J. Hum. Ecol., 8(6) : 455-461 (1997)
DOI: 10.31901/24566608.1997/08.06.08

Size and Shape Changes During Adolescence Among Bhil Boys of Rajasthan

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KEY WORDS Adolescence. Size. Shape. Factor.

ABSTRACT Size and shape are important factors in the study of human growth. Growth differentiation and gradients enable the body dimensions to arrive at the final size and shape. These size and shape changes are accounted for with the help of 23 body dimensions and 15 indices among 900 Bhil boys of Rajasthan spread over nine age-groups, the initial being 11+ years and the adult being 19+ years. The results of the study indicate that relative changes in growth of various body measurements reveal greater changes occurring in volume (weight) first, followed by breadths, girths and linear dimensions. The head and facial measurements register the least changes.

INTRODUCTION

Growth study has an important place in the study of individual differences in size and shape. Many of these arise through differential rates of growth of particular parts of the body relative to others (Tanner, 1977). There exists definite growth differentiation and relationship between different parts of the body during the growth period. An overall growth formula for the post-natal growth differentiation of the human body is 2-3-4-5, *i.e.*, head and neck dimensions increase by two times, trunk by three times, arms by four times and legs by five times. Growth differentiation is, therefore, part of total size, shape and proportion of total growth of various growth characteristics (Krogman, 1972). Thompson (1917) has first studied shape changes through 'transformation' grids. This has led to the application of a laborious photographic method of studying shapes (Tanner, 1953). Huxley (1932) has defined shape in terms of relationship between a pair of measurements of body segments, thus generating the idea of bivariate allometry. Anthony Harris (1978) is of the view that the differential growth in growth characters is also reflected in shape changes. Further, these shape changes can also be better understood through percentage changes occurring in every body dimension before arriving at the final shape. He has shown a way to calculate size and shape factors, which are much useful in the study of size and shape changes. However, the difficulty lies in measuring change in shape. Many questions on differential growth remain open because we still have insufficient data to answer them (Tanner, 1972, Anthony Harris, 1978). Change in the ratios of two absolute measurements suggests shape changes, but finding the factors affecting shape; not definitely found yet, may solve many problems of measuring change. Studies concerning body size and shape, particularly from India, are rather scarce (Sharma, 1970; Nath, 1975; Reddy, 1980, 1989). It is therefore considered useful to observe the shape changes through various body indices by means of the proportion (shape) factor. The present paper is in this direction, focusing on the changes in the body proportions resulting from differential growth of different body dimensions through size and shape factors during adolescence among Bhil boys of Rajasthan.

MATERIALS AND METHODS

The materials for the present study are Bhils, the largest tribal group in India, and the samples are drawn from the Udaipur district of Rajasthan who are environmentally better-off than others. Nine hundred boys spread over 9 yearly age-groups, *i.e.*, 100 boys in each age group, from 11+ years to 19+ years are considered. Thus, the data are drawn cross-sectionally by using purposive sampling. Twenty three mea-

surements are considered for relative changes in size and 15 indices are considered for highlighting relative changes in shape. Data on growth of different body characteristics have been presented and discussed elsewhere (Reddy, 1989). All body measurements have been taken from each subject by using standard techniques (Singh and Bhasin, 1989; Weiner and Lourie, 1969). Suitable statistical methods are employed to describe percentage change in growth characters and to identify size and shape factors.

The following formulae are used to calculate percentage change in a growth character and to identify a size factor, following Anthony Harris (1978). Similarly, for calculating percentage change and shape factor a new approach is attempted as described hereunder for the first time.

I. Size :

$$\text{i. Percentage change} = \frac{\text{Measurement value at 19+ years} - \text{Value of the measurement at 11+ years}}{\text{Value at 11+ years}} \times 100$$

$$\text{ii. Growth (size) factor} = \frac{\text{Percentage change}}{\text{Percentage change in Height}}$$

II. Shape:

$$\text{i. Percentage change} = \frac{\text{Mean Index value at 19+ years} - \text{Mean value at 11+ years}}{\text{Mean Index value at 11+ years}} \times 100$$

$$\text{ii. Proportion (shape) factor} = \frac{\text{Percentage change in proportion growth}}{\text{Percentage change in Height--Weight Index (Rohrer's)}}$$

RESULTS AND DISCUSSION

The results of size and shape changes due to proportional growth between various body dimensions are presented in table 1 and 2 and figures 1 and 2. The relative changes in growth of adolescent Bhil boys for various measurements are shown in table 1 and figure 1. Considering size factor as proportion between percentage change of a character and percentage change in height, table 1 and figure 2 show that as many as eleven body characters have outstripped height change by a factor of 4.13 to 1.03 in order of their growth factor, respectively. These growth characters are, volume (body weight) and most of the breadth and girth measurements followed by few linear measurements such as lower extremity length and trunk height. Few linear measurements, Upper extremity length, Sitting height vertex and head and neck height have shown a growth factor of less than one. All the head and facial measurements have established the least percentage of size change and a size factor of 0.54 to 0.21. This indicates growth gradients in body characters as well differential growth (size) factor. These results are well corroborated with the direct analyses of percentage change in growth

Table 1: Relative changes in growth (size) of adolescent Bhil boys for various measurements

Measurements	*Before adolescence (11 + years)*	*After adolescence (19 + years)*	*Percentage change*	*Growth (size) factor*
Weight	24.31	49.23	102.51	4.13
Chest breadth (cms)	18.90	25.77	36.35	1.46
Bitrochanteric breadth	21.38	28.98	35.55	1.36
Upper arm girth	16.99	22.72	33.73	1.36
Biiliocristal breadth	19.74	26.16	32.52	1.31
Chest depth	13.92	18.35	31.82	1.28
Biacromial breadth	27.82	36.33	30.59	1.23
Calf girth	23.71	30.94	30.49	1.23
Chest circumference	61.14	79.69	30.34	1.22
Lower extremity length	63.05	80.11	27.06	1.09
Trunk height	43.49	54.59	25.52	1.03
Stature	131.33	163.97	24.85	1.00
Upper extremity length	61.35	76.14	24.11	0.97
Sitting height vertex	68.28	83.87	22.83	0.92
Head and neck height	24.67	29.64	20.15	0.81
Bigonial breadth	9.01	10.23	13.54	0.54
Total facial height	9.89	10.96	10.82	0.42
Bizygomatic breadth	11.89	13.10	10.18	0.41
Upper facial height	6.22	6.85	10.13	0.41
Head length	13.06	13.80	5.67	0.23
Head circumference	50.41	53.16	5.46	0.22
Minimum frontal breadth	9.91	10.44	5.35	0.21

Table 2: Relative changes in proportion growth (shape) of adolescent Bhil boys for various body indices

Indices	*Index value at 11+years*	*Index value at 19+years*	*Percentage change*	*Proportion (shape) factor*
I. Linear vs Volume :				
1. Rohrer's Index (RI)	1.07	1.12	4.67	1.00
II. Linear vs Linear :				
1. Sitting Height Stature Index (SHSI)	52.03	51.18	-1.63	-0.35
2. Trunk Height Stature Index (THSI)	33.11	33.29	0.54	0.12
3. Lower Extremity Stature Index (LESI)	48.01	48.86	1.77	0.38
4. Upper Extremity Stature Index (UESI)	46.71	46.40	-0.66	-0.14
III. Linear vs Transverse :				
1. Biiliocristal Breadth Stature Index (BiBSI)	15.03	15.96	6.19	1.33
2. Bitrochanteric Breadth Stature Index (BtBSI)	16.21	17.68	9.07	1.94
3. Biacromial Breadth Stature Index (BaBSI)	21.18	22.16	4.63	0.99
IV. Linear vs Girths :				
1. Head Circumference Stature Index (HCSI)	38.39	32.36	-15.71	-3.36
2. Chest Circumference Stature Index (CCSI)	46.57	48.63	4.42	0.95
3. Upper Arm Girth Stature Index (UAGSI)	12.94	13.86	7.11	1.52
4. Chest Girth Stature Index (CGSI)	18.06	18.87	4.49	0.96
V Girths vs Girths :				
1. Calf Girth Chest Circumference Index (CGCCI)	38.80	38.82	0.05	0.01
2. Upper Arm Girth Chest Circumference Index (UAGCCI)	27.79	28.50	2.55	0.55
3. Upper Arm Girth Calf Girth Index (UAGCGI)	71.73	73.46	2.41	0.52

* *vs* = versus

of body dimensions between 11+ and 19+ years (Fig.2). It is now interesting to see the relative changes in proportion growth in relation to shape factors of various indices of body dimensions. The proportion factor (shape) is the outcome of the relation between percentage change in an index from the initial, *i.e.*, 11+ years, to the final age, *i.e.*, 19+ years, and a common value of percentage change in height-weight index. Having specified thus, shape changes can be deciphered through the respective proportion factors. Further, a common value of percentage change in height-weight index, especially of Rohrer's, is used because height and weight are composite measurements and are related to all segments of the body, equally and proportionally. Hence, this index, namely Rohrer's Index (RI) has been employed as a constant for obtaining all other shape factors. The Rohrer's Index is better suited over all other height-weight indices due to the fact that height is only a linear measurement while weight represents the body volume, requiring that these uncomparable units are to be brought to comparable units by converting the weight in grams and cubing the height in cms, thus making them more comparable and dependable units than other related indices of height-weight. The relative changes in proportion growth as well as changes in the shape factor indicate the proportional changes occurring in various body dimensions during adolescence (Table 2 and Fig. 3). Considering the relation of the height-weight Index of Rohrer as a common shape factor throughout the growth period between 11+ years, to 19+ years, its relation with other indices involving various body dimensions like, linear *vs* linear, linear *vs* transverse, linear *vs* girths and girths *vs* girths will give us the totality of shape changes occurring in relation to size during the growth period, *i.e.*, adolescence. The relative percentage changes in shape occur more than the change in height-weight percentage change (4.67) in BtBSI (9.07) outstripping the height-weight change to as much as to its double; followed by BiBSI (6.19), BaBSI (4.63) and UAGSI (1.52). The remaining all other indices, however show lower values to that of height-weight percentage change.

From table 2 and figure 3 it can be surmised that the linear *vs* transverse indices like BtBSI and BiBSI have outstripped height-weight proportions to 1.94 and 1.33 shape factor; followed by linear *vs* girths namely UAGSI (1.52) and again linear *vs* transverse namely BaBSI (0.99).

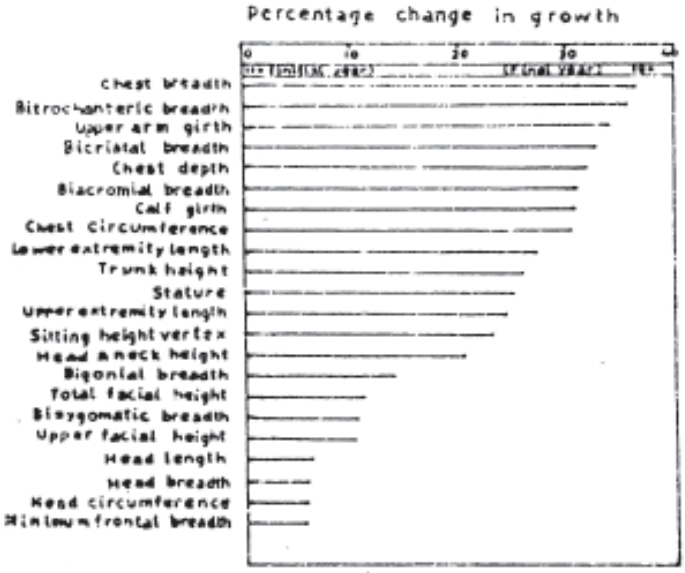

Fig. 1. Percentage change in growth of various body dimensions between 11+ & 19+ years

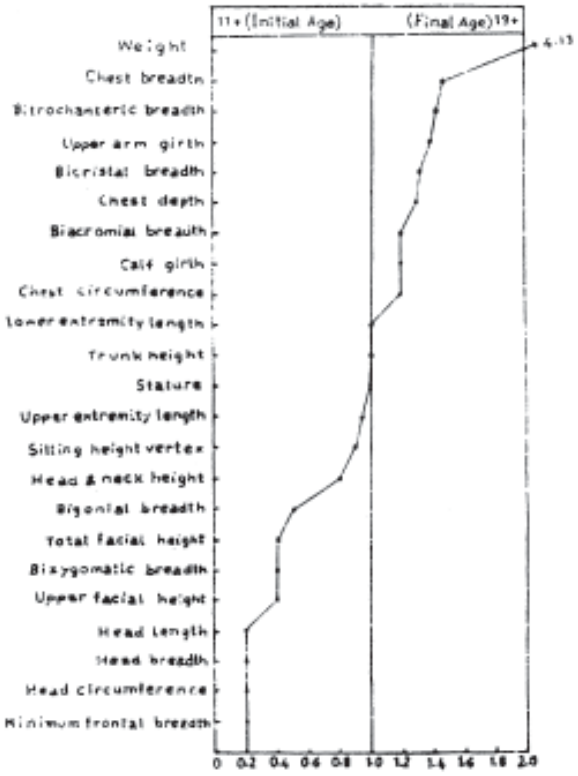

Fig. 2. Changes in size factors of various body dimensions in order of sequence from initial age (11+ years) to final age (19+ years)

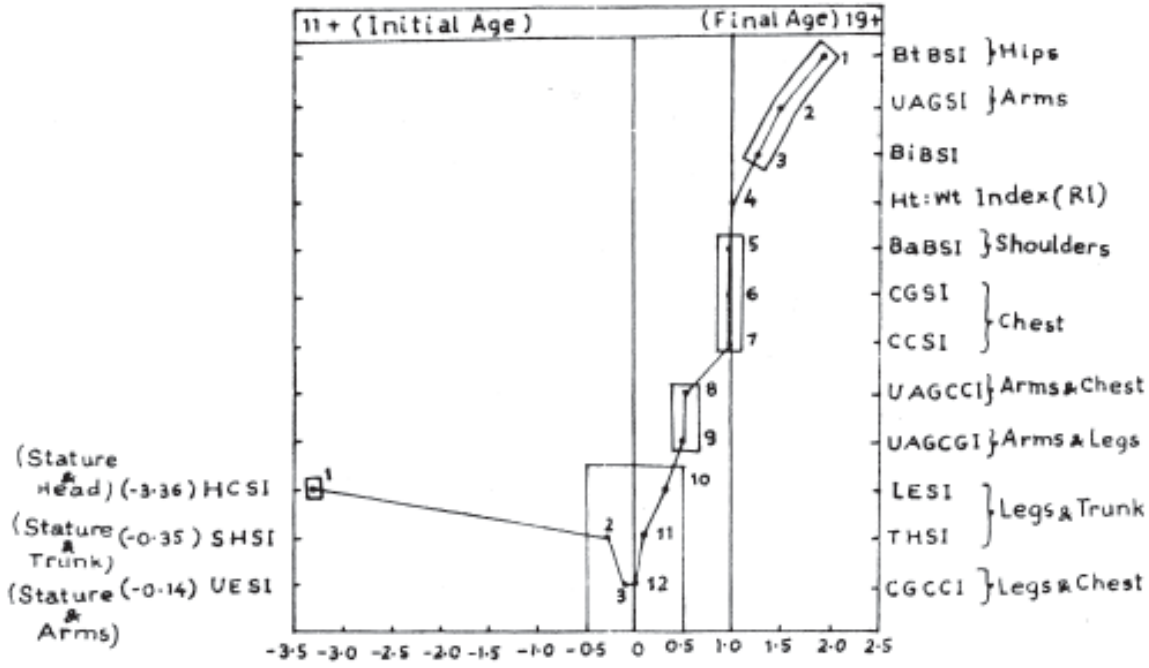

Fig. 3. Changes in shape factors of various body indices in order of sequence from initial age (11+ years) to final age (19+ years)

Next to these shape factors are again linear *vs* girth indices, namely CGSI (0.96) and CCSI (0.95); followed by girths *vs* girths namely UAGCCI (0.55) and UAGCGI (0.52). Finally a small negligible amount of positive shape factors are seen between linear *vs* linear, *i.e.*, LESI (0.38) and THSI (0.12).

Besides the above, it is also quite interesting to note that the negative shape factors have also been established namely between linear *vs* girths, HCSI (-3.36); remaining all between linear *vs* linear namely, SHSI (-0.35) and UESI (-0.14) indicating early completion of shape age for head circumference, trunk, head and neck and upper extremities in order of sequence (Fig.3).

The foregoing results explain to us the following shape changes in relation to the size of the body. It is expected that by the end of growth period *i.e.*, 19+ years, a definite size and shape of the body take place (Fig.4). The shape changes occur mainly at the regions of hips, arms, shoulders, chest and legs in order of sequence (Fig.5). These changes in proportion factors (shape) would provide a proper shape to the size attained at 19+ years. Thus, the shape of the body tends to be transformed from linearity to bulkiness during adolescence (Fig. 4 and 5). This is apparent not only in the height-weight relation during the growth period of 11+ years to 19+ years, but also the height-weight

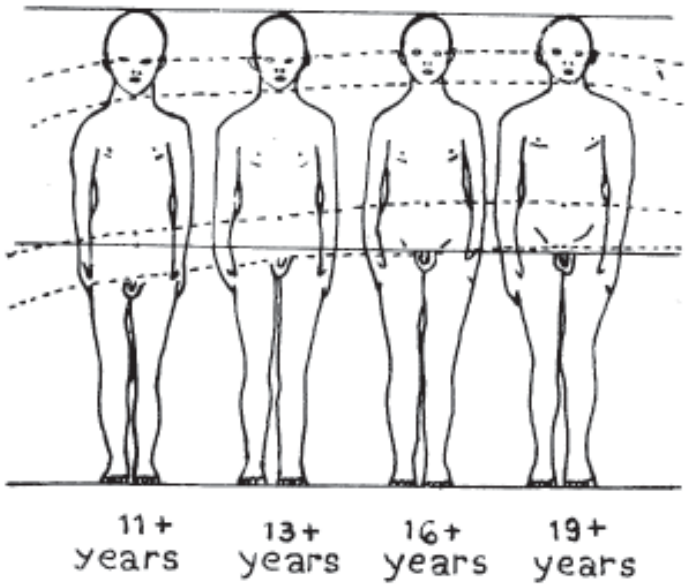

Fig. 4. Size and shape changes from childhood to adulthood (11+ to 19+ years)

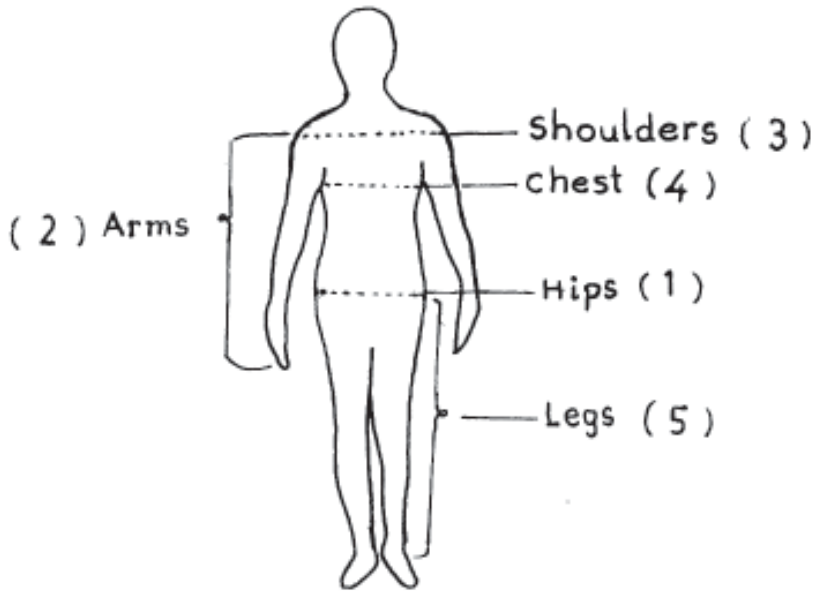

Fig. 5. Shape changes during adolescence in order of sequence (1,2,3,4,5)

relation put together combined with other shape factors like, hips, arms, shoulders, chest and legs.

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