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IMPACT OF HIGH ALTITUDE ON BODY SHAPE

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Abstract: A somatotype compresses a lot of information into a reliable form that can be comprehended as compared to isolated values of lengths, girths, breadths and skinfold thicknesses. It provides one of the simplest and the most economical descriptions of the human form. To study body shape changes 274 children from the high altitude (3.534 m) ranges of Ladakh (India) and 121 ethnically similar children from the lowland (Kulu Valley), in the age range of 11 to 19 years, were anthropometrically somatotyped, using Heath and Cater's method.

Salient features of the study are that highlanders are more mesomorphic, more ectomorphic and less endomorphic than the lowlanders, at all ages. In view of the difficult terrain and increase workload, greater mesomorphy among high altitude boys is quite expected. Lower endomorphy and greater ectomorphy among highlander boys, however, seems to be the result of number of interacting, perhaps in the opposite direction, forces, such as, hypoxia, cold, difficult terrain, work-load and undernourishment. More than the cold environment, the conditions of hypoxia, heavy work-load and undernourishment seem to maintain this kind of somatotype among the highlanders.

Key words: Body shape, High altitude, Somatotype, India.

Introduction

Adaptation of a population to its environment may be measured at least in two ways. Firstly, by examining growth and development of individuals and secondly by studying population growth in relation to reproductive performance. Studies of human growth and development have been quite popular in measuring the overall health status and adaptive fitness of population at high altitude (HA). Our earlier researches on high altitude Bods have demonstrated that Bods were well-adapted to high altitude stresses in terms of cardio-respiratory functions. Nonetheless their growth patterns were affected in number of ways (Malik 1976, 1984, Malik and Singh 1978, 1984). In particular high altitude male Bods showed slower and prolonged growth, and a non-clear adolescent spurt in stature.

The present study elucidates the impact of high altitude stresses on the anthropometric somatotype, i.e. body shape. The aims of the study are the following: (1) To study changes in the anthropometric somatotypes with age among high (HA) and low altitude (LA) Bods in the age range of 12 to 18 years. (2) To make age groupwise comparison of individual somatotype component viz., endomorphy, mesomorphy and ectomorphy, and (3) To make comparison of somatotypes with other reported Indian Populations in this age range.

Material and Methods

Leh (34°09'N–77°34'E), where the present study was conducted, is the headquarter of Ladakh distict of Jammu and Kashmir. It is one of the highest parts of the globe with permanent human habitation (3514 m). The climate of Leh is characterised by a number of complex and interlinked stresses, such as reduced atmospheric and oxygen pressure, increased cold, difficult terrain, elevated atmospheric aridity and solar radiation.

Although a detailed survey in the area is still lacking, but scanty vegetation, that too along the river Indus, suggests that the population must be living under poor nutritional

condition. This condition is accentuated in those parts of the district where transport/communication is poor. As only a few can be supported under such poor economical and harsh environmental conditions therefore the population density is very low (approx. 2 persons/sq km).

Compared to Leh(Ladakh), the Kullu valley, where a section of Bods have migrated centuries ago, is lashy green. Its pleasant environment, abundance of fruits and scenic beauty attracts thousands of tourists every year. Unlike high altitude there is plenty of rainfall and the climate, in general, is not that harsh. Although this migrant group still maintains the old traditions but it is likely that they have better nutritional conditions and the workload is not as much as in the high altitude. For comparison a sample from this population was extracted.

Anthropometric measurements, viz., stature, weight, skinfolds at triceps, subscapular, suprailiac and calf, bicondylar humerus, bicondylar femur, upper arm and calf circumference were taken following the standard techniques (Tanner et al. 1969, Carter 1975). Subjects were somatotyped using the above measurements following the method of Heath and Carter applicable for children (Heath and Carter 1967, Carter 1975). Somatotype dispersion distance (SDD) was calculated using the formula of Ross and Wilson (1973) and migratory distance was calculated as per the formula of Pařízková and Carter (1976). Heath and Carter have advocated the use of photographs, along with the anthropometric somatotyping, specially for children but at the same time maintain that anthropometric somatotypes under special circumstances serve the purpose efficiently even in absence of photographs.

A total sample of 233 male Bods in the age range of 12 to 18 years were measured and somatotyped from the high altitude ranges of Leh, Ladakh (3514 m). For comparison, 121 boys were sampled, in the same age range, from the migrant Bods settled in Kullu valley.

Results and Discussion

A somatotype compresses a lot of information into a reliable form that can be comprehended extensively as compared to isolated values of lengths, girths, breadths, and skinfold thicknesses. It provides one of the simplest and the most economical description of human form, particularly the body shape. Numerous researchers have used the method of anthropometric somatotype given by Heath and Carter to analyse body shape changes in various situations (Araujo 1977, Slaughter et al. 1977, Guimaraes and De Rose 1980), and in various ages (Eiben 1985, and others).

It is evident from the mean migratory distance (HA=19.26, LA=18.70) that the body shape changes are slightly more at high altitude than at the low altitude, in the age range of 12 to 18 years. Average somatotype distance from the mean somatotype of their respective age group is more in the high altitude than in the low altitude for the age groups 12, 13, 16, and 18 (Figs 1–2, Table 1). Dispersion in somatotype distance is, however, more in all the age groups at high altitude than at the low altitude (Fig. 1). This reflects that individuals at high altitude differ much more from each other in the same age group. Whether high altitude environment is responsible for this, is not clear. One of the reasons could be that the lowlanders are represented by a relatively more homogeneous group as one would expect that a relatively more homogeneous group would segregate during onset of migration.

In the mean somatotypes, however, both the highlander and lowlander Bods in their all age groups are in the mesomorph-ectomorph channel, generally on the lower side of

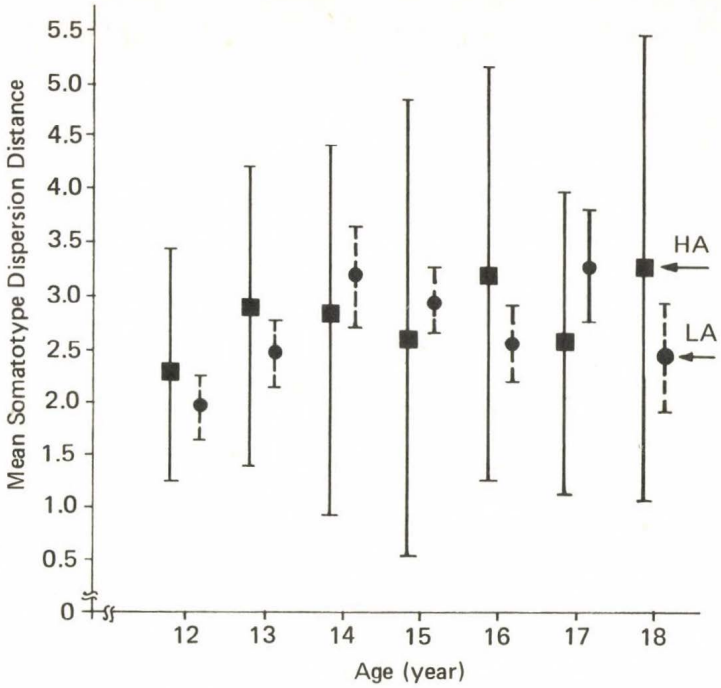

Fig. 1: Mean Somatotype Dispersion Distance among high and low altitude male Bods, in the age range of 12 to 18 years.

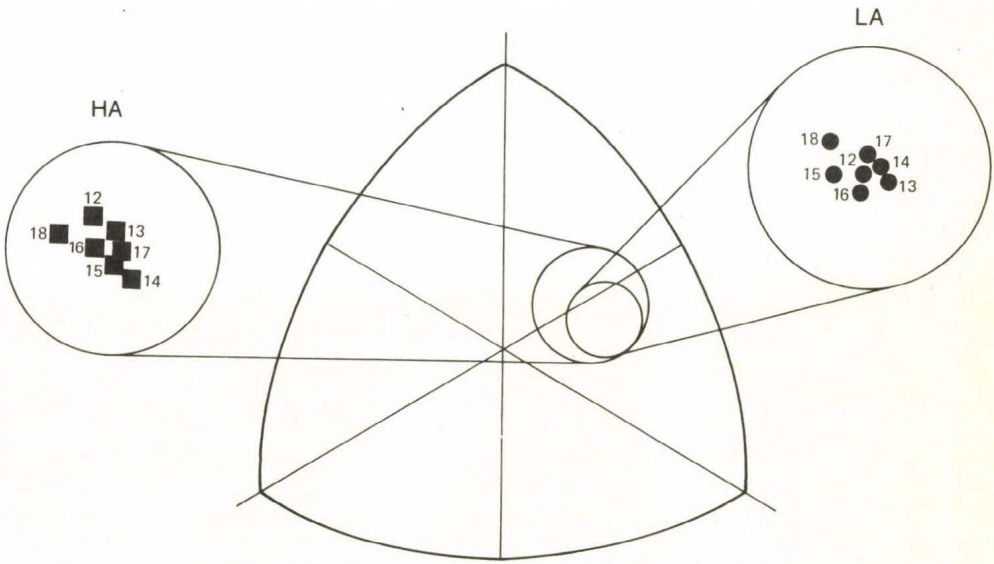

Fig. 2: Migratory distances from 12 to 18 year among high and low altitude male Bods

Table 1. Mean values of Somatotype Dispersion Distance along with their Standard Error and Variance among the High Altitude and Low Altitude male Bods

Age Group	High Altitude Mean	S.E.	DSD	Low Altitude Mean	S.E.	DSD
12	2.34	0.22	1.09	1.95	0.28	1.10
13	2.80	0.29	1.41	2.49	0.28	1.27
14	2.67	0.31	1.78	3.14	0.44	1.96
15	2.51	0.32	2.02	2.94	0.33	1.40
16	3.17	0.25	1.95	2.49	0.29	1.33
17	2.53	0.25	1.41	3.25	0.52	2.02
18	3.24	0.47	2.16	2.44	0.46	1.52

the endomorphy axis. As a comparison, the authors cite the results of the somatotype analysis of the Körmend Growth Study (K–78 investigation; Eiben 1985). The mean somatotypes of the Körmend boys in the same age groups are in the central region of the somatochart. The Körmend boys are much endomorphic (the values of their first component in age groups in question vary between 3.02 and 3.44), somewhat less mesomorphic (the values of their second component are 3.31–3.75), and less ectomorphic (3.21–3.90). These values are closer to lowlander Bod boys than the highlander ones, and the differences of somatotype components in Körmend boys compared to Bods are parts of the general differences in Asian and European boys' physique.

An analysis of individual somatotype components reveals that highlanders are less endomorphic than the lowlander Bods (Table 2). In view of the fact that fat and more endomorphic people are better adapted to cold, it is paradoxical to observe lower endomorphy among the highlanders. Štěpnička (1972, 1974, 1976) observed that more endomorphic people require greater amount of energy, to conduct same amount of work, resulting in a negative relationship between endomorphy and physical activity requiring strength and stamina. Conditions of undernutrition and low oxygen pressure limit the release of energy, on one hand, while on the other, workload is enhanced due to difficult terrain at high altitude. Succinctly all these stresses collectively outweigh the stress of cold and result into lower endomorphy. Adaptation to cold, however, takes place by cultural factors, rather than the biological ones, by utilising and conservating heat efficiently (Malik 1984).

Greater mesomorphy at high altitude, as compared to low altitude, is as expected under the conditions of difficult terrain and increased workload (Table 2) in view of positive association between mesomorphic component and physical activity (DeGaray et al. 1974, Štěpnička et al. 1976).

Highlander Bods are more ectomorphic than the lowlander Bods (Table 2). Better living conditions, specially better nutritional intake and lesser physical activity could be some of the factors responsible for the reduction of ectomorphy at low altitude.

Only limited number of studies have been conducted in India on somatotypes of children (Singh and Sidhu 1980, Parkash et al. 1986). Compared to Gaddis (Singh and Sidhu 1980) and Santhals (Parkash et al. 1986), Bods at high altitude have markedly greater ectomorphy. In endomorphy, however, they are closer to Gaddis as compared to Santhals who are living under extremely poor nutritional and hygienic conditions and as such have lower endomorphy. Greater mesomorphy and ectomorphy among highlander Bods, as compared to other Indian populations seem to be largely adaptive in nature and a result of various interlinked stresses at high altitude.

Table 2. Age groupwise comparison in endomorphy, mesomorphy, and ectomorphy between High Altitude and Low Altitude male Bods

Age (year)	High Altitude (□) N	Endomorphy Mean	Endomorphy S.E.	Mesomorphy Mean	Mesomorphy S.E.	Ectomorphy Mean	Ectomorphy S.E.	Low Altitude (o) N	Endomorphy Mean	Endomorphy S.E.	Mesomorphy Mean	Mesomorphy S.E.	Ectomorphy Mean	Ectomorphy S.E.
12	24	1.51	0.08	4.27	0.13	4.09	0.14	16	1.76	0.12	3.87	0.14	4.08	0.14
13	24	1.46	0.10	4.31	0.13	4.31	0.19	20	1.74	0.09	3.64	0.16	4.26	0.19
14	33	1.55	0.06	3.74	0.14	4.51	0.17	20	1.82	0.09	3.73	0.25	4.24	0.21
15	41	1.58	0.06	4.15	0.15	4.39	0.12	18	2.23	0.17	3.91	0.16	3.93	0.21
16	59	1.62	0.07	4.09	0.12	4.26	0.14	21	1.81	0.09	3.56	0.18	4.04	0.19
17	31	1.51	0.06	4.05	0.11	4.28	0.16	15	1.75	0.11	3.87	0.25	3.99	0.29
18	21	1.66	0.09	3.99	0.23	3.73	0.25	11	1.94	0.13	3.87	0.28	3.65	0.16

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