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Growth Differentiation and Gradients During Adolescence Among Bhil Boys of Rajasthan

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ABSTRACT Various body dimensions would reach their adult size at specific times during the growth period. On subjecting the growth data of several body dimensions to the percentage of growth attained during adolescence, it has been observed that differentiation of growth can be deciphered and growth gradients can be surmised. 23 body dimensions are taken up for the study among Bhil boys of Rajasthan from 11+ years to 19+ years to understand the growth differentiation and gradients. The present series of cross-sectional growth data from Bhil boys of Rajasthan seem to be possible to differentiate and group growth characters and establish such growth gradients, as cephalo-facial, linear, transverse and girth measurements respectively.

INTRODUCTION

There is a definite pattern of growth of all growth characteristics in the human body and reach to maturity at definite timing (Krogman, 1972; Tanner, 1978). These patterns of growth of all growth characteristics can be grouped and presented graphically. Further, growth differentiation of growth characteristics or body dimensions is also noticed (Krogman, 1972). Accordingly, various systems or organs or body dimensions grow and reach to maturity or adult size at different times in different areas of the body. Studies on growth in Indian context are many but all aiming to present trends of growth in specific populations (Sharma, 1970; Singh Raghbir, 1970; I. C. M. R., 1972; Malik and Singh, 1978). However, very few studies have covered the theoretical aspects of growth processes (Reddy, 1989). The credit goes to Scammon (1927) (cf. Krogman, 1972 and Tanner, 1978) to conceive the idea of grouping growth characteristics to reduce the growth curves of human body to four basic curves. These curves are based on the principle that at age 20 years all dimensions of the body are adult in size and have one hundred per cent of their value, starting at birth with zero per cent. This has helped Scammon to propose four systematic basic curves of man, namely, neural, general, lymphoid and genital. Thus, the theoretical aspects of growth is important to understand the mechanism of multifaceted phenomena of growth. The present paper is in the same direction aiming to decipher the differentiation and gradients of growth characteristics during adolescence among Bhil boys of Rajasthan.

MATERIALS AND METHODS

Bhils, the largest tribe of India form the subjects of the study and samples have been drawn from Udaipur district of Rajasthan where subjects of the study face the best environmental condition. They are chosen to study their present growth trends and to compare with other specific populations of India and also to construct reference standards for the population. The trends of growth during adolescence of these Bhil boys have been discussed elsewhere (Reddy, 1989). Here the theoretical aspects of growth, namely, differentiation and gradients, are presented to have more insight in understanding the process of the growth. The following measurements (growth characters) are taken on each boy and all the measurements and definitions of landmarks are taken after Singh and Bhasin (1989) and Weiner and Lourie (1969).

1. Composite measurements
    1. Weight
    2. Stature
2. Vertical or linear measurements
    1. Sitting height vertex
    2. Trunk height
    3. Head and neck height
    4. Upper extremity length
    5. Lower extremity length
3. Transverse measurements
    1. Biacromial breadth
    2. Bi-illiocristal breadth
    3. Bitrochanteric breadth

4. Chest breadth
5. Chest depth

4. Girth measurements
1. Upper arm
2. Calf
3. Chest
4. Head

5. Head and face measurements
1.Head length
2. Head breadth
3. Minimum frontal breadth
4. Bizygomatic breadth
5. Bigonial breadth
6. Morphological facial height
7. Morphological upper facial height

To cover the period of adolescence, age groups from 11 + to 19+ years have been considered with equal sample distribution of 100 subjects in each age group cross-sectionally. Only normal children who are environmentally better off are included in the study by using purposive sampling. The exact dates of birth of subjects have been given due attention to arrive at positive correct age. The methodology used for the purpose of growth differentiation and gradients is that of Scammon (1927) (cf. Tanner, 1962 and 1978; Krogman, 1972) based on the principle that at age 19+ years all body dimensions reached to their adult size and thus have one hundred per cent of growth.

RESULTS AND DISCUSSION

Differential Growth: A graphical comparison of the different rates of growth of different body dimensions through the age-range11+ to 19+ years brings out the uniformity and diversity of growth patterns in different systems of organs and tissues (Fig. 1). In this diagram, the per cent growth of each dimension in different age-groups from the mean measurements attained at 11+ years are plotted (Table 1, 2). Each vertical line joins the points indicating per cent growth of different characters attained in a particular ages, namely,12+, 13+, 14+ and so on.

The measurements are arranged from above downwards in decreasing order of their per cent growth at 19+ age group. Thus, the maximal amount of growth is obviously attained by weight (102 %), the disproportionately high values of which are not represented in this diagram. The growth of breadth and circumferences follow next in order. The growth of limb lengths, trunk length and height vertex occupy the

Table 1: Means of growth characteristics in each year of age

Growth characters	*Age in years*								
	11+	*12+*	*13+*	*14+*	*15+*	*16+*	*17+*	*18+*	*19+*
Weight	24.35	25.45	27.83	32.16	38.97	41.82	44.77	46.84	49.23
Chest breadth	18.90	19.46	20.61	21.43	23.10	2..75	24.46	24.74	25.77
Bitrochanteric breadth	21.38	22.07	23.14	24.70	26.90	27.46	28.02	28.36	28.98
Upper arm girth	16.99	17.11	17.53	18.63	20.17	21.02	21.70	22.02	22.72
Biilliocristal breadth	19.74	20.36	21.41	22.84	24.25	24.89	25.44	25.73	26.16
Chest depth	13.92	14.35	14.74	15.53	16.71	17.13	17.60	17.82	18.35
Biacromial breadth	27.82	28.38	29.44	30.95	33.14	33.55	34.79	35.31	36.33
Calf girth	23.71	23.93	24.68	25.97	27.98	28.65	29.49	29.93	30.94
Chest circumference	61.14	62.49	64.55	67.76	72.84	74.83	76.66	77.81	79.69
Lower extremity length	63.05	64.85	68.76	71.33	75.69	78.50	79.87	80.02	80.11
Trunk height	43.49	44.08	44.80	47.41	51.47	53.02	54.49	54.56	54.59
Height vertex	131.33	134.77	139.84	146.74	155.20	159.52	162.85	163.53	163.97
Upper extremity length	61.35	62.68	65.20	68.62	72.10	74.24	75.79	75.84	76.14
Sitting height vertex	68.28	69.94	71.80	75.41	79.51	81.63	82.98	83.51	83.87
Head and neck height	24.67	25.35	25.77	26.49	27.67	28.47	28.82	29.17	29.64
Bigonial breadth	9.01	9.17	9.23	9.38	9.58	9.73	9.89	10.11	10.23
Total facial height	9.89	10.03	10.05	10.17	10.54	10.67	10.85	10.90	10.96
Bizygomatic breadth	11.89	12.09	12.13	12.37	12.63	12.78	12.95	12.99	13.10
Upper facial height	6.22	6.39	6.39	6.40	6.54	6.69	6.76	6.82	6.85
Head length	16.86	16.95	17.08	17.19	17.40	17.44	17.46	17.65	17.88
Head breadth	13.06	13.18	13.27	13.34	13.42	13.49	13.58	13.69	13.80
Head circumference	50.41	50.59	50.76	51.32	52.01	52.44	52.68	53.00	53.16
Minimum frontal breadth	9.91	9.98	10.01	10.08	10.25	10.33	10.35	10.43	10.44

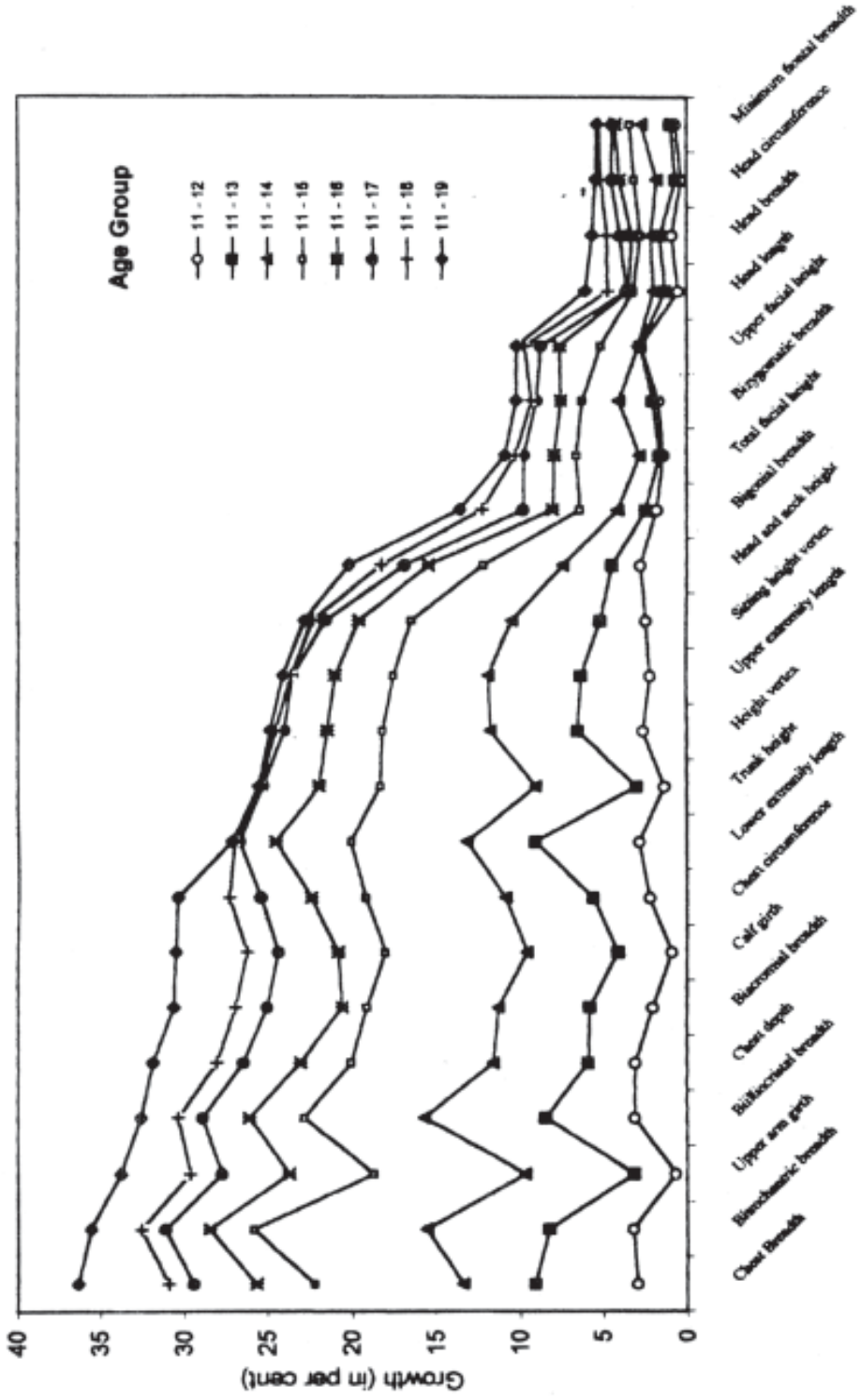

Fig. 1. Percentage growth profiles of various body dimensions

Table 2: Values of per cent growth of each growth character in different age groups from the mean characteristics attained at 11+ years

Growth characters	*Age groups*							
	11-12	*11-13*	*11-14*	*11-15*	*11-16*	*11-17*	*11-18*	*11-19*
Weight	4.52	14.29	32.07	60.04	71.75	83.86	92.36	102.18
Chest breadth	2.96	9.05	13.39	22.22	25.66	29.42	30.90	36.35
Bitrochanteric breadth	3.23	8.23	15.53	25.82	28.44	31.06	32.51	35.55
Upper arm girth	0.71	3.18	9.65	18.72	23.72	27.72	29.61	33.73
Biilliocristal breadth	3.14	8.46	15.70	22.85	26.09	28.88	30.34	32.52
Chest depth	3.09	5.89	11.57	20.04	23.06	26.44	28.02	31.82
Biacromial breadth	2.05	5.82	11.25	19.12	20.60	25.05	26.92	30.59
Calf girth	0.93	4.09	9.53	18.01	20.84	24.38	26.23	30.49
Chest circumference	2.21	5.58	10.83	19.14	22.39	25.38	27.27	30.34
Lower extremity length	2.85	9.06	13.13	20.05	24.50	26.65	26.92	27.06
Trunk height	1.36	3.01	9.01	18.35	21.91	25.29	25.45	25.52
Height vertex	2.62	6.48	11.73	18.18	21.47	24.00	24.52	24.85
Upper extremity length	2.17	6.28	11.85	17.52	21.01	23.54	23.62	24.11
Sitting height vertex	2.43	5.16	10.44	16.45	19.55	21.53	22.31	22.83
Head and neck height	2.76	4.46	7.38	12.16	15.40	16.82	18.24	20.15
Bigonial breadth	1.78	2.44	4.11	6.33	7.99	9.77	12.21	13.54
Total facial height	1.42	1.62	2.83	6.57	7.89	9.71	10.21	10.82
Bizygomatic breadth	1.68	2.02	4.04	6.22	7.49	8.92	9.25	10.18
Upper facial height	2.73	2.73	2.89	5.14	7.56	8.68	9.65	10.13
Head length	0.53	1.30	1.96	3.20	3.44	3.56	4.69	6.05
Head breadth	0.92	1.61	2.14	2.76	3.29	3.98	4.75	5.67
Head circumference	0.36	0.71	1.81	3.17	4.03	4.50	5.14	5.46
Minimum frontal breadth	0.71	1.01	2.72	3.43	4.24	4.44	5.25	5.35

intermediate position, and growth attained by head and face measurements appear to be the least of all.

However, the differential pattern of growth varies in different age-groups. For example, there is a much greater amount of growth in hip breadth, chest breadth and lower extremity length in the initial period of adolescence up to around 14 + years. The amount of growth of some measurements on face and head and neck height are also comparable to these bodily dimensions in the initial years of adolescence.

It is brought out by arranging the traits in the rank order of their amount of growth in each age, that (1) Weight displays maximum percentage of growth throughout the age range 11+ to 19+ years. (2) The lower extremity length shows maximum growth only in the initial years of adolescence. (3) The girth measurements display small percentage of growth in the initial years but attain a much higher rank in growth rate among the traits towards the late adolescence. (4) The linear measurements such as lower extremity length, trunk height, height vertex, upper extremity length and sitting height gain the least percentage growth after 17+years. (5) The bigonial breadth shows the maximum percentage of growth among all head and facial measurements. (6) A striking feature of this graph is the emergence of three broad groups of traits which show similar traits of growth. Volume and breadth measurements attained higher per cent growth followed by vertical and head measurements.

Gradients of Growth: The maturity of gradients of different measurements are brought out by plotting the percentage of adult value considering 19 + years as the maximum age and 11+ years as the initial age (Fig.2 and Table 3).

The data suggests that cephalo-caudal gradient of growth during adolescence in Bhil boys. In all ages of adolescence the head is nearer the adult size than other body dimensions and is followed by the facial measurements, vertical or linear measurements, transverse measurements of girths and breadths and body weight in order. When the average grades of the four aspects of the sexual maturation, studied in each year are expressed as percentages of the maximal grade attained in the 19+ year, it becomes apparent that reproductive development in males is behind the

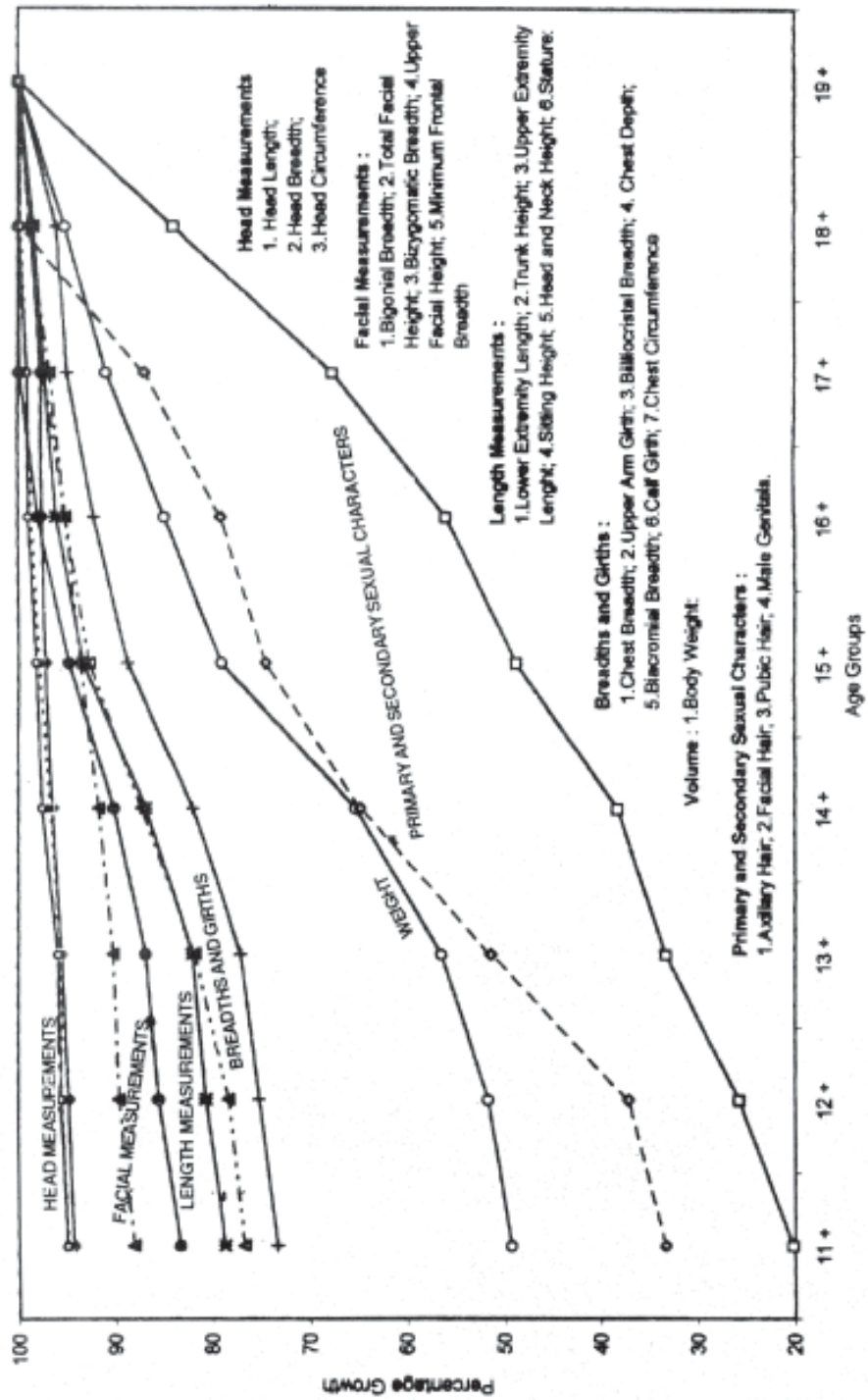

Fig. 2. Curve of growth and development of different systems of the body expressed as per cent of total attainment of growth at 19+ years in each year of age

Table 3: Values of percentage of adult value attained by each growth character including primary and secondary sexual characters in each year of age

Growth characteristics	*Age groups*								
	11+	*12+*	*13+*	*14+*	*15+*	*16+*	*17+*	*18+*	*19+*
Height Vertex	80.09	82.19	85.25	89.49	94.65	97.29	99.32	99.73	100.00
Sitting height vertex	81.41	83.39	85.61	89.91	94.80	97.33	98.94	99.57	100.00
Trunk height	79.67	80.75	82.07	86.85	94.28	97.12	99.82	99.95	100.00
Upper extremity length	80.58	82.32	85.63	90.12	94.69	97.50	99.54	99.61	100.00
Lower extremity length	78.70	81.95	85.83	89.04	94.48	97.99	99.70	99.89	100.00
Head and neck height	83.23	85.53	86.94	89.37	93.35	96.05	97.23	98.41	100.00
Weight	49.30	51.70	56.53	65.33	79.16	84.95	90.94	95.15	100.00
Biacromial breadth	76.58	78.12	81.03	85.19	91.22	92.35	95.76	97.19	100.00
Biiliocristal breadth	75.46	77.83	81.84	87.31	92.70	95.15	97.25	98.36	100.00
Bitrochanteric breadth	73.78	76.16	79.85	85.23	92.82	94.76	96.69	97.86	100.00
Chest breadth	73.34	75.51	79.98	83.16	89.64	92.16	94.92	96.00	100.00
Chest depth	75.86	78.20	80.33	84.63	91.06	93.35	95.91	97.11	100.00
Chest circumference	76.71	78.42	81.00	85.03	91.40	93.90	96.20	97.64	100.00
Upper arm girth	74.78	75.31	77.16	82.00	88.78	92.52	95.51	96.92	100.00
Calf girth	76.63	77.34	79.77	83.94	90.43	92.60	95.31	96.74	100.00
Head length	94.30	94.80	95.53	96.14	97.32	97.54	97.65	98.71	100.00
Head breadth	94.64	95.51	96.16	96.67	97.25	97.75	98.41	99.20	100.00
Head circumference	94.83	95.17	95.49	96.54	97.84	98.65	99.10	99.70	100.00
Minimum frontal breadth	94.92	95.59	95.88	97.51	98.18	98.95	99.04	99.90	100.00
Bizygomatic breadth	90.76	92.26	92.60	94.43	96.41	97.56	98.85	99.16	100.00
Bigonial breadth	88.07	89.64	90.22	91.68	93.65	95.11	96.68	98.83	100.00
Total facial height	90.24	91.51	91.70	92.79	96.17	97.35	99.00	99.45	100.00
Upper facial height	90.80	93.28	93.28	93.43	95.47	97.66	98.69	99.56	100.00
Male genitals	22.40	37.20	51.40	64.80	74.60	79.20	87.00	99.80	100.00
Pubic hair	20.20	25.80	34.00	49.20	64.00	70.40	80.20	91.40	100.00
Facial hair	33.33	33.33	35.00	43.67	61.67	65.00	71.00	95.33	100.00
Axillary hair	33.33	33.33	33.33	38.33	48.70	56.00	67.70	84.00	100.00

growth and development of different other body dimensions. This agrees with the Scammon's earlier suggestion.

Furthermore, the data also suggest that within each of the aforesaid six groups of characters, there are also maturity gradients of growth in timing. For example, within head and face measurements, the most advanced growth is observed for morphological facial height. There may also be an antero-posterior gradient in the head. The growth of lower parts of the face, such as, bigonial breadth lags behind that of the bizygomatic breadth. Within the linear-measurements, again, there may be an apparent trend of cephalo-caudal gradient. The head and neck height and sitting height show relatively advanced maturity levels in each age than the measurements of lower extremity length, which have relatively delayed maturity. The development of genitalia representing the primary sexual character is also in advance compared to the secondary sexual characters and growth of pubic hair is more advanced than facial and axiliary hair except in the initial years of adolescence.

CONCLUSION

The foregoing discussion of differential growth curves and percentage of growth and maturity gradient of each character from 11+ to 19+ years, thus, permits a general differentiation and gradients are : 1. Transverse growth of volume and breadth, 2. Growth of linear or vertical measurements, 3. Cephalo-facial measurements (head and face may represent two sub- groups) and 4. Pubertal development (primary and secondary sexual characters may form sub-groups). These results are in agreement with others (Burt and Banks, 1947; Tanner, 1977).

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