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Biology of the Tribal Groups of Rajasthan, India: 2. Physical Growth and Anthropometric Somatotypes

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ABSTRACT In the present study an attempt has been made to investigate adolescent physical growth and anthropometric somatotypes of the tribal groups of Rajasthan. Cross-sectional data on 2928 samples belonging to adolescent (8^+ to 18^+) and adult (19 & above) age groups were collected during the year 1999-2001 for various anthropometric measurements, which included height, weight, diameters, skinfolds and circumferences. The data were collected following the standard mathods and somatotypes were obtained from body measurements. The tribal groups studied experience reduced body weight and stature, low body mass, associated with reduced bone mass, thus resulting in greater risk. Both Bhil males and females show the least development in terms of stature, body weight, subcutaneous fat deposition and bone widths than the other tribal groups. Review of somatotype changes indicate that in all the population groups, ectomorphic component dominates with few changes from ectomorphy to mesomorphy, thus reflecting their linear physiques.

INTRODUCTION

Body size at a given age, the tempo of maturation, and many other characteristics of physical growth are examples of traits for which variations within and between populations are partly genetic and partly environmental in origin (Fischbein, 1977; Bergman and Goracy, 1984). The data on children's growth can serve as indicators of the extent of social inequality existing in a population, as well as of temporal change in the economic condition of a society as a whole, or of its specific subgroups. Indeed, growth of children and youth has been recommended by the WHO as one the best indices of health and nutritional status of a community (WHO, 1986).

Anthropometry is the single most universally applicable, inexpensive, and non-invasive method available to assess the size, proportions and composition of the human body. Since growth in children and body dimensions at all ages reflect the overall health and welfare of individuals and populations, anthropometry may also be used to predict performance, health and survival (Singh and Kulkarni, 1999). Anthropometric measurements assess body composition and reflect inadequate or excess food intake, insufficient exercise and disease. The poor growth in height as well as weight reflects the poor health status. Apart from height and weight, body circumference measurements such as mid upper arm circumference and calf circumference are also useful public health indices. Skinfold measure-ments are also widely used for assessing obesity among adults. They assess the thickness of subcutaneous tissue. Very low values of skinfolds indicate the depleted caloric reserves of the body and are correlated with malnutrition. Thus, variations in body mass, subcutaneous fatness, bone diameters and total body fat are good predictors of health and chronic diseases.

Many studies show that the patterns of physical growth and development, though genetically determined, are strongly influenced by socio-economic and/or nutritional status (Tanner, 1966; Eveleth and Tanner, 1976; Garn, 1980; Bharti, 1983; Eveleth, 1985; Rao and Busi, 1994). Among the environmental factors contributing to this variation, the two whose contribution is particularly significant, the adequacy of nutrition and the state of hygiene, constitute important elements of what is variously termed "the standard of living", "the quality of environmental conditions", or the well-being" of individuals, families and societies which determines the health status of the population. It is for this reason that data on children's growth can serve as indicators of the extent of social inequality existing in a population, as well as of temporal change in the economic condition of a society as a whole, or of its specific subgroups. Studies of growth rate and adult body size and gross body composition represent valuable source of nutritional status and important aspect of comprehensively defined health (WHO, 1964; Malina et al., 1981).

In the present study an attempt has been made to study the physical growth of the tribal groups – Mina, Bhil, Sahariya, Garasia, Damor and Kathodi of Rajasthan, and subsequently determine their physique, thus explaining the variability within and between the six populations.

MATERIAL AND METHODS

The present study is based on a cross-sectional investigation on 2928 samples consisting of 1503 males and 1425 females belonging to adolescent (8^+ to 18^+) and adult (19 & above) age groups (Table 1). The study was carried out on the Scheduled Tribes, namely Minas, Bhils, Sahariyas, Garasias, Damors and Kathodis, residing in the districts Sawai Madhopur, Udaipur, Baran, Sirohi, Dungarpur, respectively of Rajasthan. Total number of 474 Minas, 471 Bhils, 475 Sahariyas, 273 Garasias, 266 Damors and 262 Kathodis were studied for the purpose. Samples are collected from the place of residence and schools. For the purpose of analysis, the subjects were classified into yearly intervals. Those subjects who had completed 8 years of age but were less than 9 years even by one day were grouped under 8+ age group. Similar pattern was followed for other age groups as well. For more details of the area and people see paper of Bhasin and Jain (2007).

Anthropometric measurements taken on each subject include size, body mass, skeletal diameters, circumferences and skinfolds. The data were collected following the Internationally accepted standards of Martin and Saller (1957), Tanner et al. (1969), Weiner and Lourie (1969), Singh and Bhasin (1989). Assessment of somatotypes was made from anthropometric measurements employing the Heath-Carter method (1967). During the course of the fieldwork all necessary precautions were taken to collect the data.

RESULTS AND DISCUSSION

Table 2 shows the results of the anthropometric measurements taken on the Scheduled Tribes of Rajashan. The mean values of weight indicated that there are little differences during preadolescent ages in Minas and Sahariyas. In Bhil, Garasia, Damor and Kathodi, males are heavier than their female counterparts throughout from 8 to 18^+ years. At higher ages Mina males and females become heavier than other five populations, as a result of which Mina males and females have the highest weight. The poorest weight status is shown in Bhil and Kathodi females. With respect to height, males of all tribal groups are taller than the females with few exceptions during preadolescent ages. The results indicate that after 14^+ years, males start growing little taller than the females, ultimately achieving taller stature than the females. Females of both Minas and Damors comparatively show better heights and among males Minas are the tallest. Mean values of skinfold at triceps and subscapula are higher in females than in males thus indicating higher deposits of subscapular and triceps fat than males. Both Sahariya males and females show better values of skinfold at triceps and subscapula than the other tribal groups.

For mean values of humerus and femur bicondylar diameter, males show greater diameters than females for most of the age groups. Maximum value for femur diameter is achieved by Mina males and Garasia females followed by Mina

Table 1: Distribution of sample size in various age groups in six tribal groups of Rajasthan

Age (Yrs)	*Mina*		*Bhil*		*Sahariya*		*Garasia*		*Damor*		*Kathodi*	
	M	*F*	*M*	*F*	*M*	*F*	*M*	*F*	*M*	*F*	*M*	*F*
8+	21	26	24	20	21	24	13	13	12	12	12	12
9+	21	20	22	20	23	22	12	12	12	12	13	12
10+	21	20	21	23	22	25	14	13	12	11	12	12
11+	24	20	22	23	21	21	14	11	12	12	12	12
12+	25	20	23	23	21	21	14	12	12	12	13	11
13+	25	21	20	21	21	21	12	12	12	12	12	12
14+	21	20	22	21	24	22	12	11	12	12	11	11
15+	21	20	21	20	21	21	13	11	12	12	13	12
16+	21	19	22	20	20	23	13	11	12	11	12	12
17+	24	21	21	20	22	20	12	13	13	13	12	12
18+	22	21	22	20	22	17	12	12	12	12	11	11
>19	89	76	66	66	50	39	81	76	41	37	43	43
Total	335	304	306	297	192	170	319	313	175	169	176	172

Table 2: Anthropometric measurements (mean and standard deviation) among six tribal groups of Rajasthan

Age (Yrs)	Mina		Bhils		Garasia		Sahariya		Damor		Kathodi	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Height (cm) among Males												
8+	118.39	4.79	117.72	5.27	120.06	3.64	120.24	4.98	119.75	5.73	117.27	3.38
9+	127.31	4.62	122.19	3.68	124.4	3.56	128.34	3.88	125.02	3.81	124.25	2.95
10+	130.68	5.81	131.11	5.38	130.62	2.55	132.73	6.79	130.20	3.45	129.88	2.92
11+	136.10	4.54	138.11	3.34	137.05	3.89	139.18	5.37	138.97	3.45	134.20	4.66
12+	124.37	3.69	141.48	4.53	141.09	5.27	145.63	8.29	143.29	3.32	139.92	2.98
13+	145.98	8.12	147.68	5.34	149.55	7.18	149.92	8.85	148.27	5.08	146.57	3.77
14+	155.92	7.77	155.53	4.63	157.29	2.74	154.33	7.37	154.64	4.09	151.62	3.48
15+	159.99	4.30	154.48	4.89	159.00	3.29	161.71	4.63	157.97	4.10	156.66	4.39
16+	165.68	4.09	160.39	4.79	161.69	3.53	163.79	4.90	163.26	5.76	159.72	3.72
17+	167.21	4.05	160.59	4.56	168.15	3.72	164.93	5.88	167.63	4.21	162.46	4.42
18+	169.35	4.25	164.22	4.47	166.71	4.41	164.94	6.26	166.43	6.64	165.69	4.41
>19	169.26	4.59	163.19	3.52	164.70	5.15	164.20	5.68	164.90	5.24	164.95	3.97
Height (cm) among Females												
8+	118.84	5.29	116.72	7.05	118.00	2.53	122.37	4.17	119.40	3.68	117.81	1.96
9+	126.06	3.86	123.98	4.52	122.15	2.46	129.92	4.31	123.73	3.87	122.20	6.49
10+	132.22	4.10	128.41	5.44	124.43	2.11	130.57	6.51	130.29	3.30	131.13	3.34
11+	138.49	3.77	132.79	5.56	131.05	4.25	143.98	6.08	135.73	3.72	139.27	3.87
12+	142.35	4.15	139.05	4.52	140.70	2.36	144.10	5.67	141.28	4.13	142.20	2.89
13+	146.88	5.13	145.96	5.36	142.04	5.28	145.62	5.87	146.72	3.66	146.76	4.05
14+	151.05	4.34	147.81	6.57	147.81	4.32	150.53	5.06	150.57	2.64	150.70	4.23
15+	152.71	4.89	151.22	3.83	150.69	3.28	153.36	4.36	151.61	2.50	148.39	4.49
16+	154.96	4.48	151.45	5.71	151.82	3.25	154.46	4.06	152.98	3.31	154.61	5.90
17+	153.34	3.84	150.04	5.21	153.66	3.23	156.63	5.49	155.03	3.56	155.49	6.33
18+	154.45	4.87	151.37	4.32	152.24	4.10	153.92	5.87	154.64	4.59	152.00	5.46
>19	155.04	4.95	151.93	4.06	153.62	4.32	153.35	5.31	153.29	4.84	152.21	5.26
Body Weight (kg) among Males												
8+	17.21	2.07	16.94	2.09	18.23	2.68	19.19	2.91	16.71	2.32	17.58	1.69
9+	20.00	2.64	17.41	1.84	20.37	2.03	21.96	2.49	19.58	1.36	19.65	1.61
10+	23.50	2.85	21.64	4.52	23.43	1.89	24.09	4.18	20.50	3.09	22.67	2.75
11+	25.69	3.86	24.95	2.94	25.68	2.60	28.02	3.71	24.69	2.62	23.38	4.07
12+	28.23	2.95	27.46	3.62	28.00	2.91	32.28	6.44	28.25	3.92	30.07	2.38
13+	30.68	4.73	33.35	3.51	32.69	5.01	34.64	5.12	32.95	3.24	32.67	2.79
14+	37.45	5.59	36.36	2.68	41.12	2.10	36.63	5.68	34.95	3.73	35.36	3.35
15+	40.31	4.72	35.87	4.13	42.15	2.96	41.67	5.99	39.20	3.25	39.27	3.49
16+	44.19	4.22	40.00	4.38	43.53	2.60	45.23	3.82	42.04	4.52	41.04	2.93
17+	48.25	3.98	41.83	2.88	44.45	2.39	46.06	4.44	44.92	3.38	45.63	4.48
18+	50.16	4.69	44.04	2.91	43.37	2.71	48.23	5.72	45.41	3.58	47.73	3.71
>19	51.85	4.81	44.21	3.67	43.02	3.35	47.31	6.15	43.85	4.42	44.07	4.23
Body Weight (kg) among Females												
8+	17.67	2.18	15.80	1.40	17.10	1.35	19.48	2.84	15.71	1.43	16.21	1.45
9+	21.23	1.81	18.50	3.43	19.87	3.93	21.95	4.05	18.96	3.22	17.83	1.68
10+	22.37	2.45	20.22	3.65	20.31	2.14	23.20	4.21	22.59	2.98	21.50	2.37
11+	25.23	6.73	22.76	3.68	23.96	3.01	31.58	5.40	25.92	3.38	26.04	3.62
12+	28.60	3.17	27.46	3.70	29.17	2.25	31.05	4.24	28.88	1.94	27.04	2.29
13+	32.76	3.78	31.17	3.26	30.75	2.30	36.12	6.75	31.79	4.27	33.38	3.09
14+	35.53	4.76	33.69	4.40	32.68	2.96	39.68	4.62	38.75	4.45	35.82	3.07
15+	39.38	4.86	37.90	4.06	35.50	2.28	42.47	4.77	38.54	3.11	35.54	2.97
16+	42.21	3.92	36.85	4.56	38.46	3.18	42.07	5.04	40.68	2.69	36.75	3.23
17+	41.02	3.60	35.50	3.42	37.42	3.22	43.88	4.52	40.96	3.53	37.45	2.68
18+	43.71	4.46	38.88	3.23	39.5	2.45	42.88	5.51	40.63	3.34	37.00	3.07
>19	45.88	3.18	38.48	6.79	38.33	3.52	41.86	6.30	40.65	3.70	36.95	4.26
Triceps Skinfold (mm) among Males												
8+	5.09	1.18	5.50	1.22	5.53	0.87	5.76	1.92	4.83	0.93	5.58	0.90
9+	5.23	1.62	5.36	5.75	1.05	5.36	1.05	5.36	1.05	0.79	5.92	1.38
10+	5.95	1.36	5.76	1.26	7.21	1.76	6.25	1.62	4.91	1.24	5.75	1.05
11+	6.08	1.84	5.77	1.11	6.28	1.13	6.43	2.06	5.53	1.98	5.92	1.44
12+	5.60	1.04	5.48	0.84	6.00	1.03	6.24	1.34	6.33	1.30	6.15	1.21
13+	5.80	1.73	6.10	1.25	6.31	1.10	6.19	2.14	7.25	1.54	6.41	1.56

Table 2: Contd....

Age (Yrs)	*Mina*		*Bhils*		*Garasia*		*Sahariya*		*Damor*		*Kathodi*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
14+	5.67	1.43	5.91	1.23	7.00	1.70	6.83	2.57	5.41	1.24	6.55	2.06
15+	6.09	1.73	6.04	1.02	6.76	1.30	6.69	1.97	6.58	1.56	6.54	1.56
16+	5.95	1.16	6.00	1.27	7.61	1.44	6.40	2.11	5.33	1.30	6.08	1.44
17+	6.21	1.97	5.71	0.96	7.00	2.04	6.77	1.93	6.69	1.75	6.91	2.16
18+	5.90	1.72	5.82	1.56	6.50	1.38	7.46	1.54	6.58	1.92	6.91	2.16
>19	6.48	1.77	5.74	1.35	6.68	1.68	7.16	2.73	6.61	1.68	5.77	1.68
Triceps Skinfold (mm) among Females												
8+	5.96	1.76	6.05	1.53	6.53	1.45	6.33	2.28	5.83	1.64	5.67	1.44
9+	6.10	1.41	6.58	1.81	7.67	2.38	6.71	2.13	6.33	1.23	6.00	1.47
10+	6.00	2.08	6.21	1.67	6.85	1.14	7.68	3.32	7.36	1.85	5.83	1.03
11+	7.00	1.95	5.74	1.17	8.73	1.90	8.42	2.84	6.62	1.12	7.00	6.65
12+	6.50	1.82	7.52	1.50	7.08	0.99	8.87	2.64	6.92	1.38	6.00	1.18
13+	7.29	2.07	8.28	1.85	8.5	1.57	9.62	3.88	7.42	2.27	7.07	1.44
14+	7.80	2.86	8.09	2.25	8.27	2.15	8.77	3.46	8.58	2.02	6.54	1.03
15+	8.00	2.58	8.40	1.98	8.55	2.21	11.71	3.75	9.50	2.31	7.08	1.44
16+	8.16	2.81	8.60	1.88	8.00	1.79	10.74	3.32	9.27	2.45	7.00	1.70
17+	3.25	1.91	8.60	2.39	8.11	1.44	10.75	2.38	8.38	2.10	6.58	1.37
18+	8.24	1.67	7.55	2.46	9.41	1.78	8.94	3.07	7.92	1.93	6.63	1.28
>19	8.30	2.19	7.51	3.21	7.08	1.94	8.67	3.31	7.81	2.55	6.46	1.40
Subscapular Skinfold (mm) among Males												
8+	4.76	0.89	5.37	0.92	6.46	1.50	5.48	1.60	5.50	1.16	5.33	0.77
9+	4.57	0.81	5.41	0.95	6.75	1.21	5.36	1.49	5.00	0.85	5.23	0.93
10+	5.76	1.75	5.48	1.29	6.71	1.20	6.05	2.04	5.75	0.69	5.50	0.79
11+	5.25	1.48	5.91	1.19	6.42	1.28	6.57	1.86	5.84	1.28	5.67	0.65
12+	4.88	0.83	5.83	0.94	7.00	1.24	6.86	1.93	5.91	0.99	5.54	1.87
13+	5.80	1.29	6.40	1.04	6.84	1.67	6.71	1.19	6.33	4.07	5.83	1.33
14+	5.81	1.17	6.09	0.97	6.66	1.92	6.88	1.85	6.66	1.61	6.46	1.29
15+	6.28	1.14	6.38	1.32	6.53	1.12	7.29	2.17	7.58	1.62	6.31	1.18
16+	6.52	1.75	7.04	1.09	6.38	1.44	8.50	2.37	8.08	1.51	5.92	1.16
17+	7.33	1.83	7.00	1.00	6.83	1.58	8.50	2.11	7.23	1.16	6.08	1.44
18+	7.27	1.38	7.45	1.71	7.50	0.91	10.18	2.42	7.00	1.12	6.00	1.09
>19	8.00	1.85	6.91	1.79	6.74	1.55	9.11	3.25	6.73	1.81	6.44	1.25
Subscapular Skinfold (mm) among Males												
8+	5.35	1.41	5.40	1.14	6.46	1.51	5.63	1.38	5.91	1.37	6.08	1.56
9+	5.65	1.49	6.40	1.60	6.75	1.21	6.24	2.23	6.25	1.49	6.67	1.15
10+	6.60	2.01	5.87	1.14	6.69	1.55	7.04	2.19	7.00	2.00	6.08	1.24
11+	6.00	1.59	5.74	1.25	7.82	2.48	8.26	1.82	6.38	1.85	6.75	1.42
12+	6.55	1.85	7.69	1.29	7.58	2.15	8.19	2.36	6.50	1.97	5.63	0.92
13+	6.86	2.01	7.52	1.78	9.33	2.81	9.00	2.81	7.25	2.53	6.31	1.60
14+	7.85	2.13	7.38	1.91	8.27	3.00	9.77	2.65	8.75	2.95	5.72	0.91
15+	7.85	2.08	8.35	2.37	8.46	1.57	12.24	3.79	8.75	2.60	6.41	1.44
16+	8.21	1.78	8.85	1.90	8.46	3.50	11.30	3.05	9.55	3.32	6.08	1.31
17+	5.05	1.53	7.65	1.98	7.38	1.38	10.15	3.05	9.55	3.32	6.08	1.31
18+	9.62	2.46	7.55	1.98	7.42	1.73	10.41	3.94	7.00	1.76	5.72	1.00
>19	8.07	2.06	7.77	5.53	6.32	1.91	9.22	3.51	7.50	2.78	6.05	1.43
Triceps Skinfold (mm) among Males												
8+	6.51	0.34	6.31	0.38	6.14	0.56	6.70	0.69	6.27	0.31	6.47	0.48
9+	6.79	0.52	6.49	0.39	6.61	0.30	6.95	0.41	6.60	0.47	6.64	0.31
10+	7.01	0.54	6.92	0.42	6.90	0.21	7.15	0.51	6.85	0.48	6.90	0.42
11+	7.32	0.37	7.31	0.25	7.25	0.27	7.40	0.37	7.17	0.53	7.27	0.48
12+	7.42	0.51	7.29	0.41	7.38	0.31	7.87	0.46	7.54	0.43	8.07	0.57
13+	7.75	0.48	7.85	0.38	7.78	0.58	7.53	0.71	7.15	0.37	8.10	0.65
14+	8.20	0.43	7.88	0.39	8.18	0.57	8.08	0.49	7.39	0.44	8.11	0.65
15+	8.27	0.45	8.01	0.42	8.18	0.53	8.37	0.63	8.46	0.48	8.40	0.64
16+	8.43	0.47	8.03	0.48	8.23	0.73	8.15	0.49	8.20	0.51	8.52	0.61
17+	8.53	0.32	8.09	0.40	8.36	0.67	8.44	0.59	8.16	0.47	8.66	0.68
18+	8.72	0.46	8.26	0.31	8.56	0.84	8.40	0.47	8.31	0.47	8.63	0.75
>19	8.63	0.47	8.24	0.51	8.52	0.69	8.49	0.69	8.16	0.52	8.38	0.55

Table 2: Contd....

Age (Yrs)	*Mina*		*Bhils*		*Garasia*		*Sahariya*		*Damor*		*Kathodi*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Femur Bicondylar Diameter (cm) among Males												
8+	6.07	0.53	5.72	0.37	5.92	0.35	6.21	0.60	5.93	0.47	6.03	0.23
9+	6.52	0.29	6.17	0.38	6.08	0.34	6.76	0.45	5.95	0.45	6.18	0.52
10+	6.58	0.30	6.37	0.48	6.41	0.18	6.82	0.56	6.29	0.37	6.65	0.24
11+	6.89	0.51	6.49	0.36	6.54	0.53	7.22	0.60	6.82	0.55	6.90	0.48
12+	7.20	0.46	7.04	0.39	6.99	0.42	7.00	0.72	6.97	0.42	6.81	0.45
13+	7.24	0.49	7.08	0.56	7.31	0.41	7.39	0.45	7.15	0.47	7.78	0.30
14+	7.71	0.45	7.19	0.62	7.52	0.50	7.41	0.70	7.48	0.45	7.94	0.57
15+	7.76	0.78	7.46	0.43	7.60	0.54	8.04	0.42	7.78	0.67	7.93	0.43
16+	7.73	0.51	7.41	0.51	7.89	0.62	7.81	0.54	7.87	0.62	7.79	0.65
17+	7.59	0.46	7.53	0.61	8.17	0.48	7.83	0.50	8.03	0.48	8.05	0.48
18+	7.86	0.59	7.45	0.70	8.06	0.37	7.35	0.67	7.80	0.83	7.84	0.65
>19	7.79	0.52	7.41	0.58	8.09	0.46	7.57	0.59	7.83	0.58	7.20	0.54
Humerus Bicondylar Diameter (cm) among Males												
8+	4.20	0.76	4.05	0.38	4.31	0.47	4.15	0.67	4.04	0.52	4.32	0.27
9+	4.37	0.31	4.33	0.33	4.65	0.41	4.52	0.40	4.48	0.45	4.87	0.57
10+	4.54	0.38	4.72	0.39	4.93	0.34	4.69	0.47	4.67	0.42	5.07	0.49
11+	4.48	0.46	5.14	0.35	4.93	0.41	4.99	0.62	5.02	0.34	5.18	0.42
12+	5.08	0.43	5.27	0.39	5.35	0.44	5.63	0.51	5.39	0.23	5.92	0.61
13+	5.48	0.45	5.87	0.53	6.07	0.49	5.69	0.57	5.73	0.56	6.04	0.47
14+	5.91	0.59	6.00	0.41	6.40	0.43	5.87	0.69	6.00	0.41	6.32	0.46
15+	6.31	0.52	6.21	0.44	6.51	0.48	6.32	0.41	6.48	0.36	6.45	0.49
16+	6.50	0.28	6.39	0.40	6.70	0.49	6.17	0.55	6.63	0.42	6.76	0.38
17+	6.63	0.52	6.59	0.47	6.70	0.45	6.49	0.48	6.61	0.51	6.78	0.29
18+	6.62	0.47	6.57	0.28	6.72	0.35	6.61	0.58	6.77	0.43	6.85	0.53
>19	6.65	0.54	6.64	0.48	6.75	0.50	6.66	0.62	6.82	0.62	6.53	0.43
Humerus Bicondylar Diameter (cm) among Females												
8+	0.96	0.28	3.92	0.32	4.15	0.33	4.41	0.67	4.01	0.43	4.10	0.34
9+	4.43	0.39	4.23	0.52	4.19	0.26	4.64	0.28	4.26	0.31	4.13	0.47
10+	4.55	0.33	4.47	0.47	4.71	0.56	4.64	0.43	4.53	0.52	4.43	0.33
11+	4.66	0.41	4.71	0.34	4.73	0.38	5.06	0.51	4.85	0.40	4.98	0.36
12+	5.19	0.34	5.07	0.35	5.20	0.22	5.15	0.50	5.69	0.50	5.65	0.31
13+	5.37	0.41	5.45	0.46	5.23	0.34	5.29	0.52	5.73	0.62	6.04	0.46
14+	5.75	0.58	5.58	0.45	5.42	0.59	5.43	0.69	5.75	0.45	5.81	0.42
15+	5.59	0.70	5.78	0.39	5.83	0.45	5.63	0.47	6.05	0.46	5.74	0.48
16+	5.73	0.52	5.60	0.34	6.06	0.39	5.75	0.49	5.86	0.49	5.72	0.65
17+	5.63	0.33	5.78	0.35	6.22	0.32	5.86	0.50	5.99	0.53	6.15	0.49
18+	5.90	0.35	5.85	0.48	6.33	0.32	6.04	0.66	6.13	0.51	6.05	0.61
>19	5.85	0.44	5.77	0.37	6.21	0.49	5.83	0.52	6.05	0.52	5.92	0.53
Upper Arm Circumference (cm) among Females												
8+	13.93	0.93	13.40	1.08	13.82	1.19	14.61	0.87	13.8	0.64	13.41	1.02
9+	14.38	0.98	13.95	0.78	14.33	1.19	15.21	1.44	15.55	1.66	13.32	1.18
10+	15.66	1.16	14.89	1.07	14.62	0.92	15.51	1.16	15.02	0.90	14.76	1.02
11+	15.53	1.44	15.83	0.94	15.20	0.85	16.69	1.36	15.63	1.26	15.01	1.15
12+	16.27	1.84	16.17	0.97	16.48	1.26	18.16	2.26	16.33	1.56	15.87	1.29
13+	17.01	0.91	17.95	1.48	17.01	1.40	18.36	1.73	16.25	1.03	18.14	1.10
14+	19.18	2.02	19.18	2.45	17.45	0.67	18.69	1.56	18.10	1.03	18.14	1.10
15+	19.15	1.31	19.19	1.16	17.23	0.79	20.39	1.43	19.50	1.02	19.12	1.15
16+	19.91	1.28	19.75	1.81	18.64	1.10	21.47	1.82	19.99	1.85	21.27	1.35
17+	21.42	1.39	20.17	1.09	18.97	1.15	21.21	1.85	20.21	1.25	22.18	1.97
18+	22.27	2.38	21.33	1.31	19.04	1.25	23.01	2.01	21.24	1.01	23.32	1.88
>19	22.99	1.57	21.45	1.40	22.74	1.12	22.18	2.21	22.13	1.78	21.57	1.68
Upper Arm Circumference (cm) among Males												
8+	14.55	0.84	13.37	0.80	14.27	0.81	14.75	1.24	13.89	0.89	13.54	0.79
9+	15.09	0.94	14.25	1.30	14.49	0.92	15.66	1.04	13.88	1.14	14.35	0.77
10+	15.33	1.20	15.23	1.72	14.87	1.17	15.65	1.37	15.69	1.03	14.76	0.95
11+	16.54	1.70	15.19	1.13	16.97	0.87	18.09	1.71	16.46	1.22	16.85	0.99
12+	16.59	1.16	16.75	1.14	17.13	1.73	18.22	2.48	16.87	1.12	17.06	1.53
13+	17.75	1.48	17.90	1.76	18.21	0.95	18.88	1.95	17.93	1.51	18.46	1.07
14+	18.48	1.29	18.14	1.32	19.36	1.34	18.69	1.56	20.23	0.72	18.36	1.45

Table 2: Contd....

Age (Yrs)	Mina		Bhils		Garasia		Sahariya		Damor		Kathodi	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
15+	19.69	1.96	19.26	0.98	19.57	1.15	20.54	1.78	19.70	1.10	18.88	1.45
16+	19.89	1.71	19.09	1.44	20.34	0.89	20.56	1.58	22.01	1.82	19.89	1.59
17+	19.51	1.63	19.47	1.20	20.85	0.85	21.01	1.22	21.14	2.19	20.17	1.61
18+	21.18	2.87	19.96	0.97	21.11	0.75	20.29	2.28	21.80	2.59	20.45	1.36
>19	20.68	1.46	20.15	2.10	21.77	1.15	20.24	2.04	22.10	1.73	20.22	1.23
Calf Circumference (cm) among Males												
8+	20.44	1.76	19.95	1.23	20.13	1.44	21.10	1.35	19.91	0.93	19.95	1.14
9+	21.05	2.06	21.12	0.21	20.41	1.05	21.88	2.61	20.86	1.42	20.56	1.43
10+	22.96	1.46	20.09	1.57	21.52	1.27	22.88	2.23	22.08	1.45	22.22	1.13
11+	22.96	1.77	22.87	1.27	22.86	1.29	24.41	1.69	23.01	1.51	23.57	2.19
12+	23.49	2.17	23.59	1.31	24.48	0.97	25.45	2.85	24.01	1.43	24.57	1.58
13+	25.07	1.65	25.93	1.83	24.10	1.31	25.10	3.07	25.20	0.93	25.65	1.99
14+	26.91	2.16	26.76	1.27	24.28	0.81	26.46	1.76	26.10	1.45	25.00	0.94
15+	27.15	1.52	27.51	1.63	24.88	1.16	27.65	2.31	28.15	1.20	25.95	1.51
16+	27.61	1.18	27.80	1.82	26.38	1.42	28.94	2.36	28.63	1.78	27.81	1.21
17+	29.11	1.51	28.27	1.08	25.79	0.95	29.06	2.31	28.77	0.64	27.92	1.52
18+	29.17	1.92	28.48	1.05	25.73	1.22	28.82	3.83	28.70	1.24	28.42	1.36
>19	30.03	2.01	28.63	1.75	27.87	1.40	28.45	2.79	28.72	1.31	29.32	1.44
Calf Circumference (cm) among Females												
8+	20.84	1.24	19.78	0.67	19.84	0.83	21.15	1.25	19.58	0.77	20.45	0.86
9+	21.76	1.48	20.44	1.53	20.27	1.06	22.41	1.17	20.12	1.24	21.06	0.86
10+	21.29	4.59	21.74	1.73	21.34	1.69	22.78	2.02	21.90	0.89	22.13	1.23
11+	23.12	1.84	21.37	2.22	23.26	1.79	25.20	2.14	24.19	1.55	23.95	1.65
12+	24.69	1.69	24.04	1.92	23.96	2.48	24.71	2.44	24.31	1.01	24.78	1.54
13+	25.33	1.24	24.89	1.50	25.50	1.05	26.14	3.17	24.95	1.78	26.21	1.10
14+	25.55	1.96	26.05	1.99	26.51	0.88	26.17	6.15	26.87	0.74	27.73	1.10
15+	26.92	1.93	25.77	3.23	26.96	1.00	27.74	1.73	27.23	1.25	28.00	1.36
16+	27.42	1.38	25.92	2.57	28.32	1.10	27.76	1.57	28.34	1.55	27.54	1.57
17+	26.27	2.04	26.05	1.09	28.05	1.48	28.97	2.65	28.16	1.99	27.93	1.90
18+	27.84	2.23	27.23	1.26	28.71	0.95	26.37	2.63	28.17	2.52	29.53	1.90
>19	26.40	1.41	26.73	2.07	27.94	1.48	26.11	2.58	28.74	2.09	27.67	1.88

females. Both Garasia males and females show maximum diameters attained for humerus. No marked differences are observed among males and females with respect to upper arm and calf circumference, but in general, males are seen to have better vales for both the measurements. As seen in inter-population differences, the Sahariya males upto 15^+ years and at 18^+ years show higher upper arm circumference as compared to males of other tribes; whereas among females the highest values is observed in Minas. Both male and females of Mina exhibit of mina greater mean values for calf circumference than the other populations.

Physical growth and development of an individual and a population are simple and strong predictors of future ill health, functional impairment and mortality, in turn the body measurements may be modified by diseases. Anthropometric measurements thus, assess body size and composition and reflect inadequate and excess food intake and disease. Simple body measurements also permit the selection of individuals, families and communities for intervention designed to improve not only nutrition but also health in general and thus survival.

The tribal groups studied experience reduced body weight and stature, low body mass, which is also associated with reduced bone mass, thus resulting in greater risk. Both Bhil males and females show the least development in terms of stature, body weight, subcutaneous fat deposition and bone widths than the other tribal groups. Late maturity is thus indicative of delayed growth due to factors like inadequate diet and poor socio-economic conditions. Sahariya males and females in the present study exhibit delayed onset of maturational events with regards to various anthropometric measurements studied. Females are seen at greater risk of underweight and lean body mass.

Chronic undernutrition from early childhood continuing through adolescence into adult life is common among tribal populations. The primary

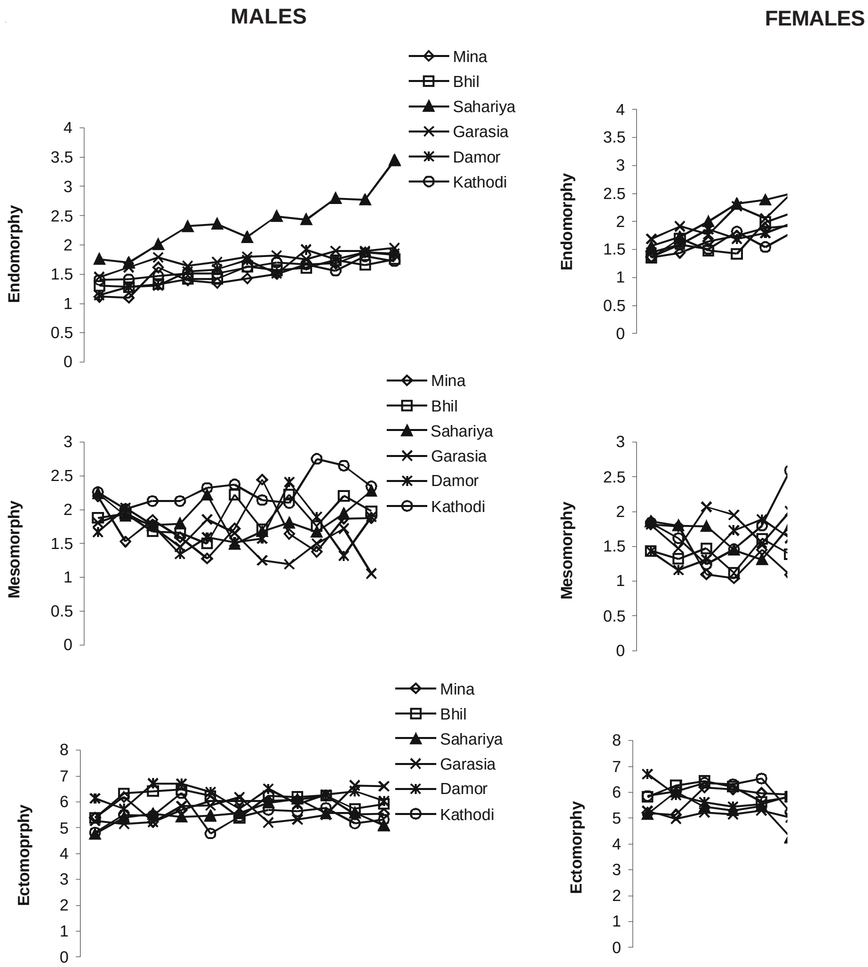

Fig. 1. Comparison of anthropometric somatotypes of Minas, Bhils, Sahariyas, Garasias, Damors and Kathodis

cause of malnutrition is inadequate diet, which has been manifested, in the present study by reduced growth and delayed maturity. Apart from extreme poverty and other socio-economic factors, environmental factors play an important role in aggravating the dietary deficiencies and precipitating nutritional and growth deficiencies. These precipitating factors are widespread chronic infections among poor living conditions, poor sanitation conditions and personal hygiene. Sometimes lack of opportunities associated with poverty or the choices concerning education and occupation may have indirect long-term effects on health.

The anthropometric somatotypes of the six tribal groups studies are shown in Table 3. In all the population groups, ectomorphic component is dominant in younger age groups and continues to be so till 18^{+} years of age; with few changes from ectomorphic to mesomorphic component. No regular spurt could be recognized in somatotypes component during adolescence. High prevalence of ectomorphic component in the present study indicates their linear physiques.

Sahariya males and females showed highest endomorphy ratings thereby indicating greater relative fatness than the other five populations. Mina males at young age group showed minimum endomorphy values, whereas among females, Kathodis exhibited the same. Mina males and Garasia females showed greater musculo-skeletal development than the others, which is indicated

Table 3: Anthropometric somatotypes of the tribal groups of Rajasthan

	Mina				*Bhil*				*Sahariya*			
	Male		*Female*		*Male*		*Female*		*Male*		*Female*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Endomorphy Ratings												
8+	1.11	0.28	1.36	0.42	1.30	0.31	1.35	0.34	1.76	0.75	1.56	0.42
9+	1.10	0.31	1.44	0.38	1.28	0.28	1.70	0.49	1.70	0.55	1.72	0.52
10+	1.62	0.93	1.65	0.61	1.33	0.35	1.48	0.35	2.01	0.68	2.00	0.72
11+	1.39	0.50	1.75	0.47	1.42	0.33	1.42	0.33	2.32	0.86	2.32	0.68
12+	1.35	0.38	1.88	0.62	1.42	0.20	1.99	0.41	2.36	0.59	2.39	0.78
13+	1.43	0.37	1.93	0.56	1.63	0.29	2.17	0.56	2.14	0.56	2.52	0.90
14+	1.50	0.42	2.27	0.76	1.57	0.24	2.18	0.57	2.49	0.95	2.58	0.81
15+	1.67	0.43	2.33	0.77	1.61	0.35	2.45	0.74	2.43	0.96	3.45	0.81
16+	1.68	0.39	2.41	0.71	1.74	0.30	2.53	0.56	2.80	1.13	3.20	0.69
17+	1.87	0.62	1.97	0.60	1.66	0.21	2.30	0.74	2.77	0.89	3.23	0.85
18+	1.83	0.47	2.66	0.50	1.76	0.44	2.07	0.65	3.45	0.87	2.74	0.97
>19+	2.09	0.56	2.28	0.65	1.68	0.34	2.12	0.91	2.25	0.78	2.54	0.91
Mesomorphy Ratings												
8+	2.20	1.03	1.82	0.59	1.88	0.48	1.44	0.99	2.24	0.99	1.86	0.74
9+	1.53	0.65	1.79	0.62	1.94	0.53	1.32	0.65	1.91	0.88	1.80	0.67
10+	1.85	0.58	1.10	0.97	1.68	0.60	1.47	0.67	1.77	0.78	1.79	0.75
11+	1.59	0.73	1.04	0.96	1.66	0.45	1.12	0.61	1.79	0.79	1.45	0.85
12+	1.28	0.79	1.45	0.66	1.50	0.57	1.61	0.78	2.22	0.54	1.31	0.86
13+	1.72	0.76	1.09	1.36	2.22	0.91	1.39	1.08	1.49	0.61	1.80	0.95
14+	2.44	0.54	1.55	0.92	1.71	0.71	1.56	0.87	1.68	0.74	1.29	0.85
15+	1.64	0.71	1.66	1.28	2.22	0.76	1.59	0.78	1.81	0.96	1.97	0.99
16+	1.38	0.79	1.57	0.72	1.76	1.10	1.36	0.81	1.67	1.12	1.88	0.83
17+	1.87	0.66	1.43	0.88	2.21	0.78	1.87	0.78	1.94	1.35	1.94	1.03
18+	1.88	0.69	2.19	1.05	1.98	0.62	1.89	0.71	2.28	1.06	1.66	0.61
>19+	2.12	0.27	1.73	0.88	2.24	0.86	1.83	1.12	2.28	1.16	1.65	1.04
Ectomorphy Ratings												
8+	5.39	1.49	5.21	1.37	5.37	1.55	5.81	1.81	4.76	1.61	5.15	1.19
9+	6.20	1.65	5.12	1.03	6.32	1.09	6.27	1.39	5.39	0.93	6.02	2.45
10+	5.23	0.85	6.19	1.17	6.42	1.37	6.43	1.21	5.54	1.18	5.43	1.18
11+	5.68	1.15	6.12	1.53	6.47	0.89	6.21	0.96	5.42	0.92	5.29	1.10
12+	6.04	0.87	5.96	1.33	6.23	1.17	5.64	1.34	5.47	1.06	5.47	1.28
13+	6.05	1.20	5.92	2.44	5.38	0.94	5.82	1.28	5.56	0.91	4.25	1.38
14+	6.03	0.83	5.55	1.04	6.23	1.15	5.40	1.09	5.96	1.14	4.20	1.19
15+	6.08	1.14	4.77	1.36	6.20	1.19	4.84	1.04	6.11	1.22	4.08	1.34
16+	6.22	1.19	4.46	1.23	6.25	1.48	5.21	1.10	5.55	1.32	4.41	1.04
17+	5.52	0.86	4.42	1.07	5.73	0.88	5.28	1.00	5.58	1.19	4.40	1.19
18+	5.53	1.19	3.98	1.04	5.91	0.72	4.88	1.17	5.10	1.31	4.10	1.47
>19+	5.14	1.15	3.55	0.99	5.67	0.83	4.99	1.43	5.20	1.58	4.28	1.59

by higher mesomorphy ratings in them. Maximum mean value of ectomorphy is exhibited by Damor males and females followed by Garasias among males and Kathodis among females, thus revealing their higher linearity as compared to the other populations.

The graphs indicate a high predominance of linearity. A review of somatotype composition shows that in all the population groups, ectomorphic component is dominant in young age groups and continues to be so till 18 years, with few changes in the ratings from ectomorphic to mesomorphic component. From the studies of Singh and Sidhu (1980), Singh and Bhasin (1990), Bhasin and Singh (1991), Singh and Singh (1991) and Bhasin and Singh (1992), it has been reported that Indian population groups are ectomorph, endo-ectomorph, meso-ectomorph and balanced ectomorph and their ratings are considerably lower than their western counterparts (Heath and Carter, 1971; Parizkova and Carter, 1976; Singh and Sidhu, 1980; Singh, 1987). The data of the present population also show a similar trend. No regular spurt is recognized in somatotype components during adolescence.

Comparison with national and international standards shows that the tribal groups are much below the reference values. Short stature and low body mass may be determinants of concurrent functional impairment. Short stature in adolescents resulting from prior chronic undernutrition is associated with lean body mass and defi-

Table 3: Contd....

	Garasia				*Damor*				*Kathodi*			
	Male		*Female*		*Male*		*Female*		*Male*		*Female*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Endomorphy Ratings												
8+	1.45	0.26	1.69	0.44	1.14	0.28	1.45	0.38	1.40	0.15	1.37	0.33
9+	1.62	0.32	1.91	0.49	1.28	0.19	1.59	0.31	1.41	0.34	1.59	0.27
10+	1.79	0.40	1.77	0.33	1.30	0.30	1.86	0.49	1.47	0.27	1.51	0.29
11+	1.64	0.41	2.28	0.55	1.54	0.51	1.69	0.38	1.51	0.34	1.82	0.43
12+	1.71	0.37	2.05	0.41	1.58	0.31	1.79	0.45	1.51	0.30	1.54	0.22
13+	1.80	0.31	2.55	0.38	1.74	0.32	1.99	0.73	1.62	0.42	1.83	0.37
14+	1.82	0.49	2.34	0.75	1.51	0.38	2.55	0.68	1.70	0.47	1.59	0.25
15+	1.76	0.30	2.48	0.65	1.92	0.34	2.62	0.79	1.67	0.41	1.87	0.42
16+	1.90	0.40	2.41	0.86	1.76	0.34	2.63	0.89	1.56	0.40	1.76	0.39
17+	1.90	0.52	2.10	0.39	1.87	0.37	2.23	0.71	1.81	0.49	1.60	0.35
18+	1.95	0.21	2.34	0.56	1.85	0.39	2.08	0.52	1.72	0.43	1.60	0.33
>19+	1.78	0.34	1.80	0.57	1.81	0.50	2.15	0.84	1.61	0.39	1.66	0.44
Mesomorphy Ratings												
8+	1.81	0.81	1.81	0.68	1.67	0.60	1.43	0.72	2.26	0.46	1.84	0.46
9+	1.95	0.81	1.47	0.48	2.03	0.81	1.16	0.68	2.01	0.56	1.62	0.70
10+	1.75	0.47	2.07	0.64	1.77	0.65	1.31	0.61	2.13	0.69	1.24	0.69
11+	1.45	0.63	1.95	0.74	1.34	0.69	1.73	0.68	2.13	0.90	1.46	0.67
12+	1.86	0.53	1.55	0.90	1.59	0.67	1.89	0.71	2.32	0.92	1.80	0.79
13+	1.66	0.66	2.01	0.82	1.52	0.82	1.62	1.27	2.37	0.94	2.59	0.72
14+	1.25	0.72	1.92	0.97	1.57	0.73	2.01	0.59	2.14	0.89	2.21	0.62
15+	1.19	0.36	2.05	0.67	2.41	0.63	2.28	0.79	2.10	1.05	2.59	0.80
16+	1.50	0.93	2.65	0.62	1.89	0.87	1.61	1.02	2.75	0.88	1.95	1.33
17+	1.72	0.83	2.55	0.64	1.32	0.61	2.37	0.81	2.65	0.73	2.31	1.17
18+	1.06	0.94	2.11	0.74	1.89	0.79	2.54	1.06	2.34	1.48	2.56	1.27
>19+	2.37	0.82	2.90	0.75	2.21	0.95	2.55	0.91	2.10	0.90	2.00	0.76
Ectomorphy Ratings												
8+	5.25	1.12	5.27	0.89	6.14	1.72	6.70	1.52	4.81	1.33	5.86	1.08
9+	5.14	0.76	4.98	1.85	5.73	0.74	5.90	1.76	5.51	1.31	6.02	1.47
10+	5.23	0.81	5.22	1.21	6.72	1.07	5.61	1.05	5.46	1.41	6.36	0.92
11+	5.84	0.83	5.14	1.44	6.69	1.03	5.45	1.18	6.34	1.92	6.30	1.28
12+	5.86	0.92	5.29	0.73	6.37	1.33	5.53	0.80	4.77	0.95	6.53	1.31
13+	6.17	0.92	5.02	1.38	5.72	1.29	5.85	1.83	5.42	1.02	5.23	1.20
14+	5.20	0.50	5.68	1.19	6.51	1.09	4.46	0.98	5.69	0.97	5.33	1.11
15+	5.31	0.61	5.42	1.13	5.91	0.70	4.71	0.93	5.63	1.56	4.91	1.48
16+	5.51	0.74	4.79	1.10	6.29	1.45	4.41	1.02	5.77	1.18	5.92	1.52
17+	6.63	0.82	5.50	1.07	6.41	0.77	4.79	1.12	5.17	0.73	5.88	1.06
18+	6.61	0.87	4.56	0.78	6.02	0.84	4.79	0.79	5.32	0.83	5.27	1.49
>19+	6.29	0.94	5.23	1.04	6.14	1.08	4.51	1.25	6.10	1.24	5.35	1.10

ciencies in muscular strength and working capacity (Spurr, 1988). Study of body physique reveals that in all the tribal groups ectomorphic component is dominant, which indicates their linear physique. This is also reflective of their overall poor conditions and undernutrition prevailing in the area. Both males and females of Bhils show least endomorphy rating i.e. lowest relative fatness and highest ectomorphy rating indicating linear physique than the other tribal groups.

High prevalence of ectomorphic component in all the tribal groups may be attributed to the difference in their gene pools or the environment. This could also be due to the undernutrition and other environmental pressures prevalent in the community as they vastly influence the physique and body composition (Kansal, 1981; Rangan, 1982; Tanner and Whitehouse, 1982; Eiben, 1985). Lower socio-economic classes have less height-weight ratio (HWR) than the upper socio-economic class and are therefore, more linear or ectomorphic as reported by Clements and Pickett (1952, 1954a, 1957), Healy (1952), Hammond (1953). Study by Prakash and Malik (1989) reported more ectomorphy in smokers than nonsmokers as smoking reduces lung functions, increases disorders in digestive tract and impairs human body functions in many other ways. The present study tribal groups show a high rate of smoking which also affects the overall anthropometric somatotypes, giving them a more linear build. The causes of socio-economic differential may be due to nutrition where, in the present study population inadequate diet with no regular meals, high intake of liquor and tobacco, unfavorable living conditions like *kuchcha* houses with no separate lavatory facility, unhygienic surroundings, and lack of medical facilities are rampant.

The development of the growing child, though chiefly determined by the inherent genetic potential, is equally influenced by environmental stresses, revealing that the two sets of factors are not entirely independent of each other. In the present study also, at all stages of life environmental factors are constantly conditioning and modifying the expression of inherited potentials. Other factors like socio-economic conditions and nutrition also influence decisively the environment in which the growing child develops.

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