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Pre-adolescence Growth Differentiation among the Ladiya of Madhya Pradesh: AMultivariate Distance Analysis

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ABSTRACT

Background: Multivariate distance analysis of growth is a combined measure of all body measurements put together and examine their changes during the growth period. To understand the combined effect of growth of all body dimensions and to examine their changes during growth period, multivariate analysis on the data is very useful.

Aims and objectives: To perform multivariate distance analysis on the basis of growth differentiation during pre-adolescence period among the Ladiya of Madhya Pradesh, India. To compare the present findings with other similar studies.

Material and Methods: Data consists of a cross-sectional sample of 411 Ladiya children (201 boys and 210 girls) aged 6-12 years from Sagar district, Madhya Pradesh.Children were measured for stature, weight, head length, head breadth, zygomatic breadth, nasal height, nasal breadth, morphological facial height, physiognomic facial height and head circumference. Four formulae viz, mean multivariate distance (MMD), co-efficient of percentgrowth (CPG), co-efficient of standardized growth (CSG) and t-distance (TD) were calculated for multivariate distance analysis.

Results: Pre-adolescent growth spurt occurred between 11-12 years among the Ladiya boys and girls.

Conclusion: Findings of this study do not support the findings from other parts of India. And multivariate distance analysis emerge no definite trend of pre-adolescent growth among the Ladiya.

Genetic as well as environmental factors may be responsible as paraphernalia for pre-adolescence growth differentiation in this population.

Key words: Growth differences. Pre-adolescence. 6-12 years. Composite multivariate distances. Ladiya. Madhya Pradesh.

INTRODUCTION

Human body is characterized with growth differentiation in body characters and also gradients of growth in attaining the maturity of growth characters (Krogman 1972). Growth is reflective of increase in size of the various parts and organs of the body. This increase is limited by pre-established constitution or has dietary factors and influenced by exogenous factors (climate, diet, environment etc.). Study on growth involves body as a whole and also all external dimension. It is usual practice to consider certain composite measurements, like, stature and weight, as a means to study the body as a whole and few others, like, sitting height and certain girths for describing the growth of external dimensions (I.C.M.R. 1972, Kaul and Nyamongo 1990; cf. Reddy and Basha 1997).

Human growth is an active dynamic process which involves incessant change in an organism not yet mature and spends nearly first two decades of their life in growing, development and training their abilities to survive. The progression of growth follows a pattern that is consistent within individual but involves a wide range of differences with regard to age of onset and duration of specific stages as well as in the intensity of these changes. However, basic developmental norms are constant for all children belonging to different ethnic groups (Valadin and Ponter 1977; c.f. Sharma 2004).

Central India has had a strong tradition of growth study among the children. One can find out a good number of such studies here in the recent pasts (Patni et al. 2001; Gautam. 2007; Tiwari et al. 2007; Wankhede et al. 2015; Thakur and Gautam 2017).

Reddy (1980) emphasized:

"It is important to note that the magnitude of growth of a body character is important though it differs with others during the growth period. The combined effect of growth of all body dimensions is important to understand the process of growth further. This can only be studied by subjecting the measuremental values of all body dimensions to multivariate distance analysis."

Multivariate distance analysis of growth is a combined measure of all body measurements put together and examine their changes during the growth period. Integrated measure of all body dimensions put together to see the changes during the growth period has already been examined by Reddy (1980), Reddy and Mukherjee (1981), Mukherjee (1989), Sharma (2004) and others.

Present study is an attempt to understand the growth differentiation of the Ladiya of Madhya Pradesh, India using multivariate distance analysis in its holistic perspective.

MATERIALS AND METHODS

The Ladiya of Pathariya Jat and surrounding villages of Sagar district, Madhya Pradesh were considered. Children (boys and girls) attending educational institution of Pathariya Jat village were selected. Data were collected from the pre-adolescent Ladiya boys and girls aged 6-12 years. Data consists of a cross-sectional sample of 411 Ladiya children (201 boys and 210 girls). Children were measured on the basis of stature, weight, head

length, head breadth, bizygomatic breadth, nasal height, nasal breadth, morphological facial height, physiognomic facial height and head circumference. Every care was taken to record the correct date of birth. Care was also taken to include only apparently physically and mentally normal children. All the measurements were taken following the technique ofWeiner and Lourie (1969).

The Ladiya are landless people with dependence on labour in urban areas. Their men are mainly engaged as daily labourer (30.21%), bidi worker (26.56%) and masonry (25%), whereas most of the women are engaged in bidi making occupation (75.53%). However, a good number of them are also homemakers (Adak and Bharati 2011).

To find out the cumulative growth from 6-12 years in both the genders, the morphometric data were subjected to multivariate distance analysis. Four formulae viz, mean multivariate distance (MMD), co-efficient of percent growth (CPG), co-efficient of standardized growth (CSG) and t-distance (TD) were calculated following Reddy and Mukherjee (1981) and Mukherjee (1989).

$$\text{Mean multivariate distance: (MMD)} = \frac{\frac{\sum m_2 - m_1}{6_1} \times 100}{V}$$

Where m_1 and 6_1 are mean and standard deviation of measurement at the lowest age i.e., 6 years, m_2 is the mean of measurement in the successive age i.e., 7 years, V stands for total number of measurements.

$$\text{Co-efficient of percent growth: (CPG)} = \frac{\frac{\sum m_2 - m_1}{m_1} \times 100}{V}$$

Co-efficient of percent growth is the average of growth percentage per annum of growth characteristics.

$$\text{Co-efficient of standardized growth: (CSG)} = \frac{\frac{\sum m_2 - m_1}{SD_1}}{V}$$

Co-efficient of standardized growth is the average of standardized growth of each character between two consecutive age groups.

$$\text{t-distance: (TD)} = \frac{\sum t}{V}$$

t-distance is the average of univariate distance between successive age groups.

RESULTS

Mean and standard values of ten anthropometric measurements are furnished in Tables 1a and 1b for Ladiya boys and girls respectively. Mean values of different

measurements in all age groups increased with advancement of age with some exceptions. This is true for both the genders. Among the boys more fluctuation is noticed in mean values in head length, nasal height and nasal breadth (Table 1a), while among the girls no such trend is perceptible (Table 1b). Side by side, fluctuation of standard deviation values is noticed in stature and weight for both the genders.

A continuous increase is evident in stature and weight in both the genders of the Ladiya from the age of 6 years onward. Among the boys highest increment is noticed from 10-11 years for head breadth (0.37 cm), 8-9 years for stature (6.36 cm), 9-10 years for weight (3.15 kg) and nasal height (0.33 cm), 10-11 years for bizygomatic breadth (0.26 cm) and headcircumference (0.99 cm) and 11-12 years for head length (0.15 cm), nasal breadth (0.55 cm), morphological facial height (0.39 cm) and physiognomic facial height (0.82 cm) (Table 1a). Side by side, among the girls highest increment is noticed from 6-7 years for physiognomic facial height (0.55 cm),7-8 years for stature (8.27 cm), 9-10 years for nasal height (0.29 cm), 10-11 years for head breadth (0.58 cm), bizygomatic breadth (0.69 cm) and morphological facial height (0.47 cm) and 11-12 years for weight (3.26 kg), head length (0.42 cm), nasal breadth (0.38 cm) and head circumference (0.86 cm) (Table 1b).

The distance and velocity or increment curves of ten measurements are shown in Figures 1 to 20 for better understanding and clarification of various multivariate distance and velocity curves and also to demonstrate the effectiveness of multivariate distant analysis. As these figures are quite self-explanatory these need no further description.

Table 1a: Mean and standard deviation of growth characteristics: Boys (n = 201)

Growth characteristics	AGE IN YEARS						
	6 (n = 29)	7 (n = 30)	8 (n = 29)	9 (n = 26)	10 (n = 26)	11 (n = 29)	12 (n = 32)
Stature (cm)	109.50 (5.69)	113.18 (5.88)	118.00 (4.09)	124.36 (4.94)	129.62 (3.94)	135.38 (4.53)	136.43 (3.71)
Weight (kg)	16.37 (2.09)	16.96 (2.03)	18.48 (2.16)	21.23 (2.00)	24.38 (1.44)	24.37 (3.11)	27.31 (2.37)
Head length (cm)	17.29 (0.48)	17.08 (0.60)	17.03 (0.89)	17.28 (0.78)	17.47 (0.75)	17.36 (0.77)	17.87 (0.54)
Head breadth (cm)	12.92 (0.42)	13.14 (0.54)	13.30 (0.46)	13.18 (0.53)	13.21 (0.40)	13.58 (0.48)	13.94 (0.94)
Bizygomatic breadth (cm)	9.91 (0.62)	10.00 (0.54)	10.10 (0.43)	10.12 (0.75)	9.98 (0.34)	10.24 (0.57)	10.46 (0.57)
Nasal height (cm)	3.63 (0.14)	3.87 (0.29)	3.76 (0.32)	3.78 (0.28)	4.11 (0.35)	4.28 (0.40)	4.27 (0.27)
Nasal breadth (cm)	2.74 (0.18)	2.95 (0.25)	2.84 (0.21)	2.81 (0.28)	2.86 (0.16)	2.94 (0.18)	3.49 (0.17)
Morphological facial height (cm)	9.14 (0.57)	9.31 (0.48)	9.15 (0.55)	9.55 (0.48)	9.95 (0.40)	9.93 (0.30)	10.32 (0.52)
Physiognomic facial height (cm)	14.26 (0.66)	14.92 (0.59)	14.71 (0.74)	14.87 (0.69)	15.17 (0.81)	15.21 (0.53)	16.03 (0.62)
Head Circumference	49.18 (1.36)	49.12 (1.28)	49.23 (1.33)	49.83 (1.73)	50.02 (1.12)	51.01 (1.28)	50.75 (0.72)

(cm)							

Note: Figures in parenthesis indicate standard deviation value

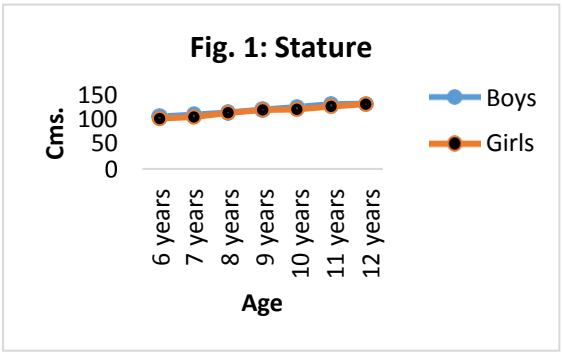
Table1b: Mean and standard deviation of growth characteristics: Girls (n = 210)

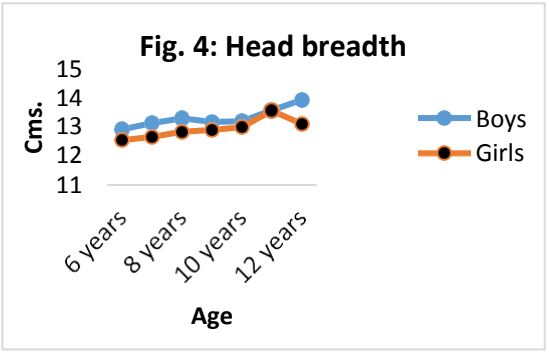
Growth characteristics	AGE IN YEARS						
	6 (n = 29)	7 (n = 30)	8 (n = 29)	9 (n = 26)	10 (n = 26)	11 (n = 29)	12 (n = 32)
Stature (cm)	105.60 (4.70)	108.85 (5.32)	117.12 (3.15)	123.22 (3.33)	125.00 (4.48)	130.56 (5.35)	135.74 (2.71)
Weight (kg)	14.93 (1.48)	15.50 (1.57)	16.86 (1.33)	19.63 (1.73)	21.80 (1.90)	23.10 (2.29)	26.36 (2.65)
Head length (cm)	16.34 (0.53)	16.54 (0.61)	16.64 (0.65)	16.99 (0.68)	17.07 (0.60)	17.17 (0.70)	17.59 (0.60)
Head breadth (cm)	12.55 (0.32)	12.66 (0.28)	12.84 (0.41)	12.91 (0.56)	12.99 (0.48)	13.57 (0.27)	13.12 (0.51)
Bizygomatic breadth (cm)	9.40 (0.26)	9.45 (0.49)	9.71 (0.48)	9.71 (0.43)	9.96 (0.50)	10.65 (0.36)	10.34 (0.42)
Nasal height (cm)	3.63 (0.24)	3.67 (0.32)	3.76 (0.31)	3.97 (0.32)	4.26 (0.34)	4.26 (0.05)	4.37 (0.20)
Nasal breadth (cm)	2.61 (0.22)	2.67 (0.21)	2.69 (0.27)	2.79 (0.19)	2.85 (0.16)	2.97 (0.27)	3.35 (0.23)
Morphological facial height (cm)	8.81 (0.52)	8.93 (0.50)	9.20 (0.50)	9.44 (0.46)	9.69 (0.48)	10.16 (0.35)	10.51 (0.43)
Physiognomic facial height (cm)	13.77 (0.44)	14.32 (0.35)	14.56 (0.49)	14.74 (0.70)	15.01 (0.58)	15.76 (0.61)	15.99 (0.51)
Head circumference (cm)	47.72 (1.47)	48.56 (1.13)	48.60 (1.39)	49.21 (1.49)	49.85 (1.24)	50.43 (2.00)	51.29 (1.51)

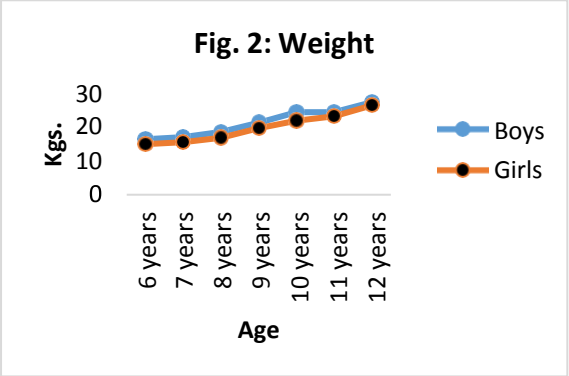
Note: Figures in parenthesis indicate standard deviation value

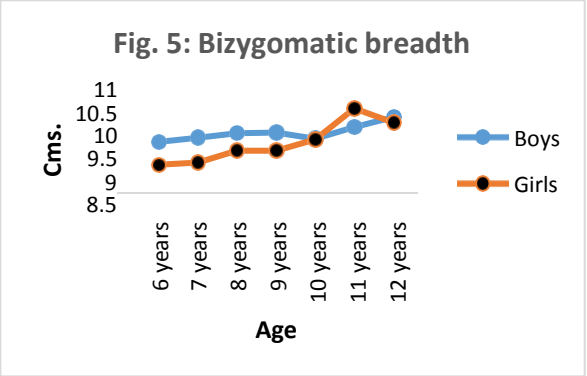
The girls show more value than the boys in terms of total absolute growth between 6 and 12 years in eight characters (stature, weight, head length, bizygomatic breadth, nasal height, morphological facial height, physiognomic facial height and head circumference). While, the boys show more value than their counterpart does in two characters (head breadth and nasal breadth) in this respect (Table 2).

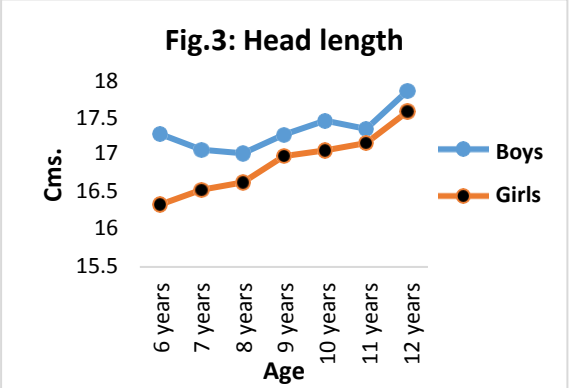
DISTANCE CURVE

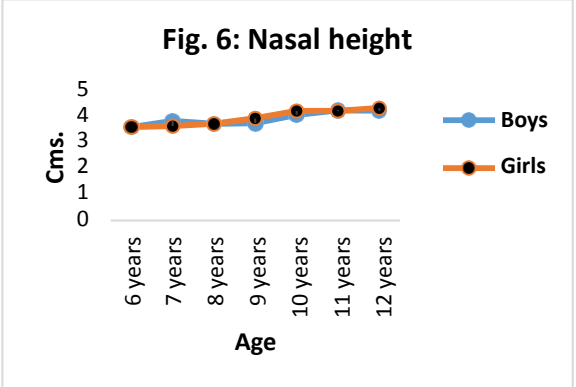












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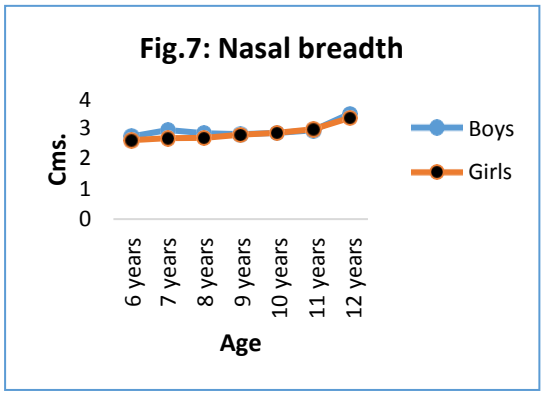
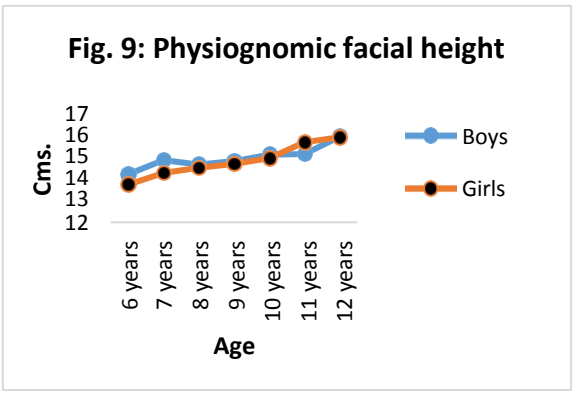
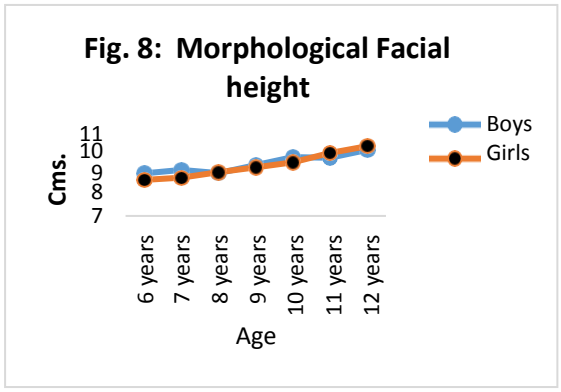
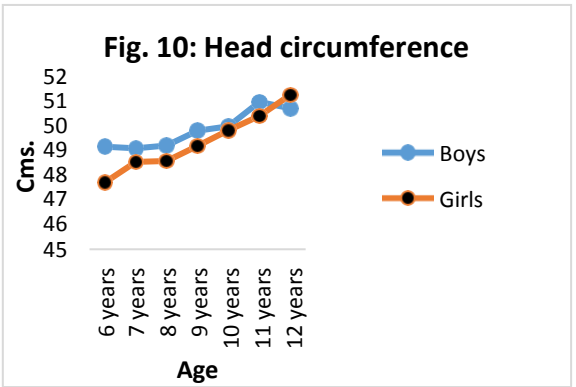
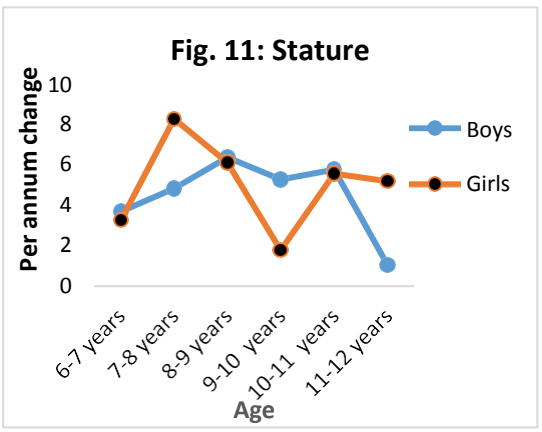


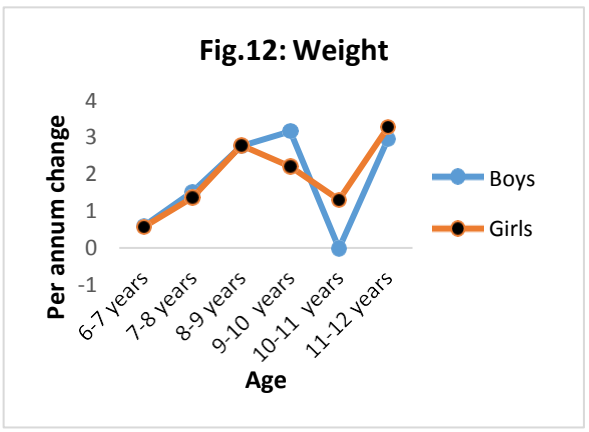


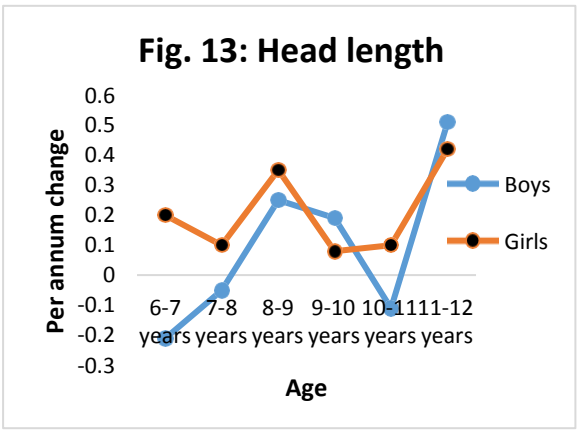


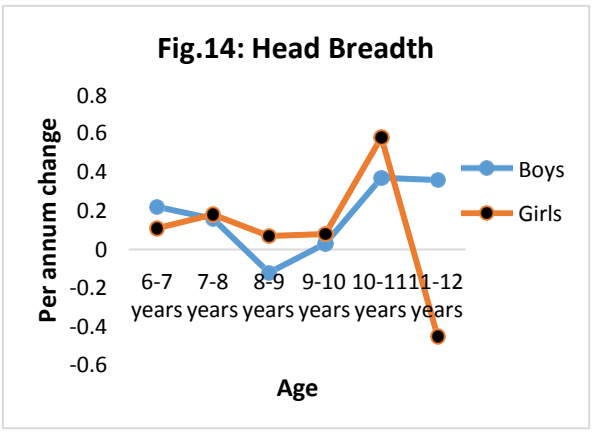


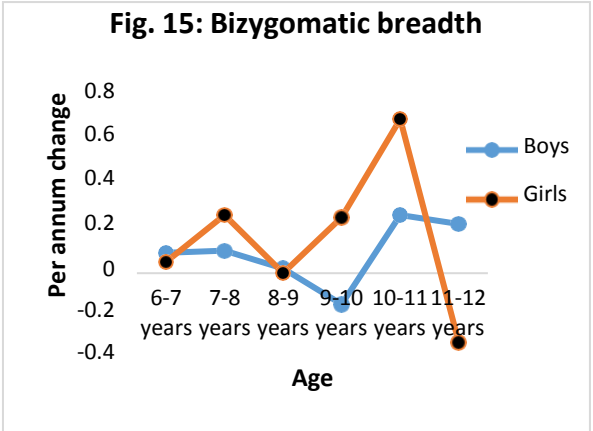
VELOCITY CURVE

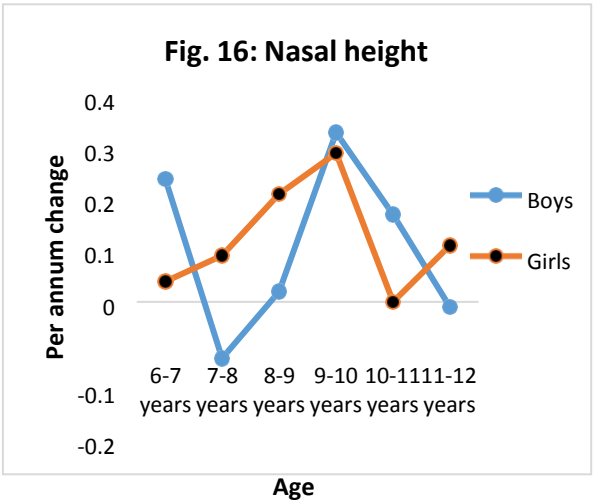




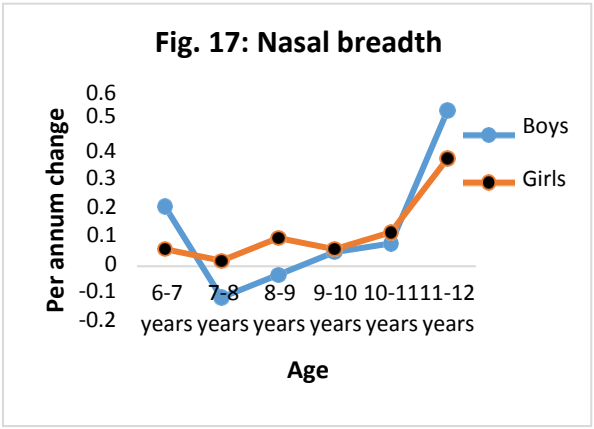


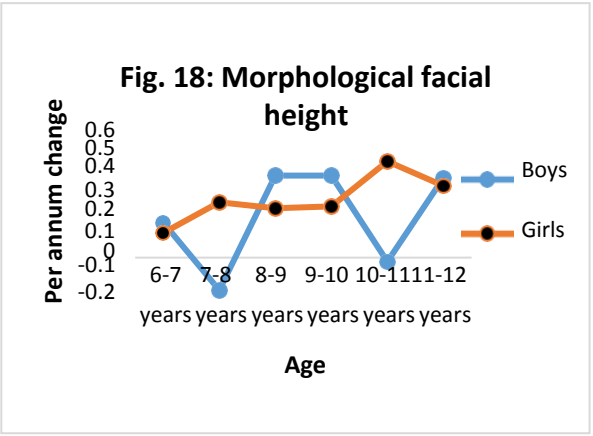


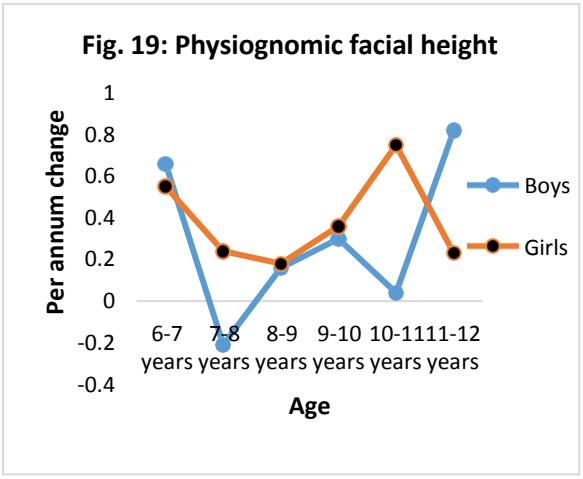




VELOCITY CURVE







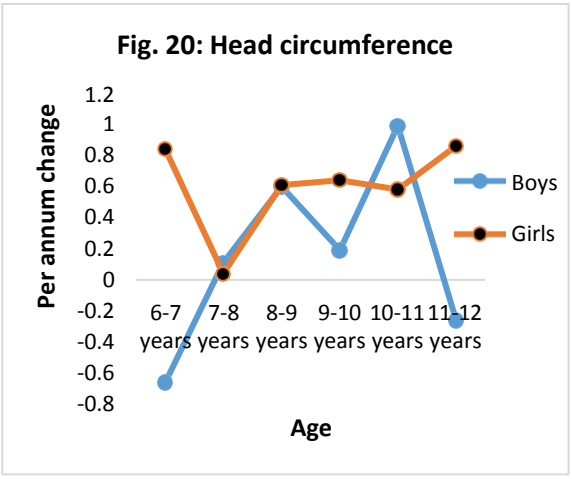


Table 2: Total absolute growth between 6 and 12 years of all characters

Characters	Boys	Girls
Stature (cm)	26.93	30.14
Weight (kg)	10.94	11.43
Head length (cm)	0.58	1.25
Head breadth (cm)	1.02	0.57
Bizygomatic breadth (cm)	0.55	0.94
Nasal height (cm)	0.64	0.74
Nasal breadth (cm)	0.75	0.74

Morphological facial height (cm)	1.18	1.70
Physiognomic facial height (cm)	1.77	2.22
Head circumference (cm)	1.57	3.57

MULTIVARIATE DISTANCE

In this section an attempt has been made to bring out the combined growth pattern of different body dimension (Table 3) by calculating four different formulae i.e. mean multivariate distance (MMD), co-efficient of percent growth (CPG), co-efficient of standardized growth (CSG) and t-distance (T-D).

In respect of general similarities in growth pattern for linear, transverse and girth measurements and during accelerated growth or growth spurt in boys and girls, mean multivariate distance (MMD) (Table 3) values are calculated. Findings of MMD analysis are indicative of the fact that it exhibits a sharp pre- adolescent growth spurt between 11-12 years among the Ladiya boys (9.45) and girls (10.77). MMD curve (Fig.21) appears to be similar with the distance curves obtained from Fig. 1, 2, 3, 7, 8 and 9 among the boys. But in girls, the upper end shows a downward trend in Fig. 4, 5 and10.Velocity curves of multidimensional growth are obtained by plotting the values of CPG (Table 3 and Fig. 22), CSG (Table 3 and Fig. 23) and T-distance (Table 3 and Fig. 24) in each yearly age. The velocity curves obtained by using these formulae depict a similarity with those of velocity curves for different anthropometric measurements (Figs. 11 to 20). Efficacy of multivariate distance analysis shows a sharp pre-adolescent growth spurt among the boys between 8-9, 9-10 and 11-12 years and among the girls between 7-8 and 10-11 years. These show a resemblance with those of velocity curves for weight and different linear and transverse body measurements.

Results of CPG show that pre-adolescent growth spurts occurs between 11-12 years in the boys (4.78) and between 10-11 years in the girls (3.75). In case of CSG pre-adolescent growth spurt occurred between 8-9 years for boys (3.98) and 7-8 years for girls (5.69). Results of T-D showed that pre-adolescent growth spurt occurred between 9-10 years for boys (3.95) and 11-12 years for girls (3.58).

Table 3: Value of indices of various multivariate distance analysis

Multivariate distance	Age (in years)													
	Boys							Girls						
	6	7	8	9	10	11	12	6	7	8	9	10	11	12
Mean multivariate distance (MMD)	0.00	3.95	0.51	3.70	5.37	4.40	9.45	0.00	4.73	5.25	7.32	5.26	7.13	10.77
Co-efficient of percent growth (CPG)		2.90	0.57	2.61	3.60	1.81	4.78		2.00	2.91	3.55	3.14	3.75	3.65
Co-efficient of standardized		0.46	0.02	3.98	3.70	0.17	3.24		3.13	5.69	1.99	3.09	1.51	0.88

growth (CSG)														
t-distance (T-D)		2.15	1.69	1.88	3.95	1.72	3.66		1.86	2.21	2.71	1.98	3.69	3.58

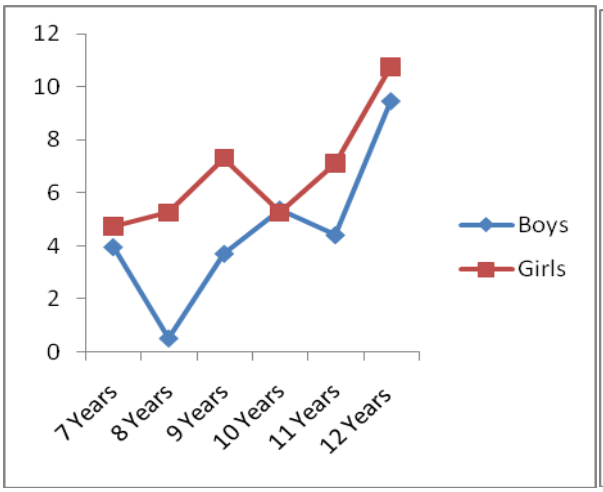


Fig. 21: Mean multivariate distance

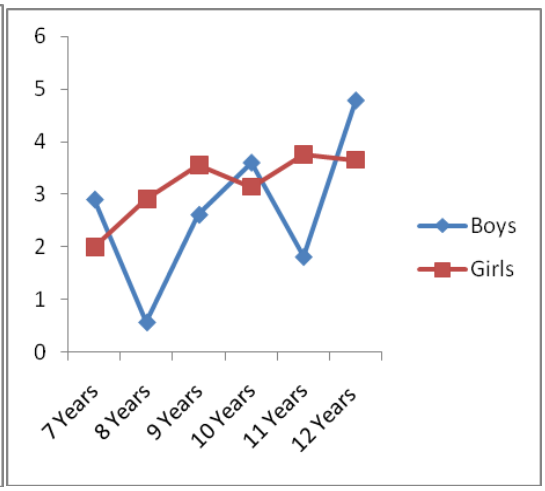


Fig. 22: Co-efficient of percent growth

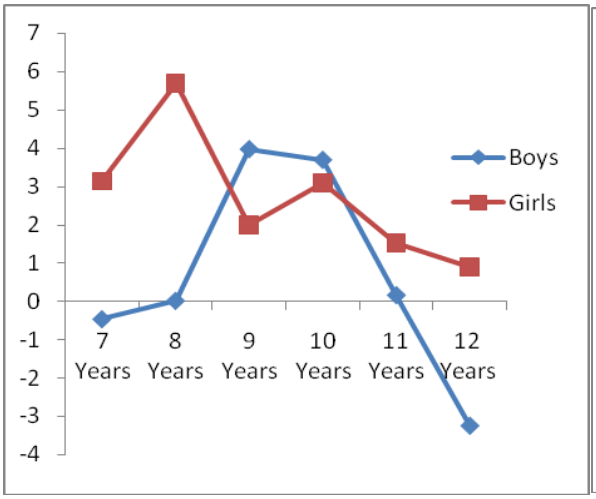


Fig. 23: Co-efficient of standardized growth

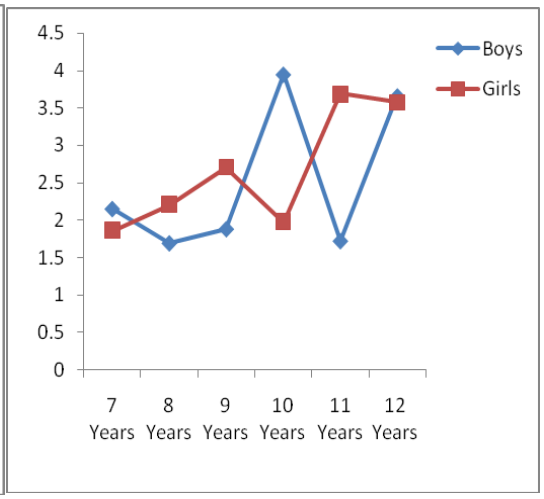


Fig. 24: T distance (T-D)

DISCUSSION AND CONCLUSION

The composite multivariate distances based on different formula display the pattern of total growth of the individuals instead of those for individual characters. The multivariate distance analysis in anthropological studies are mainly utilized to predict the similarities and differences between the populations studied for a set of genetic and morphological characters to get some idea about the nature of the forces which have prevailed upon in the evolutionary history of the population (Sharma, 2004).

Growth studies in Central India are mainly on the individual or collective efforts of the anthropologists. These studies are either in the form of dissertation/doctoral reports or as research articles. Though much work have been done on growth in this region amongdifferent populations, multivariate distance analysis on pre-adolescent Ladiya boys and girls has not been done to the best of authors knowledge.

Findings of MMD analysis show that it exhibits a sharp pre-adolescent growth spurt between 11-12 years among the Ladiya boys (9.45) and girls (10.77). The velocity curves obtained by using these formulae show a similarity with those of velocity curves for different anthropometric measurements (Figs. 11 to 20). Multivariate distance analysis shows a sharp pre-adolescent growth spurt among the boys between 8-9, 9-10 and 11-12 years and among the girls between 7-8 and 10-11 years.

Sharma (2004) noticed a sharp pre-adolescent growth spurt among the Yadav girls of Eastern Uttar Pradesh between 9-10 years, whereas among the Yadav boys a different trend is perceptible. Analysis of Baruah et al. (2015) reveals a sharp pre-adolescent growth spurt between 4-5 years as well as between 7-8 years among the Garo boys and girls of Assam respectively. The same study reveals a sharp pre-adolescent growth spurt among the Rabha boys and girls of Assam between 4-5 years.

Side by side, Mishra et al (2019) found a sharp pre-adolescent growth spurt among the Maria boys and girls of Chchattisgarh between 11-12 years and 8-9 years respectively. Therefore, findings of this study do not support the findings from other parts of India. And multivariate distance analysis emerge no definite trend of pre-adolescent growth among the Ladiya. In fine, it can be said that genetic as wellas environmental factors may be responsible as paraphernalia for such discrepancy.

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