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Skeletal Frame Size of Spitian Children

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ABSTRACT The present study aims at elucidating the age changes in the frame size from skeletal diameters of boys inhabiting Spiti valley (Himachal Pradesh) of the North Western Himalayas, India. The present cross sectional study has been conducted on Spitian boys, ranging in age from 5 to 20 years. Skeletal measurements of humerus bicondylar diameter, femur bicondylar diameter, biacromial diameter and bicristal diameter were taken on 636 subjects during 1996-1998 from various areas of Spiti valley. Metropolitan Life Insurance Company (1983) gave its own standards for American men on the basis of humerus bicondylar diameter according to their body size (height). The frame size was termed as 'small' (<6.4 cm), 'medium' (6.4 to 7.2 cm) and 'large' (> 7.2 cm). According to the Metropolitan Life Insurance Company standards also, the Spitian young adults between 18 to 20 years can be designated as on the 'borderline' between the small and medium frame size. Comparison of the mean values of humerus and femur bicondylar diameters expressed in percentage of their adult values amongst themselves indicate that it is femur bicondylar diameter which surpasses in maturity to humerus bicondylar diameter up to 15 years. However, after the age of 15 years, humerus bicondylar diameter is ahead of femur bicondylar diameter in its maturity status.

INTRODUCTION

Human physique as described by Sheldon et al. (1940) encompasses three components, viz., endomorphy, mesomorphy and ectomorphy. Endomorphy represents relative fatness, mesomorphy the relative musculo-skeletal development and ectomorphy the relative linearity. One of the major constituents of mesomorphy is the robustness of the skeletal frame. According to Carter and Heath (1990) the persons with relatively less muscles but with a broad and well developed skeleton can be rated up to 5 in mesomorphy, a relatively very high value. Similarly persons with well developed muscles but with a fragile skeleton can also be rated up to a value of 5. However, both these types of persons can not be rated above 5 for mesomorphy. It is mandatory to have equally developed muscles and skeleton if a person is to achieve a value of 6 or 7 for mesomorphy. Skeletal frame of the individual is thus an important characteristic which not only determines his physique but provides an idea about the toughness of the human body in much the same way as the foundation of a building determines its stability. Behnke (1959) who was one of the pioneers of human body composition research, was of the opinion that body widths are also the important determinants of fat-free mass. In a way, the indicators of skeletal frame which are the bone widths also contribute towards body composition. Skeletal frame has an interesting application in clothing and equipment design for human use.

Many researchers tried to estimate the skeletal frame size with the help of anthropometric measurements. Notable among them were the humerus bicondylar width, the wrist breadth and chest breadth (Grant, 1980; Frisancho and Flegel, 1983; Garn et al., 1983; Frisancho, 1984). In United States, Metropolitan Life Insurance Company (1983) recommended elbow width (humerus bicondylar diameter) as an estimator of skeletal frame. It made three categories of skeletal frame as small, medium and large for use in insurance purposes. The persons falling with the range of 25^{th} and 75^{th} centiles were referred to as being medium, those below 25^{th} centile as small and above 75^{th} centile as large. Himes and Bouchard (1985) studied the correlations between various skeletal diameters and percent of body fat among French Canadians. The findings conclusively indicated that wrist and ankle breadths gave almost zero correlation with body fat and hence can be taken as good indicators of skeletal frame size. There are very few studies on the age changes in skeletal frames of different populations. The present study aims at elucidating the age changes in the frame size with the help of skeletal diameters of boys inhabiting Spiti valley (Himachal Pradesh) of the North Western Himalayas, India.

MATERIAL AND METHODS

The present cross sectional study has been conducted on Spitian boys, ranging in age from 5 to 20 years. Skeletal measurements of humerus bicondylar diameter, femur bicondylar diameter, biacromial diameter and bicristal diameter were taken on 636 subjects during 1996-1998 from various areas of Spiti valley by PPS. These areas range in altitude between 3500 - 4200 meters above mean-sea-level. The Spitian tribe enjoys a special place in the Diaspora of the populations of Himachal Pradesh by virtue of their uncanny ability to survive and procreate at high altitudes. Spiti valley is in geographical proximity to the Tibetan Province of People's Republic of China. This population has overbearing Mongoloid features and have been living in virtual isolation due to lofty mountainous barriers and thus seem to have kept an intact gene pool. .

The age of every child was calculated from the date of birth and the date of examination. The birth dates were taken from the school registers in case of school going children and from the parents of those children who did not attend the school. Yearly age groups were formed so as the mid-point coincided with the whole year figure, e.g., all subjects from 4.500 to 5.499 years were included in 5- year age group, those from 5.500 to 6.499 years in the 6- year age group and so on. The measurements were taken following the techniques of Carter and Heath (1990).

RESULTS

In Spitian boys, the mean humerus bicondylar diameter is 4.31 cm at the age of 5 years which attains the maximum mean value of 6.44 cm at 20 years of age (Table 1). The maximum yearly gain of 0.37 cm takes place during 11-12 years old. The total gain from 5 years to 20 years in humerus bicondylar width is 2.13 cm which amounts to 33.07% of the maximum adult value.

The mean value of femur bicondylar diameter is 6.57 cm at the age of 5 years in Spitian boys. There is a gradual increase in it with the advancement of age and it ultimately records a value of 9.17 cm at the age of 20 years (Table 2). The total increment in femur bicondylar diameter during this period is 2.6 cm, which is 28.35% of its maximum adult value obtained at the age of 20 years.

Table 1: Humerus bicondylar diameter (cm) of Spitian Males.

Age	*No.*	*Mean*	*S.D*	*S.E.M*	*C.V*	*Gain/yr.*
5	37	4.31	0.30	0.05	6.96	-
6	37	4.32	0.25	0.04	5.79	0.01
7	40	4.58	0.56	0.09	12.23	0.26
8	40	4.59	0.27	0.04	5.88	0.01
9	36	4.88	0.38	0.06	7.79	0.29
10	36	5.10	0.62	0.10	12.16	0.22
11	46	5.27	0.53	0.08	10.06	0.17
12	70	5.64	1.42	0.17	25.18	0.37
13	37	5.62	0.52	0.09	9.25	-0.02
14	33	5.71	0.46	0.08	8.06	0.09
15	38	5.97	0.67	0.11	11.22	0.26
16	45	6.21	0.43	0.06	6.92	0.24
17	40	6.29	0.50	0.08	7.95	0.08
18	38	6.39	0.49	0.08	7.67	0.10
19	33	6.41	0.49	0.09	7.64	0.02
20	30	6.44	0.61	0.11	9.47	0.03

Table 2: Femur bicondylar diameter (cm) of Spitian Males.

Age	*No.*	*Mean*	*S.D*	*S.E.M*	*C.V*	*Gain/yr.*
5	37	6.57	0.46	0.08	7.00	-
6	37	6.65	0.39	0.06	3.76	0.08
7	40	6.67	0.68	0.11	10.19	0.02
8	40	6.98	0.52	0.08	7.45	0.31
9	36	7.32	0.40	0.07	5.46	0.34
10	36	7.45	0.61	0.10	8.19	0.13
11	46	7.75	0.55	0.08	7.10	0.30
12	70	7.77	0.85	1.10	10.94	0.02
13	37	8.03	0.72	0.12	8.97	0.26
14	33	8.25	0.89	0.15	10.30	0.22
15	38	8.51	0.68	0.11	7.99	0.26
16	45	8.65	0.46	0.07	5.32	0.14
17	40	8.66	0.61	0.10	7.04	0.01
18	38	8.87	0.86	0.20	9.70	0.21
19	33	9.13	0.59	0.10	6.46	0.26
20	30	9.17	0.73	0.13	7.96	0.04

The mean value of biacromial diameter in Spitian males increases continuously from 22.1 cm at the age of 5 years to a value of 39.3 cm at the age of 20 years (Table 3). During these years (5 years to 20 years) the total increase in shoulder width is 17.2 cm, and it amounts to 43.77% of the maximum adult value achieved at the age of 20 years.

Bicristal diameter of Spitian males from 5 to 20 years is presented in Table 4. At the age of 5 years, the mean value of bicristal diameter is 16.7 cm which increases to 29.9 cm at the age of 20 years. There is a trend of general increase in bicristal diameter from 5 years to 20 years of age with a total increment of 13.2 cm. The increase for hip width during this period is

Table 3: Biacromial diameter (cm) of Spitian Males.

Age	*Number*	*Mean*	*S.D*	*S.E.M*	*C.V*	*Gain/yr.*
5	37	22.1	1.13	0.19	5.11	-
6	37	22.8	1.37	0.22	6.01	0.70
7	40	23.9	1.91	0.30	7.99	1.10
8	40	24.8	1.46	0.23	5.89	0.90
9	36	25.9	1.91	0.32	7.37	1.10
10	36	26.8	2.29	0.38	8.54	0.90
11	46	27.8	2.09	0.31	7.52	1.00
12	70	28.9	1.89	0.23	6.54	1.10
13	37	30.3	2.48	0.41	8.18	1.40
14	33	31.0	3.27	0.57	10.55	0.70
15	38	32.1	3.12	0.51	9.72	1.10
16	45	33.7	2.40	0.36	7.12	1.60
17	40	34.0	3.15	0.50	9.26	0.30
18	38	35.3	2.76	0.45	7.82	1.30
19	33	38.1	3.97	0.69	10.42	2.80
20	30	39.3	3.62	0.66	9.21	1.20

Table 4: Bicristal diameter (cm) of Spitian Males.

Age	*No.*	*Mean*	*S.D*	*S.E.M*	*C.V*	*Gain/yr.*
5	37	16.7	1.30	0.21	7.78	-
6	37	17.2	1.15	0.19	6.69	0.50
7	40	17.9	1.04	0.16	5.81	0.70
8	40	18.3	1.11	0.18	6.07	0.40
9	36	19.5	1.42	0.24	7.28	1.20
10	36	19.9	1.61	0.27	8.09	0.40
11	46	20.4	2.36	0.35	11.57	0.50
12	70	21.4	2.72	0.33	12.71	1.00
13	37	21.3	1.49	0.24	7.00	-0.10
14	33	22.1	2.10	0.37	9.50	0.80
15	38	22.6	2.00	0.32	8.85	0.50
16	45	23.6	2.01	0.30	8.52	1.00
17	40	24.0	2.07	0.33	8.63	0.40
18	38	25.5	2.14	0.35	8.39	1.50
19	33	29.9	4.44	0.77	14.85	4.40
20	30	29.9	4.42	0.81	14.78	0.00

44.15% of the maximum adult value obtained at the age of 20 years.

DISCUSSION

Humerus bicondylar diameter categories for American men in the age range of 18-24 years reported by Frisancho (1984) were 'small' (≤6.6 cm), 'medium' (6.7 to 7.6 cm) and 'large' (≥7.7cm). The humerus bicondylar diameter of the present sample between the ages of 18 to 20 years is from 6.39 cm to 6.44 cm. Judging by the above standards, the present Spitian boys have a 'small skeletal frame size'. Since the American men are taller than the Spitians therefore a comparison of skeletal frame measurements in absolute terms seems flawed. In ordre to overcome this difficulty, it is advisable to compare the skeletal diameters for similar heights. Metropolitan Life Insurance Company (1983) gave its own standards for American men on the basis of humerus bicondylar diameter according to their body size (height). The frame size were termed as 'small' (.<6.4 cm), 'medium' (6.4 to 7.2 cm) and 'large' (> 7.2 cm). According to these Metropolitan Life Insurance Company standards also, the Spitian young adults between 18 to 20 years can be designated as on the 'borderline' between the small and medium frame size. Thus the Spitians are lightly built than the Americans. However, the ethnic variations and differences always exist in the body measurements which may well be attributed to the adaptive strategies of the specific populations to their own environmental conditions.

The mean values of humerus and femur bicondylar diameters expressed in percentage of their adult values indicate that it is femur bicondylar diameter which surpasses in maturity to humerus bicondylar diameter up to 15 years. However, after the age of 15 years, humerus bicondylar diameter is ahead of femur bicondylar diameter in its maturity status. It means in general the skeletal diameter of lower extremity is faster in development up to adolescence than that of the upper extremity. The biacromial and bicristal diameter have shown the picture where shoulder width is ahead in maturity to the hip width. Regarding the mechanism of origin of growth gradients in the extremities, Tanner (1978) pointed out that "in the embryonic limb bud, before any differences between the three segments can be discerned, there must be differences in the concentration of some chemical substance. Thus a concentration gradient of the chemical substance leads eventually to a maturity gradient in developing physical structure." The growth gradients in different populations have been described and elicited by many authors. These studies have indicated that by and large the hand is always ahead in maturity to forearm and upper arm. Similarly in the lower extremity, the foot is nearer its mature value to that of calf and thigh. In the body, head is always advanced in maturity to trunk which in turn is ahead of the lower extremity (Davenport, 1932; Sidhu, 1969; Nath, 1987; Kaur et al., 2000 and Singh, 2000).

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