in mm)/10

Ectomorphy was calculated using three different equations according to the height-weight ratio (HWR) which can be calculated as height divided by cube root of weight.

If HWR was greater than or equal to 40.75 then,

Ectomorphy = 0.732 × HWR − 28.58

If HWR was less than 40.75 and greater than 38.25 then,

Ectomorphy = 0.463 × HWR − 17.63

If HWR was equal to or less than 38.25 then,

Ectomorphy = 0.1

Using the formula given by Carter (1980), Individual somatotypes were plotted on a somatochart by calculating values of X and Y coordinates.

X-coordinate = Ectomorphy – Endomorphy

Y-coordinate = 2 × Mesomorphy – (Endomorphy + Ectomorphy)

The values thus obtained were plotted in somatochart. Somatochart, which was first devised by Sheldon (Sheldon et al. 1940), is a schematic, triangular shaped, two-dimensional representation of the theoretical range of known somatotypes. It shows the distribution of the somatotypes plotted as points, and their concentration on the chart. Furthermore, Somatotype dispersion distances, Mean somatotype dispersion, Standard deviation of somatotype dispersion distance have been calculated using Ross and Wilson's (1973) method.

Somatotype Dispersion Distance (S.D.D.)

The distance between mean somatoplot and each individual somatotype is referred to as somatotype dispersion distance (S.D.D). It was calculated by using the formula given by Ross and Wilson (1973). It is given as follows:

S.D.D. = $[3 * (X1 - X2)^2 + (Y1 - Y2)^2]^{½}$
Where, X1 and Y1 are the scalar coordinates of mean somatoplot and X2 and Y2 are the co-ordinates of individual somatoplot. The S.D.D. is represented in Y distance units, that is, in terms of distances at Y - axis of a somatoplot.

Mean Somatotype Dispersion (S.D.M.)
It was calculated as the average of all the Somatotype dispersion distances.
S.D.M. = Σ S.D.D. / N
The S.D.D. is ideal in comparing two mean somatotypes whereas S.D.M. is useful in knowing about the distribution of somatotypes in a group from its mean somatotypes.

Dispersion of Somatotype Distance (D.S.D.)
It can be calculated as the standard deviation of the somatotype dispersion distance.

Data Analysis
All statistical analyses were carried out using the MS-Excel and Statistical Package SPSS (IBM) version 20 (Statistical Package for the Social Sciences). Mean and standard deviation were calculated in descriptive. Pearson's correlation coefficient was computed to find out the association between somatotype components and body mass index.

RESULTS:
Results of age changes in body physique among Dangi boys are presented in this section. The age-wise distribution of all the three somatotype components among Dangi boys of Udaipur are presented in Table 1.

Table 1: Age group-wise distribution of mean somatotypes among Dangi boys

Age group (years)	N	Endomorphy	Mesomorphy	Ectomorphy
		Mean ± S.D.	Mean ± S.D.	Mean ± S.D.
10+	30	2.4 ± 1.2	3.4 ± 1.3	4.6 ± 1.8
11+	30	3.0 ± 1.2	3.8 ± 1.7	4.5 ± 2.1
12+	30	2.8 ± 1.5	3.7 ± 1.6	4.6 ± 1.6
13+	30	2.4 ± 1.1	3.1 ± 1.3	4.9 ± 1.5
14+	30	2.1 ± 0.4	3.0 ± 1.3	5.1 ± 1.3
15+	30	2.5 ± 1.4	2.8 ± 1.6	5.0 ± 1.6
16+	30	2.6 ± 1.1	2.4 ± 1.2	5.4 ± 1.2
17+	30	2.3 ± 0.8	2.1 ± 1.5	5.3 ± 1.3

Endomorphy
Age group wise distribution of endomorphic component of body physique in Dangi boys is shown in table 1. Endomorphy or the ‘component of relative fatness’ in

physique demonstrates an increase with age till 11 years of age in boys afterwards the value is not stable. The mean values for endomorphy shows non-linear distribution with the depression at the age of 14 years. Younger age group boys (10 to 12 years) are comparatively more endomorphic than the higher age group ones (13 to 17 years) with a slight difference in values. This could be because of puberty, as puberty begins in man, their somatotype increases in mesomorphy and ectomorphy but decreases in endomorphy, due to reduction of subcutaneous fat of lower and dorsal regions of the thorax and the upper and lower limbs.

Mesomorphy

Age group wise distribution of mesomorphic component of body physique in Dangi boys is set out in table 1. Mesomorphy, the second component of physique is an indicator of relative musculo-skeletal development per unit of length. A marginal decline in the mean values with age is visible in the boys between 10 to 17 years of age. Mesomorphy is assessed in relation to stature. The younger boys have greater mesomorphic component than the older boys. This however, does not mean that younger ones are more muscular than the older ones, partly because of the fact that mesomorphy is adjusted for height. However, the trend of mesomorphic component among the various age-sets of sample population is to some extent linear and it decreases with age.

Ectomorphy

Table 1 delineates the age group wise distribution of ectomorphic component of body physique in Dangi boys ranging in age from 10 to 17 years. Ectomorphy, the third component is an indicator of relative linearity or thinness of individual physique. In the present study, the average ectomorphy components of the boys were between 4.5 and 5.4. The distribution pattern of mean of Ectomorphic component across the age-sets of sample population shows a steady increase with age. It clearly shows that ectomorphy increases as one progresses from the age 10 years towards 17 years of age.

Table 2: Mean Somatotype categories by age

Age group (years)	N	Mean Somatotype	Mean Somatotype Category
10+	30	2.4-3.4-4.6	Mesomorphic ectomorph
11+	30	3.0-3.8-4.5	Mesomorphic ectomorph
12+	30	2.8-3.7-4.6	Mesomorphic ectomorph
13+	30	2.4-3.1-4.9	Mesomorphic ectomorph
14+	30	2.1-3.0-5.1	Mesomorphic ectomorph
15+	30	2.5-2.8-5.0	Mesomorphic ectomorph
16+	30	2.6-2.4-5.4	Balanced ectomorph
17+	30	2.3-2.1-5.3	Balanced ectomorph

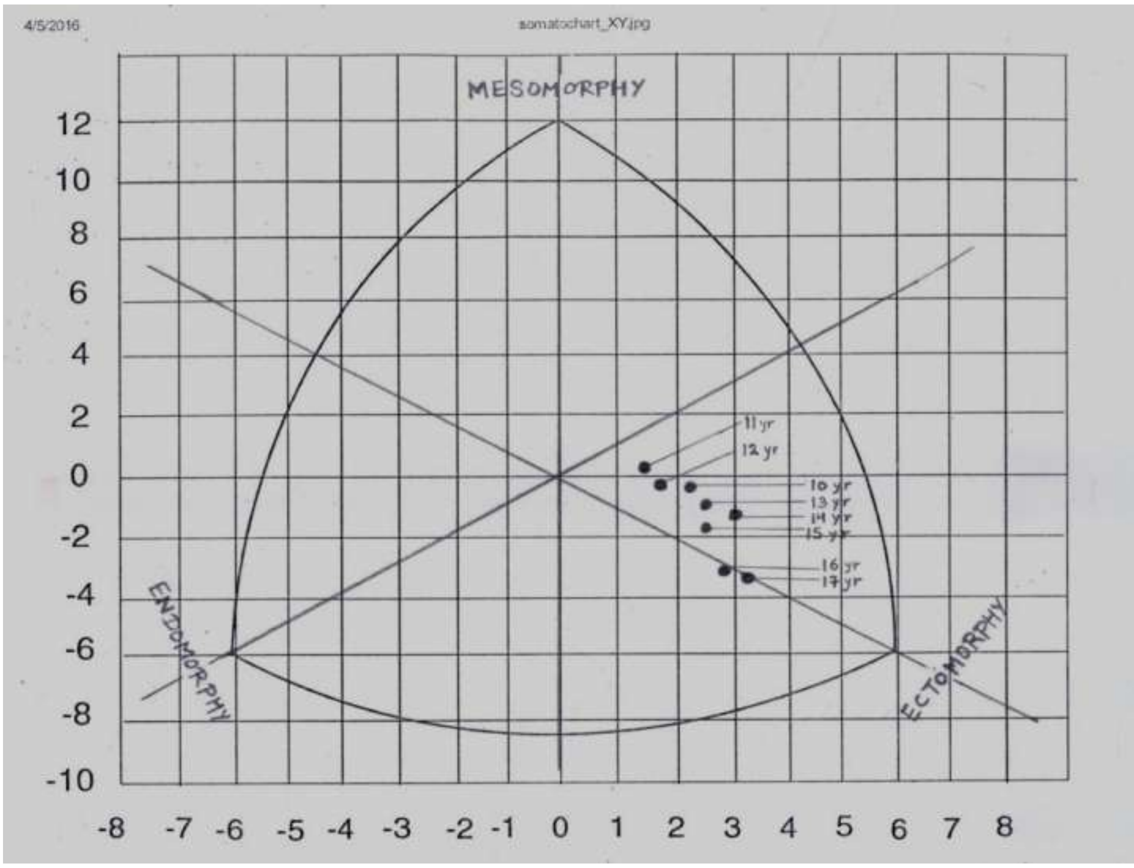

Figure 1: Somatochart showing mean somatotype distribution among Dangi boys of Udaipur (Aged 10-17 years)

Table 2 and figure 1 represents the mean somatotype distribution among the Dangi boys of Udaipur. The somatochart clearly displays the highest percentage of mesomorphic-ectomorph component among the boys of sample population. The representation of age wise distribution of somatotype category through calculated mean somatotype is well marked and predictable from the somatochart. From the somatochart, it can also be observed that age 16 and age 17 years boys fall in category of balanced ectomorph. Thus, it can be said that the Dangi boys in younger age groups belongs to the somatotype category of mesomorphic-ectomorph which later on with progressing age is turning into the balanced ectomorph category.

Somatotype Dispersion Distance (S.D.D)

Among the Dangi boys the somatotype dispersion distance (S.D.D) is found to be highly variable at various age-sets (Table 3). The mean somatotype dispersion distance (S.D.M) is found to be greater at lower age groups and the standard deviations of the somatotype dispersion distance (D.S.D) is found to be highest at the lower age groups of the sample population. From the result, significant variation can be noticed all through the ages, for the mean somatotype dispersion.

Table 3: Descriptive Statistics: Mean somatotype dispersion distance and Standard deviation of Somatotype dispersion distance among Dangi boys at various age-sets

Age group (years)	N	S.D.M	D.S.D
10+	30	4.12	3.86
11+	30	5.67	3.92
12+	30	5.14	3.23
13+	30	4.35	2.79
14+	30	3.10	3.08
15+	30	5.14	3.04
16+	30	4.03	2.03
17+	30	3.85	2.66

The age-wise distribution of mean of S.D.D (that is S.D.M) is showing its least value at the age of 14 years which means that in the sample population children in age group 14 are less dispersed and on the other hand highest at the age 11 years which means that children in that age group are more dispersed. Standard deviations of the somatotype dispersion distance (D.S.D) reveal the pattern within the range of 2.03 to 3.92. Dispersion is found to be higher among lower age groups as compared to higher age groups.

The mean value of S.D.D is highest at the age of 11 years and in other age groups is more or less same. The deviation of S.D.D value is smallest at the age 16 years. This implies that dispersion seen in somatotype distance with least value suggests the maximum inter-individual variation with respect to body physique.

Association with BMI

In children, BMI is calculated as in adults, but BMI values are compared against percentiles of the same gender and age to diagnose obesity rather than using fixed thresholds, because healthy weight ranges depend on age and gender. Because BMI changes substantially as children get older, BMI-for-age is the measure used for children ages 2 to 20. Here, the concept of percentiles comes into play in order to trace the pattern through growth charts.

Table 4: Distribution of BMI among Dangi boys aged 10-17 years

Age group (years)	N	Under-weight		Normal		Over-weight	
		N	%	N	%	N	%
10+	30	18	7.50	9	3.75	3	1.25
11+	30	11	4.56	16	6.67	3	1.25
12+	30	14	5.83	15	6.25	1	0.42
13+	30	16	6.67	13	5.41	1	0.42
14+	30	21	8.75	8	3.33	1	0.42
15+	30	18	7.50	12	5.00	Nil	Nil
16+	30	20	8.33	10	4.17	Nil	Nil
17+	30	23	9.59	7	2.91	Nil	Nil
Total	**240**	**141**	**58.75 %**	**90**	**37.50 %**	**9**	**3.75 %**

The tabular and graphical representation of age-wise distribution BMI of Dangi boys is very well marked and predictable (Table 4). The changes occurred across the age groups when one progresses with age is clear. Majority of the population (58.75 %) fall into the underweight category with the highest values at the age of 14 and 17 years. Secondly, 37.5 % of total boys fall under category of normal and with the highest value at age 11 years. Lastly, under overweight category very few boys of lower age groups fall. Here, in this study the lower BMI of most boys indicated the poor health status in respect of caloric intake capacity, although the socioeconomic condition was good, then it can easily be accepted that the social awareness about the food habits and proper lifestyle is required.

Table 5: Correlation between somatotype components and BMI

Age group (years)	N	Endomorphy	Mesomorphy	Ectomorphy
		r	r	r
10+	30	0.880**	0.846**	-0.914**
11+	30	0.871**	0.736**	-0.934**
12+	30	0.897**	0.587**	-0.944**
13+	30	0.765**	0.712**	-0.924**
14+	30	0.446*	0.720**	-0.929**
15+	30	0.782**	0.703**	-0.945**
16+	30	0.667**	0.401*	-0.904**
17+	30	0.533**	0.595**	-0.956**

**.Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5 delineates the correlation of three somatotype components named endomorphy, mesomorphy and ectomorphy with the Body Mass Index (BMI) for the various age-groups of Dangi boys. It was observed that BMI was significantly ($p \leq 0.01$) and positively correlated with endomorphy in each age group. The mesomorphy component of somatotype was also found to have positive significant correlation with BMI ($p \leq 0.01$) in each age group. Whereas, BMI had negative correlation with ectomorphy component in each age group among the sample population.

With endomorphy, the BMI shows a positive correlation at each age group in the sample population which reveals that the association of BMI with somatotype component-endomorphy is significant at 1 percent level and also the changes occurred are in positive direction therefore, we can infer that as one progresses with age this somatotype component would also varies according to various physical and environment conditions. The correlation is found to be lowest at the age 14 years and highest at the age 12 years.

The second component, mesomorphy also shows a positive correlation with BMI at each age group in sample population which reveals that the association of BMI with mesomorphy is significant at 1 percent level and also the changes occurred are in positive direction therefore, we can infer that as one progresses with age mesomorphic component would also varies according to various physical and environment conditions. The correlation is found to be lowest at the age 16 years and highest at the age 10 years.

The third component, ectomorphy is showing a negative correlation with BMI at each age-group among Dangi boys. At 1 percent probability level it reveals the significant negative correlation indicating an inverse relationship with the BMI. With almost every age-group it is showing its strong association but in opposite direction because with age the ectomorphic component greatly varies based on socio-economic, genetical and physiological conditions.

DISCUSSION:

The present study show the following trends in somatotypes among the Dangi boys from childhood through adolescence: (1) younger age group boys (10 to 12 years) are comparatively more endomorphic than the elder age group ones (13 to 17 years) with a slight difference in values; (2) mesomorphic component among the various age-sets of sample population decreases with age; (3) ectomorphy is the dominant component of the body physique at all age-sets and showed maximum changes with the age. The mean somatotype distribution among the Dangi boys of Udaipur clearly displays that the majority of the sample population belong to the somatotype category of mesomorphic-ectomorph in younger age groups (10 to 15 years) which later on with progressing age turn into the balanced ectomorph category during 16 to 17 years, showing a great linearity among the Dangi boys.

Dispersion is found to be higher among lower age groups as compared to higher age groups. The mean value of S.D.D is highest at the age of 11 years and in other age groups is more or less same. The deviation of S.D.D value is smallest at the age 16 years. This implies that dispersion seen in somatotype distance with least value suggests the maximum inter-individual variation with respect to body physique. The trend of higher dispersion of S.D.D at lower age groups is reported in the study on Rajput and Brahmin boys of Himachal Pradesh in age between 10 to 20 years (Ghosh and Malik 2014).

In the BMI distribution of age-specified categories, majority of the boys 58.75 % belonged to the underweight category at various age-groups and then next to it normal category with 37.50 % and lastly very few under the category of overweight with 3.75 %. The association between BMI and three somatotype components found to be that with endomorphy and mesomorphy, BMI shows significant positive correlation ($p \leq 0.01$) while on the other hand; ectomorphy shows the negative correlation with the BMI ($p \leq 0.01$). During adolescence, ectomorphy remains the dominant component and endomorphy decreases with age among the boys of sample population.

In children, there is a general tendency to an increase in endomorphy, a decrease in mesomorphy and an increase in ectomorphy during growth (Stepnicka 1976; Holopainen et al. 1984; Carter and Heath 1990; Hebbelinck et al. 1995). In comparison with other Indian children of the same age like Gaddi Rajputs (Singh and Sidhu 1980), high altitude population of male Bods from Leh, Ladakh and low altitude Bods settled in Kullu Valley (Malik et al. 1986), Dogras of Jammu and Kashmir (Singh and Bhasin 1990), Brahmins of Himachal Pradesh (Singh and Singh 1991), Jats of Delhi (Gakhar and Malik 2002), Rajput and Scheduled caste adolescents from Sirmour district of Himachal Pradesh (Gaur et al. 2008) and Ao Naga boys of Nagaland (Longkumer 2014), the subjects of the present study exhibit similar trends in the body physique with age, that is lower values of endomorphy and mesomorphy and higher values of ectomorphy.

If compared with their similar counterparts like Manus boys of Papua and New Guinea (Heath and Carter, 1971), Basque boys (Rosique et al. 1994), Chinese youth (Ji and Ohsawa 1996), Saskatchewan boys of Canada (Carter et al. 1997) and Yogyakarta children of Indonesia (Rahmawati et al. 2004), the Dangi boys appear more ectomorphic and less endomorphic and mesomorphic. This difference in the body physique could be due to wide range of variation between environments, the lifestyle that is diet, physical activity and different ethnic backgrounds.

CONCLUSION:

On the basis of the analysis it can be concluded that the boys of Dangi community of Udaipur, Rajasthan were predominantly ectomorphic. The tendency towards higher ectomorphic component among the Dangi boys could also be explained that they have experienced caloric inadequacy in their diets, thus, exhibiting greater linearity in their physique. The variations in the physical structures are determined by genetic as well as environmental factors. As the present study is examining body physique among Dangi boys, more research would be helpful along with fitness and physiological variables to compare somatotype, involving both boys and girls among different ethnic groups of Rajasthan.

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