

Study of Physical Growth and Respiratory Functions in Two High Altitude Populations—Bodhs and Baltis of Ladakh, Jammu and Kashmir, India

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ABSTRACT In the present paper, anthropometric and physiological variables among two high altitude groups—Bodhs and Baltis of Ladakh are being reported. 1009 male subjects from age 8 to 50 years have been incorporated in the study. The subjects were studied for twenty three anthropometric and three respiratory variables. In general, Bodhs show higher values of various anthropometric variables, whereas a mixed trend has been observed for respiratory functions. Poor growth spurt has been observed in both the population groups.

Every ecological situation involves complex interactions between the various components of an environment. Physical elements interact with each other to determine the total impact they make on living organisms, and these biotic elements not only determine each other but react back to affect physical conditions. There are many components in the successful occupation of an environment, individual adaptability at both physiological and developmental levels, specific genetic adaptations produced by natural selection in the environment.

There has been two schools of thought regarding growth trends of highlanders. Studies on Andean populations have established that they have relatively greater chest circumference than their counterparts at low altitude, other features are lower body mass, prolonged growth period and poorly defined growth spurt (Baker, 1969; Hoff, 1973). Whereas findings on Ethiopian and some Himalayan populations (Clegg et al., 1972; Harrison et al., 1969, Malik and Singh, 1978) have established that high altitude children have higher body weight, and are taller than their low altitude counterparts.

Keeping in mind, above views, an attempt has been made to study anthropometric and physiological variables in two high altitude population

groups—Bodhs and Baltis of Ladakh division of Jammu and Kashmir.

MATERIAL AND METHODS

In the present paper two population groups of Ladakh division—Bodhs and Baltis staying in Inner Himalayan Zone are being reported. A cross-sectional sample of 1009 males were collected in 1989. Bodh sample were mostly collected from Leh district while Baltis (a Shia Muslim Community) sample were collected from Kargil district of Ladakh division. Kargil town is situated at 2750 metres and Leh town at 3500 metres above mean sea level. The sample ranged from 8+ years (9th year onwards) upto 50 years of age. The adolescent sample ranged from 8+ to 18+ year (during which most of the growth occurs); whereas all those subjects in 20th year and above were grouped as 19+ and above (adults). All the subjects aged between 8.00 to 8.99 were grouped in 8+ year age group. Similar pattern was followed while grouping the subjects of other age groups. The age of subject's was recorded from school registers, office records and was cross checked from various sources. The age wise distribution of subjects has been given in table 1. The subjects were studied using the standard techniques after W.H.O. (1964); Weiner and Lourie (1969) and Singh and Bhasin (1989).

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Morgan's portable spirometer was used to study lung functions.

Table 1: Sample size for anthropometric and respiratory variables in Bodhs and Baltis of Ladakh, Jammu and Kashmir, India

Age Year	Age Range	Anthropometric Variables		Respiratory Functions	
		Bodhs	Baltis	Bodhs	Baltis
8+	8.00-8.99	34	37	7	6
9+	9.00-9.99	37	41	6	10
10+	10.00-10.99	41	38	8	7
11+	11.00-11.99	47	46	7	7
12+	12.00-12.99	52	44	5	8
13+	13.00-13.99	41	47	5	10
14+	14.00-14.99	43	51	6	7
15+	15.00-15.99	47	54	6	5
16+	16.00-16.99	43	46	6	7
17+	17.00-17.99	31	40	5	6
18+	18.00-18.99	33	36	4	5
19+ & above	19.00-50.00	34	46	5	5

The following measurements were taken on each subject:

A. Anthropometric Variables:

I. (1) Body Weight

II. Projective Height Measurements:

- (2) Height Vertex
- (3) Sitting Height Vertex

III. Diameters

- (4) Biacromial Diameter
- (5) Bicristal Diameter
- (6) Transverse Diameter of Chest
- (7) Antero-posterior Diameter of Chest
- (8) Humerus Bicondylar Diameter
- (9) Femur Bicondylar Diameter
- (10) Wrist Diameter
- (11) Ankle Diameter

IV. Circumferences

- (12) Chest Circumference-Normal
- (13) Chest Circumference- At maximum inspiration
- (14) Chest Circumference-At maximum expiration
- (15) Upper Arm Circumference-Relaxed
- (16) Upper Arm Circumference-Contracted
- (17) Calf Circumference

V. Skinfold Thickness

- (18) Biceps
- (19) Triceps
- (20) Subscapular
- (21) Suprailiac
- (22) Calf
- (23) Forearm

B. Physiological Variables

- (24) Forced Vital Capacity (FVC)
- (25) Forced Expiratory Volume in one second (FEV1.0)
- (26) Peak Expiratory Flow [PEF (ml/sec.)]

RESULTS AND DISCUSSION

The results of the investigation on two population groups of Ladakh *i.e.* Bodhs and Baltis are presented in table 2. The results are discussed under following heads:

- I. Body Weight,
- II. Projective Height Measurements,
- III. Diameters,
- IV. Circumferences,
- V. Skinfold Thickness and,
- VI. Respiratory Functions.

A. Anthropometric Variables:

I Body Weight:

Body weight show continuous increase from 8+ to 18+ years for both Bodhs and Baltis. Former show better body weight when compared to latter. Highest peak values corresponding to adolescent growth spurt have been observed between 13+ and 14+ years in Bodhs, whereas Baltis show almost equal increments for year 13+ and 14+, and 14+ and 15+ years of age. In the age groups 19+ and above *i.e.*, adults Bodhs show higher body weight than Baltis by one kg.

II. Projective Height Measurements:

For both height vertex and sitting height there is a continuous growth at all the yearly intervals from 8+ to 18+ years in both Bodhs and Baltis of Ladakh division. For height vertex Baltis are taller than Bodhs of Ladakh. Both the population groups show highest peak value corresponding to adolescent growth spurt between 13+ and 14+ years of age. For the age group 19+ and above also, Baltis are slightly taller than Bodhs at 8+ years but Bodhs end up taller than Baltis at 18+ years showing that increment during the period under study is higher in Bodhs than Baltis. Highest peak value for sitting height has been

Table 2: Anthropometric variables and respiratory functions in Bodhs and Baltis of Ladakh, Jammu and Kashmir, Ind

Age Years	Bodhs		Baltis		Bodhs		Baltis	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1. BODY WEIGHT (kg)				2. HEIGHT VERTEX (cm)				
8+	21.20	2.90	21.38	3.49	117.57	6.43	118.97	6.73
9+	22.88	3.46	23.22	3.17	122.53	7.69	123.66	6.69
10+	26.24	4.23	24.62	3.03	129.90	7.25	127.21	6.87
11+	28.06	4.57	25.68	2.31	132.82	6.55	129.50	4.86
12+	31.09	6.12	28.97	5.29	139.25	8.34	135.37	7.75
13+	32.33	4.81	30.03	3.69	140.40	7.85	138.14	6.96
14+	38.72	6.19	35.05	6.69	150.32	8.64	146.90	10.74
15+	41.01	4.70	40.09	5.96	154.09	5.34	153.90	8.45
16+	45.23	5.26	41.51	7.33	156.47	7.56	155.56	9.73
17+	50.48	4.62	46.35	6.78	161.76	5.88	159.00	8.52
18+	50.86	4.81	48.91	3.91	161.83	4.97	163.19	5.90
19+ & ab.	55.59	6.95	54.78	6.37	164.62	4.44	166.45	4.44
3. SITTING HEIGHT (cm)				4. BIACROMIAL DIAMETER (cm)				
8+	64.60	4.99	64.78	5.14	23.69	1.44	24.78	1.66
9+	65.79	2.78	66.42	3.23	24.38	1.68	26.58	1.36
10+	69.73	4.01	68.58	3.28	25.92	1.89	27.38	1.66
11+	69.94	3.82	68.48	3.16	26.47	1.87	27.48	1.41
12+	72.95	4.91	72.01	5.05	27.62	2.25	28.26	2.38
13+	73.06	4.26	72.05	3.83	29.18	2.45	28.95	2.08
14+	78.03	4.95	75.59	5.04	30.65	2.18	30.55	2.82
15+	79.95	3.60	79.98	5.43	31.50	2.12	32.89	2.50
16+	81.60	4.95	81.71	5.47	33.08	2.79	33.43	2.70
17+	84.39	3.42	82.59	5.50	35.69	1.99	35.29	2.62
18+	85.54	4.41	84.32	5.71	36.98	2.02	36.56	1.75
19+ & ab.	86.52	3.15	87.14	3.68	36.24	2.23	37.46	2.68
5. BICRISTAL DIAMETER (cm)				6. TRANSVERSE DIAMETER OF CHEST (cm)				
8+	17.50	1.35	18.84	1.63	16.06	1.28	17.51	1.74
9+	18.06	1.25	20.30	1.17	16.92	1.23	19.22	1.53
10+	19.64	1.84	20.81	1.48	17.87	1.75	19.59	1.41
11+	19.83	1.86	20.95	1.51	18.02	1.90	19.37	1.62
12+	20.53	1.68	21.79	1.94	18.55	1.80	19.50	1.80
13+	21.94	1.96	22.22	1.70	19.72	1.92	19.84	1.75
14+	23.19	2.53	23.64	2.26	20.76	1.55	20.77	2.06
15+	24.25	2.26	25.52	2.18	21.30	1.86	22.26	1.95
16+	24.56	2.37	26.10	2.54	22.19	2.33	22.59	2.22
17+	26.26	1.63	27.22	1.98	24.00	2.18	24.27	2.05
18+	27.84	2.14	28.08	1.32	25.40	1.72	24.88	1.89
19+ & ab.	27.89	1.96	28.20	1.61	25.44	3.01	25.56	1.58
7. ANTERO-POSTERIOR DIAMETER (cm)				8. HUMERUS BI-CONDYLAR (cm)				
8+	12.03	1.60	13.58	1.81	4.67	0.39	4.52	0.25
9+	12.25	1.45	14.70	1.34	4.83	0.73	4.75	0.30
10+	13.05	1.78	14.56	1.31	5.03	0.41	4.86	0.36
11+	12.91	1.68	14.56	1.24	5.25	0.41	4.97	0.35
12+	12.94	1.36	14.49	1.52	5.50	0.46	5.25	0.41
13+	14.07	1.51	14.72	1.58	5.53	0.54	5.36	0.39
14+	14.78	1.70	15.69	1.84	5.90	0.44	5.62	0.47
15+	15.11	1.60	16.49	1.55	6.04	0.36	6.02	0.42
16+	16.24	2.02	16.81	1.61	6.19	0.37	5.99	0.52
17+	17.05	1.59	17.68	1.51	6.47	0.28	6.19	0.34

ab. = above

Age Years	Bodhs		Baltis		Bodhs		Baltis		
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
18+	19.16	1.71	18.25	1.10	6.42	0.36	6.26	0.34	
19+ & ab.	18.76	2.28	19.10	1.49	6.45	0.31	6.40	0.30	
9. FEMUR BI-CONDYLAR DIAMETER (cm)					10. WRIST DIAMETER (cm)				
8+	7.05	0.52	7.19	0.37	3.80	0.27	3.72	0.44	
9+	6.99	0.48	7.30	0.44	3.78	0.33	3.86	0.27	
10+	7.45	0.58	7.49	0.40	4.11	0.33	3.97	0.28	
11+	7.66	0.61	7.60	0.39	4.18	0.29	4.03	0.28	
12+	7.86	0.51	7.86	0.43	4.38	0.36	4.17	0.30	
13+	8.05	0.50	8.03	0.45	4.49	0.34	4.36	0.29	
14+	8.31	0.54	8.36	0.51	4.74	0.33	4.56	0.41	
15+	8.57	0.40	8.58	0.38	4.92	0.30	4.80	0.29	
16+	8.70	0.45	8.60	0.56	4.94	0.28	4.81	0.41	
17+	8.89	0.27	8.71	0.39	5.13	0.29	4.95	0.32	
18+	8.78	0.52	8.77	0.50	5.17	0.42	4.94	0.27	
19+ & ab.	9.01	0.51	8.88	0.32	5.18	0.27	5.10	0.37	
11. ANKLE DIAMETER (cm)					12. CHEST CIRCUMFERENCE INSPIRED (cm)				
8+	5.39	0.45	5.28	0.52	64.26	3.65	63.91	3.29	
9+	5.58	0.44	5.71	0.39	65.81	4.30	67.22	3.32	
10+	5.90	0.53	5.88	0.46	69.13	4.30	67.12	3.63	
11+	6.08	0.42	5.95	0.40	70.81	4.98	68.83	3.62	
12+	6.27	0.48	6.21	0.41	73.22	4.53	71.72	4.70	
13+	6.42	0.45	6.34	0.43	75.10	4.77	73.14	3.67	
14+	6.60	0.41	6.64	0.52	79.82	5.73	77.06	5.55	
15+	6.84	0.40	6.85	0.39	80.79	4.39	81.42	4.56	
16+	6.83	0.36	6.74	0.47	84.72	4.97	80.83	6.51	
17+	7.08	0.49	6.93	0.46	89.93	4.32	84.79	5.38	
18+	7.01	0.49	7.00	0.41	86.83	3.37	85.54	3.58	
19+ & ab.	7.28	0.56	7.16	0.48	93.49	5.66	92.78	4.44	
13. CHEST CIRCUMFERENCE-NORMAL (cm)					14. CHEST CIRCUMFERENCE-EXPIRED (cm)				
8+	60.93	3.45	59.39	2.83	58.76	3.29	56.83	3.17	
9+	62.21	3.62	62.00	3.40	59.80	3.55	59.31	2.80	
10+	65.56	3.91	62.47	3.50	62.99	3.62	59.89	3.64	
11+	66.90	4.46	63.83	3.71	64.35	4.09	61.10	3.32	
12+	68.36	4.68	66.78	4.84	65.89	4.73	64.20	4.51	
13+	70.75	4.38	67.83	3.65	68.01	4.31	64.96	3.30	
14+	74.89	5.66	71.75	5.85	72.53	5.60	68.96	6.08	
15+	76.07	4.49	75.62	4.83	73.07	4.32	72.80	4.85	
16+	79.98	4.29	75.83	6.22	77.17	4.68	72.91	6.44	
17+	84.66	4.27	79.25	5.64	81.61	4.49	75.90	5.15	
18+	81.89	3.81	80.96	3.16	78.53	3.90	77.35	2.91	
19+ & ab.	89.22	4.74	89.13	4.16	85.55	4.84	83.86	9.90	
15. UPPER ARM CIRCUMFERENCE-RELAXED (cm)					16. UPPER ARM CIRCUMFERENCE-CONTRACTED (cm)				
8+	15.39	1.33	14.01	0.93	16.93	1.57	15.67	1.17	
9+	15.65	1.35	14.67	1.23	17.26	1.46	16.54	1.70	
10+	16.30	1.32	15.10	0.93	18.00	1.41	16.84	1.23	
11+	16.71	1.35	15.37	1.20	18.29	1.93	17.22	1.60	
12+	17.20	1.51	15.96	1.43	19.32	1.81	17.92	2.02	
13+	17.54	1.34	15.97	2.23	19.63	1.78	18.08	2.43	
14+	19.00	1.65	17.19	1.71	21.15	2.13	19.39	2.00	
15+	19.12	1.43	18.27	1.55	21.70	1.74	20.90	1.90	
16+	19.96	1.35	18.81	1.89	22.71	2.26	21.43	2.15	
17+	21.36	1.22	20.22	1.98	24.70	1.73	23.04	2.57	
18+	21.67	1.64	20.28	1.27	24.80	1.77	23.47	1.63	
19+ & ab.	22.08	1.36	22.06	1.80	25.22	1.87	25.27	2.38	

ab.= above

Age Years	Bodhs		Baltis		Bodhs		Baltis	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
17. CALF GIRTH (cm)				18. BICEPS SKIN-FOLD (mm)				
8+	22.14	1.83	21.06	1.52	2.67	0.87	2.45	0.69
9+	22.83	1.77	21.82	1.57	2.75	1.16	2.53	0.67
10+	23.76	2.11	22.69	1.44	2.73	1.04	2.47	0.64
11+	24.40	1.80	22.74	1.43	2.70	1.19	2.47	0.80
12+	25.41	2.24	23.91	2.13	2.73	1.06	2.68	0.70
13+	25.93	2.07	24.36	1.74	2.75	0.83	2.44	0.68
14+	27.81	2.29	25.94	2.30	2.76	0.94	2.54	0.80
15+	28.19	1.94	27.24	2.11	2.74	0.97	2.77	0.69
16+	29.34	1.95	27.20	2.86	3.06	0.73	2.80	0.71
17+	31.06	1.76	28.88	2.23	3.29	0.69	2.92	0.85
18+	30.62	2.20	29.36	1.65	3.18	0.84	3.05	1.01
19+ & ab.	31.06	2.25	30.92	2.12	3.58	1.37	3.23	1.67
19. TRICEPS SKINFOLD (mm)				20. SUBSCAPULAR SKINFOLD (mm)				
8+	6.97	1.85	4.75	1.18	3.61	0.77	3.16	0.68
9+	6.21	2.12	4.82	1.32	3.43	0.72	3.56	0.63
10+	6.58	2.52	4.71	1.33	4.02	1.31	3.31	0.57
11+	6.48	2.15	5.10	1.70	3.93	1.07	3.58	0.74
12+	6.23	2.24	5.13	1.35	3.86	0.92	3.81	0.81
13+	5.95	1.56	4.78	1.45	3.95	0.94	3.74	0.79
14+	6.00	1.51	5.23	1.43	4.53	0.88	4.17	1.10
15+	5.31	1.86	4.79	1.20	4.63	0.98	4.75	0.90
16+	6.27	1.73	5.10	1.46	5.51	1.40	4.78	1.05
17+	6.48	1.82	5.80	1.36	6.77	1.78	5.95	1.37
18+	5.84	1.56	5.69	1.92	5.78	1.26	6.08	1.02
19+ & ab.	6.38	2.41	5.80	2.49	7.50	3.22	8.00	2.79
21. SUPRA-ILIAC SKINFOLD (mm)				22. CALF SKINFOLD (mm)				
8+	2.94	1.07	2.45	0.80	5.50	2.04	4.21	1.20
9+	3.13	1.22	2.43	0.70	4.70	1.95	3.82	1.20
10+	3.14	1.65	2.55	0.55	5.12	1.95	3.78	1.11
11+	3.42	1.49	2.73	0.71	4.89	2.06	4.15	1.68
12+	3.61	1.90	3.25	1.16	5.38	1.99	4.65	1.58
13+	3.36	1.17	3.17	1.02	4.85	1.61	4.02	1.37
14+	3.83	1.11	3.37	0.89	5.65	2.21	4.86	1.81
15+	3.80	0.94	3.55	0.94	5.46	2.25	4.74	1.37
16+	4.88	1.46	3.95	1.36	6.04	2.03	4.60	2.12
17+	5.22	1.17	4.57	1.61	5.74	1.52	4.82	1.37
18+	5.09	1.07	4.63	1.17	4.63	1.74	4.97	1.34
19+ & ab.	5.82	2.47	5.73	3.14	4.70	1.81	4.50	1.98
23. FOREARM SKINFOLD (mm)				24. FORCED VITAL CAPACITY (FVC-lit)				
8+	4.05	1.43	3.10	0.84	1.54	0.21	1.62	0.16
9+	3.67	1.73	2.80	0.67	1.43	0.17	1.77	0.39
10+	3.70	1.69	2.57	0.64	1.73	0.18	2.11	0.46
11+	3.25	1.37	2.80	0.98	1.89	0.27	2.30	0.10
12+	3.36	1.58	2.88	1.06	2.29	0.19	2.81	0.15
13+	3.26	1.34	2.70	0.71	2.62	0.13	2.87	0.16
14+	2.69	0.83	2.96	0.99	2.82	0.34	3.19	0.25
15+	2.82	1.02	2.77	0.57	3.23	0.25	3.32	0.28
16+	3.27	1.07	2.93	1.14	3.36	0.40	3.15	0.70
17+	3.06	0.68	3.10	0.84	3.84	0.19	3.56	0.34
18+	3.00	0.79	3.00	0.67	4.24	0.24	3.71	0.34
19+ & ab.	3.17	1.33	2.93	1.43	-	-	3.62	0.66

ab.= above

Age Years	Bodhs		Baltis		Bodhs		Baltis	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
25. FORCED EXPIRATORY VOLUME (FEV 1.0- lit)					26. PEAK EXPIRATORY FLOW [PEF (ml/sec)]			
8+	1.38	0.18	1.53	0.08	165.28	23.50	170.00	14.09
9+	1.45	0.16	1.57	0.42	160.00	28.71	201.10	43.83
10+	1.59	0.15	1.91	0.33	192.00	28.60	182.14	22.64
11+	1.80	0.25	2.05	0.25	202.28	15.47	254.28	69.60
12+	2.17	0.17	2.46	0.27	233.20	18.32	278.18	29.36
13+	2.62	0.15	2.79	0.14	242.00	21.31	300.20	12.53
14+	2.69	0.31	2.95	0.20	262.00	34.11	304.42	20.39
15+	3.11	0.21	3.04	0.32	329.00	22.50	301.20	23.44
16+	3.07	0.42	2.87	0.72	390.00	43.53	374.85	74.87
17+	3.83	0.14	3.37	0.31	393.60	52.64	336.66	39.30
18+	3.95	0.22	3.52	0.26	450.50	50.23	389.40	71.87
19+ & ab.			3.39	0.63			396.40	83.68

ab.= above

observed between 13+ and 14+ years in the former and a year later in the latter. In the age group 19+ and above again, Baltis are taller than Bodhs of Ladakh division of Jammu and Kashmir.

III. Diameters:

In all the eight diameters studied *i.e.* biacromial, bicristal, transverse and antero - posterior diameter of chest; humerus and femur bicondylar; wrist and ankle diameters with a few exceptions there has been a continuous increase at all the yearly intervals from 8+ to 18+ years in both the population groups under study. In general for all the body diameters being reported, Bodhs show higher diameter than Baltis with exception of bicristal diameter, where Baltis have higher diameter than Bodhs. Whereas in femur bicondylar diameter growth is almost similar though Bodhs show higher overall growth. It has been observed that no marked adolescent peak occurs during adolescent phase thus exhibiting a confused adolescent growth spurt. In the age group 19+ and above, Bodhs show higher diameter than Baltis for humerus bicondylar, femur bicondylar, wrist and ankle diameters, whereas for biacromial diameter, bicristal diameter, transverse and antero-posterior diameter of chest Baltis show higher diameters than their Bodh counterparts.

IV. Circumferences:

Chest circumferences have been studied at normal level; at the level of maximum inspira-

tion and at the level of maximum expiration. Other circumferences studied include arm girth at normal (relaxed) and contracted and calf circumferences.

For the chest circumference at various levels it has been observed that Bodhs show higher chest circumference as compared to Baltis. Highest peak value corresponding to adolescent growth spurt has been observed between 13+ and 14+ years for all the chest circumferences for both the population groups. For the age group 19+ and above also Bodhs show higher circumferences than Baltis of Ladakh division. For upper arm circumferences and calf circumference, higher values have been observed in Bodhs as compared to their Balti counterparts of same age. No marked adolescent growth spurt has been observed in any of the population groups. In the age group 19+ and above, for upper arm circumference (relaxed) and calf circumference, Bodhs show higher values than Baltis, whereas for upper arm circumference (contracted) Baltis show slightly higher circumference than Bodhs.

V. Skinfold Thickness:

The skinfolds have been categorized into two-one trunk skinfolds including subscapular and suprailiac, and the other the skinfolds of extremities. Whereas no regular trend has been observed for extremity fat folds, trunk skinfolds show a trend of continuous increase. Bodhs show higher skinfold as compared to Baltis in general, however for subscapular and calf skinfolds; Baltis end

up with higher value than Bodhs at 18+ years of age. For the age group 19+ and above Bodhs have higher fat folds as compared to Baltis of Ladakh.

B. Physiological Variables:

VI. Respiratory Functions:

There has been gradual increment in case of all the three lung functions; Forced Vital Capacity (FVC), Forced Expiratory Volume (FEV1.0) and Peak Expiratory Flow (PEF) from 8+ to 18+ years in Bodhs and Baltis of Ladakh division with a few exceptions (Table 2). For forced vital capacity and forced expiratory volume in one second, Baltis show higher value than Bodhs from 8+ to 15+ years, and 16+ year onwards Bodhs show higher values than Baltis. For peak expiratory flow (PEF) the trend is more or less irregularised and no clear trend emerges during adolescence. In general, no conspicuous spurt corresponding to adolescent growth spurt has been observed in any of the Ladakhi groups under study (Table 2).

Research at high altitude in the Andes has indicated that high altitude natives at various ages exhibit relatively greater chest circumference than their counterparts at low altitude (Baker, 1969; Hoff, 1973) Indirectly it may suggest higher lung capacity of populations at high altitude. It has also been hypothesized that the large chest cage size may be the result of adaptation to low oxygen pressure encountered at high altitude (Baker, 1969; Beall et al., 1977). Other silent features of high altitude populations in Andean altiplano are small body size, lower body mass, prolonged growth period and poorly defined, delayed adolescent growth spurt (Frisancho, 1969; Pawson, 1976).

In contrast to these findings, the Ethiopian high altitude children are taller and heavier than their counterparts of similar genetic make-up at low altitude (Clegg et al., 1972; Harrison et al., 1969). Similar findings have been reported for Bods of Ladakh division in Western Himalayas (Malik and Singh, 1978). Findings on the population groups under study show that in general no

marked growth spurt has been observed for Bodhs and Baltis of Ladakh.

Comparison has been made with adjoining population groups of the state for body weight, height vertex and chest circumference. Gujjars show higher body weight than Bodhs and Baltis of Ladakh, whereas comparatively similar body weight has been shown by other population groups viz., Dogra - Brahmans, - Rajputs, - Scheduled Castes and Tibetans. For the age group 19+ and above, it has been observed that Bodhs and Baltis of Ladakh show less body weight than Gujjars, Dogra - Brahmans, - Rajputs, - Scheduled Castes and Tibetans (Bhasin and Singh, 1991).

For height vertex also Bodhs and Baltis are shorter than Gujjars; Dogra - Brahmans, - Rajputs, - Scheduled Castes, though the values are higher in Tibetans also but they show comparatively similar stature as among Bodhs and Baltis of the same area. For the age group 19+ and above, Bodhs and Baltis are shorter than Gujjars; Dogra - Brahman, - Rajput, - Scheduled Castes but Bodh and Balti adults are taller than their Tibetan counterparts.

For chest circumference Gujjars and Tibetans show comparable chest circumference to Bodhs, whereas Bodhs show higher value than Dogra - Brahmans, - Rajputs, and - Scheduled Castes. Baltis show higher value than Dogra Brahmans, less than Gujjars; Dogra-Rajputs, - Scheduled Castes and Tibetans. For the age group 19+ and above, less chest circumference has been observed in Bodhs and Baltis as compared to Gujjars; Dogra - Rajputs, - Scheduled Castes and Tibetans. Whereas Dogra - Brahmans show lower value of chest circumference than Bodhs and Baltis of Ladakh division.

Bodhs and Baltis of Ladakh show higher lung functions than Dogras, Gujjars and Tibetans at most of the age intervals especially in the later adolescence spurt Ladakhis population groups under study show higher lung functions (Bhasin and Singh, 1991).

To sum up, it may be evaluated that for most of the anthropometric and respiratory variables, Bodhs show higher value than Baltis. Since these population groups have been inhabiting similar

environmental set-up these differences may be attributed to their varied genetic make-up.

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