CHAPTER 7
SUMMARY

The present study describes how morphological and physiological traits of Shin boys living at high altitude develop based on their genetic makeup in tuned with surrounding environment, consisting of tough terrain, cold climate and high altitude along with existing socio cultural practices. The study has generated for the first time growth charts for height, weight and body mass index for the Shin adolescents from the Gurez valley, Jammu and Kashmir using LMS method given by Cole and Green (1992).

The aim of the present cross-sectional study was to assess the physical growth and nutritional status of 900 adolescent boys of Shin tribe, aged 10 to 19 years living at high altitude in Gurez valley of Jammu and Kashmir. The data were collected from various government and two private schools of Gurez valley using random sampling. Boys of these schools belonged to low socioeconomic group where families were less educated and were living under financial constraints. The subjects selected were Shin by origin residing in Gurez valley. Purpose of the study was explained to the subjects in the light of importance of growth studies. A prior written consent was obtained from subjects and principals of various schools for carrying out study on the students. The data were divided into ten age groups each of the magnitude of one year. Apparently normal, healthy boys without any chronic illness were selected. Data collection involved anthropometric measurements, physiological parameters and personal interview. Information was collected regarding dietary pattern, dietary habits, socio-demographic variables, physical activity, mode of transportation, family size, sib ship, birth order, income, educational and occupational status of parents using interview based schedule. Sixteen anthropometric measurements were taken on each subject which included height, weight, humerus bicondylar diameter, femur bicondylar diameter, upper arm circumference, chest circumference, waist circumference, hip circumference, thigh circumference, calf circumference, biceps skinfold, triceps skinfold, subscapular skinfold, suprailliac skinfold, thigh skinfold, and calf skinfold. Four physiological variables were also assessed i.e. blood pressure, pulse rate, grip strength and vital capacity by using standardized techniques.
The results of the present study revealed that height, weight, circumferences and diameters of the adolescent boys of Gurez valley showed an increasing trend in the mean values with the advancing age. However, their skinfold measurement showed a fluctuating trend. The maximum annual gain in height in boys of all the three zones occurred between 13 and 14 years but the magnitude of annual gain was different for different zones. It was 8.04 cm among boys of Kanzalwan; 9.16cm among Dawar boys and 8.37cm among Tulail boys. Pooled sample also showed an increasing trend with maximum annual gain from 13 to 14 years i.e. 8.67cm. Significant differences in height among boys of all the three zones with advancing age were noticed only at the age of 15 years.

The maximum annual gain in weight among boys of all the three zones occurred between 13 and 14 years. Boys of Dawar gained maximum of 8.01kg in weight followed by boys from Tulail (6.31kg) and Kanzalwan boys showed the minimum annual gain of 5.38 kg. Adolescent boys from Tulail showed lower mean values of weight from 13 to 18 years. Maximum annual gain in weight among pooled sample (6.57 kg) was witnessed between 13 and 14 years. Significant differences in weight of all the three zones with advancing age were noticed at 15 and 19 years only.

The maximum annual gain in humerus bicondylar diameter in boys from Kanzalwan occurred between 12 to 13 years (0.38 cm); among boys from Dawar between 10 and 11 years (0.60 cm) and in case of Tulail boys between 13 to 14 years (0.30cm). Maximum annual gain in this dimension is witnessed in pooled sample (0.28 cm) between 10 and 11 years. ANOVA revealed significant differences in this diameter among boys of all the three zones at all ages except for 12 and 16 years.

The maximum annual gain in femur bicondylar diameter among boys of Kanzalwan, Dawar and Tulail occurred between 13 and 14 years (0.44 cm; 0.28cm and 0.22 cm respectively). Boys from Dawar attained the highest adult value of 9.76 cm at 19 years as compared to their counterparts from Kanzalwan (9.42cm) and Tulail (9.43cm). The maximum annual gain in femur bicondylar diameter of pooled sample (0.31cm) was between 13 to 14 years.
Statistically significant differences in this diameter were observed at 10, 15 and 19 years as is evident from p-values.

Upper arm circumference among boys increased regularly with the advancing age. The maximum annual increase in Kanzalwan and Dawar occurred between 15 to 16 years (1.69 cm) and (2.28 cm) respectively. In case of Tulail the maximum annual gain in this circumference in boys occurred between 18 to 19 years (2.99 cm). Maximum annual gain in upper arm circumference of pooled sample (1.61 cm) was seen between 15 and 16 years. p-values clearly depicted significant differences in this circumference at all age groups except 12, 15, 16 and 18 years.

Chest circumference showed maximum annual gain among boys from Kanzalwan between 16 and 17 years (5.26 cm), among boys of Dawar between 13 and 14 years (4.55 cm) and among Tulail boys between 15 to 16 years (3.43 cm). The maximum annual gain from in chest circumference of pooled sample was (3.91 cm) observed between 16 to 17 years. Statistically significant differences have been reported in this circumference at 10, 15, and 17 years only as is revealed by the p-values.

The mean value of waist circumference of Kanzalwan boys showed maximum annual gain of 3.04 cm between 16 and 17 years. Dawar boys gained maximum of 3.28 cm between 13 and 14 years. In case of Tulail the maximum annual gain in waist circumference among boys occurred between 12 to 13 years (2.56 cm). The maximum annual gain in this circumference among pooled sample was noticed between 13 to 14 years (2.16 cm) and 18 to 19 years (2.32 cm). ANOVA revealed statistically significant differences in this circumference at 10, 15 and 19 years.

Hip circumference revealed maximum annual gain among boys from Kanzalwan between 14 and 15 years (4.06 cm) followed by 16 to 17 (4.03 cm) years. Dawar and Tulail boys showed the maximum annual gain of 5.52 cm and 5.37 cm respectively between 13 and 14 years. The maximum annual gain in hip circumference of pooled sample (4.18 cm) was seen between 13 to 14 years. p-values clearly depicted non significant differences among the three groups in hip circumference except for 17 years.
Thigh circumference witnessed maximum annual gain among boys from Kanzalwan and Dawar between 13 to 14 years (2.11cm) and (2.18cm) respectively. In case of Tulail it occurred between 11 to 12 years (2.17cm). Maximum annual gain in thigh circumference of pooled sample (1.77 cm) was witnessed between 13 to 14 years. ANOVA did not reveal any significant differences in this parameter among all the three groups with the advancing age.

Calf circumference showed maximum annual gain (1.83 cm) in boys from Tulail zone between 13 and 14 years followed by boys from Kanzalwan (1.63cm) between 12 to 13 years. Dawar boys exhibited maximum gain of 1.61 cm but it is noticed between 16 and 17 years. Maximum annual gain in calf circumference of pooled sample (1.46 cm) was witnessed between 13 to 14 years. p-values revealed significant differences only at 19 years.

Dawar boys possessed highest mean values of biceps skinfold thickness than their peers from other zones from 14 to 18 years. The mean value of pooled sample showed an increasing trend till 15 years where it had a maximum value (3.51mm) thereafter, it decreased till 19 years. ANOVA showed significant differences at 13, 15 and 16 years of age (p <0.05). Triceps skinfold thickness of Shin boys from Tulail showed considerably lower values as compared to their counterparts from the other two zones. The mean value of pooled sample showed an increasing trend till 17 years where it acquired its maximum value (6.39 mm) thereafter, it decreased till 19 years. The triceps skinfold thickness showed significant differences among boys of three zones at 13, 15, 16 and 17 years of age as is clear from the p-value.

Subscapular skinfold thickness depicted an initial decrease followed by a regular increase till 17 years in case of Kanzalwan and Dawar boys and up to 18 years in case of Tulail boys after which the curve dipped down till 19 years. Tulail boys displayed substantially lower values after 13 years than their counterparts. The mean value of pooled sample showed an initial decrease at 11 years, followed by an increasing trend till 17 years where it depicted maximum value (7.63 mm) thereafter, it decreased till 19 years. p-value revealed significant differences at 10, 14, 15, 17 and 19 years.
Suprailiac skinfold thickness showed a gradual increase till 16 years followed by a rapid increase till 17 years and declined thereafter among the boys of all the three zones. The mean value of pooled sample showed an initial decrease at 11 years, thereafter, it revealed an increasing trend till 18 years where it has a maximum value (6.18mm) there after it decreased till 19 years. p-values revealed significant differences among boys of three zones for supra iliarc skinfold at 10, 13, 15 and 17 years.

Thigh skinfold thickness exhibited an overall increasing trend till 17 years with a minor fluctuation at 14 and 15 years, after 17 years, there is a trend of gradual decrease till 19 years among all the three groups. p-values for thigh skinfold thickness showed significant differences at all age groups except for 12 and 19 years.

Calf skinfold showed over all increasing trend till 17 years followed by a gradual decrease till 19 years. The mean value of calf skinfold of adolescent boys of Kanzalwan was 5.10mm at 10 years of age and it increased to its maximum value of 6.93mm at the age of 17 years. Dawar boys attained a mean value of 4.85mm at 10 years of age and reached their maximum value of 6.98mm at 17 years. Calf skinfold thickness of Tulail boys was 4.30mm at 10 years of age and it increased to their maximum value of 6.20mm at 16 years. The distance curve of adolescent boys of Kanzalwan and Dawar showed increase till 17 years but for Tulail boy’s till 16 years followed by a decrease till 19 years. The distance curve of pooled sample showed an overall increasing trend till 16 years, where it has a maximum value (6.58mm) thereafter, it showed a regular decrease till 19 years. p-values reported significant differences at 15, 16 and 17 years only.

The distance curve of body mass index showed an increasing trend with the advancing age in all the three groups. The maximum annual gain in body mass index among boys from Kanzalwan occurred between 14 to 15 (1.47 kg m$^2$) years. Dawar boys showed maximum gain between 13 to 14 (1.36 kg/m$^2$)
years, and among Tulail boys it was witnessed between 17 to 18 (1.12 kg/m$^2$) years. Pooled sample experienced first greatest increase in the index between 13 and 14 years (0.82kg/m$^2$) followed by maximum annual gain (1.28kg/m$^2$) between 18 and 19 years. No significant differences in body mass index among boys of all the three zones were observed except for 19 years as is evident from the F-values.

A comparison of mean BMI values of adolescent boys of Shin tribe with various national standards (Agarwal et al. 1992, khadilkar et al. 2009, Marwaha et al. 2011 and Khadilkar et al. 2015) revealed lower mean values of Shin adolescents at all ages. As compared with BMI percentiles of Agarwal et al. (1992) mean values of Shin tribe lied between 25$^{th}$ and 50$^{th}$ percentile. In comparison to nationwide reference (Marwaha et al. 2011), BMI percentiles of Shin boys fell between 10$^{th}$ and 25$^{th}$ percentile till 13 years, thereafter, values merged with 25$^{th}$ percentile till 18 years. Mean values of present study as compared to BMI percentile of affluent Indians (Khadilkar et al. 2009) coincided 25$^{th}$ percentiles except for 12 and 13 years, where the values lied between 10$^{th}$ and 25$^{th}$ percentiles. However in comparison to IAP growth charts (khadilkar et al. 2015) the BMI percentile of present study mostly merged with 25$^{th}$ percentile. These differences in BMI may be attributed to socio-economic differences, environmental stresses and inadequate nutrition.

BMI of the boys of present study were compared with BMI of adolescents residing at high, moderate and low altitude. The findings revealed that Shin boys possessed higher BMI values than their counterparts from high and moderate altitude. However, Chamba boys and Kullu boys from low altitude had slightly greater values than them at only select age groups.

BMI of adolescent Shin boys was compared with BMI of adolescents of different Indian tribal populations residing in plains. Sonowal kacharis from Assam (Singh and Mondal 2014), Khasi from Meghalya, (Khongsdier and
Mukherjee 2003), Karbi Anglong from Assam (Mondal and Terangpi 2014) and Rajbanshi from West Bengal (Sen et al. 2015), exhibited greater values for BMI as compared to Shin boys. Shin boys possessed higher BMI at all ages than Bhils from Rajasthan (Bhasin and Jain. 2007). When compared with Bharia from Madhya Pradesh (Tiwari et al. 2007) Shin boys had lesser values at 10, 11, 13 and 15 years. As compared to Santal tribal boys of West Bengal (Das and Bose 2011) Shin boys had greater values at all ages except for 12, 16 and 18 years.

BMI values of Shin boys of present study have also been compared with international standards (BMI percentiles of CDC 2000 and WHO 2007). As compared to CDC percentiles the BMI values of Shin boys from Gurez valley fell between 5th and 25th percentile, these overlapped mostly with the 10th percentile till 17 years, where after these corresponded between 10th and 25th percentile. When compared with WHO percentiles, BMI of Shin boys from Gurez valley fell between 5th and 25th percentiles, these overlapped mostly with the mean values of 15th percentile till 18 years where after as it showed slightly higher values than 25th percentile. The lower BMI value of Shin adolescents in relation to international standards may be a result of differences in genetic, geographical, cultural and socio-economic factors.

The distance curve of chest height ratio of boys showed an increasing trend with the advancing age in all the three groups with minor fluctuations. Pooled sample also showed an increasing trend except at the age of 11, 13, and 14 years. Significant differences have been observed for this ratio among boys of three groups at 10, and 11 years as is evident from the p-value.

Waist hip ratio showed a decreasing trend with the advancing age in all the three groups. It is also evident from the tables that the distance curve of waist hip ratio for pooled sample showed a decreasing trend with the advancing age. Non-significant differences have been observed for this ratio among boys of three groups at almost all the ages except for 11, 17 and 19 years.
Shin boys deposit, more fat on the hip region as compared to waist region during adolescence.

Waist height ratio of Kanzalwan and Dawar boys exhibited almost similar values for this ratio from 10 to 19 years and ranged between 0.38 to 0.39 only. Among Tulail boys this ratio fluctuated between 0.37 and 0.41. Pooled sample also exhibited almost similar values for this ratio from 10 to 19 years and this ratio ranged between 0.38 to 0.39. Significant differences have been observed for this ratio among boys of three groups at 10, 11, 14 and 19 years only as is evident from the p-value.

Ratio of upper to lower skinfold among boys from Dawar and Tulail zone increased steadily till 14 years and dipped till 15 years, thereafter, it reached almost similar value at 19 years. However, Kanzalwan boys also gain steadily till 13 years followed by a fluctuating trend till 17 years, thereafter, the curve inclined to catch up with their counterparts from other two zones. Pooled sample showed an overall increasing trend with minor fluctuations at 15 years. p-values exhibited significant differences only at 11, 14 and 17 years. Shin adolescents depicted greater deposition of upper body fat as compared to lower body fat.

Ratio of central to peripheral skinfold showed an overall increasing trend with initial decrease at 11 years among boys of all the three zones. However, the curve witnessed an increase of greater magnitude after 14 years among all the groups of boys. Pooled sample showed maximum gain (0.09) from 15 to 16 years. p-value clearly depicted non-significant differences in this ratio at all ages except for 15 years. A trend of deposition of central fat as compared to peripheral fat was noticed among Shin adolescents.

Grand mean thickness showed an overall increasing trend up to age of 13 years among Kanzalwan boys and among 14 years among Dawar and Tulail boys followed by a fluctuating pattern in all the groups till 17 years, where
after a trend of decline was observed among all the boys. The distance curve of grand mean thickness of pooled sample showed an overall increasing trend up to age of 17 years with fluctuations at 15 years, where after a trend of decline was observed. Statistically significant differences were observed for grand mean thickness among boys of all three zones at almost all ages except for 11, 12, and 19 years.

Body fat percentage among boys from Dawar and Tulail witnessed maximum gain in between 15 and 16 years (2.09 % and 1.78 %) respectively, whereas, Kanzalwan boys showed a maximum gain of 1.66 % between 16 and 17 years. The distance curve for body fat percentage of pooled sample depicted initial decrease at 11 years with an overall rising trend till 17 years with minor fluctuations observed at 15 years and declined thereafter till 19 years. p-values clearly depicted significant differences in body fat percentage at the age of 10, 13, 14, 15 and 17 years. Minimum percentage of body fat was among Tulail boys.

Maximum gain in fat mass among Shin boys of Dawar and Tulail occurred between 14 and 15 i.e. 1.61kg and 1.21kg respectively, whereas, maximum annual gain in Kanzalwan boys (1.35kg) was found between 16 and 17 years. The distance curve of body fat mass of pooled sample showed an overall increasing trend up to age 17years, where maximum value (7.73kg) was witnessed, and then displayed decreasing trend with the advancing age. p-value clearly depicted significant difference in body fat mass at the age of 10, 13 and 17 years.

Fat free mass among boys of Dawar and Tulail showed maximum gain between 13 and 14 years i.e. 6.77kg and 5.11kg respectively whereas, maximum annual gain in Kanzalwan boys (4.07kg) was found to be from 16 to 17years. The maximum annual gain in fat free mass in boys of Gurez valley occurred between 13 and 14 (5.24kg) years. No significant differences were seen in fat free mass with the advancing age among boys except for 19 years.
The maximum annual gain in fat mass index in boys of Dawar and Tulail occurred between 15 and 16 years i.e. 0.46kg and 0.32kg respectively, whereas, maximum annual gain in Kanzalwan boys (0.42kg) was noticed from 12 to 13 years. Pooled sample witnessed an initial decrease followed by an overall increasing trend with the advancing age till 17 years, where, it has maximum value (2.62kg), thereafter it decreased till 19 years. p-value showed significant differences in fat mass index at the age 10, 13, 15 and 17 years. Fat free mass index showed maximum annual gain in Kanzalwan (1.55kg) and Dawar boys (1.53kg) between 18 and 19 years, whereas, in Tulail boys (0.91kg) it was observed between 17 and 18 years. The maximum annual gain in fat free mass index in pooled sample (1.30kg) was observed from 18 to 19 years. The distance curve of fat free mass index showed an overall increasing trend with the advancing age with initial decrease at 11 years, as is evident from p-values. Statistically significant differences have been observed only at the age of 19 years.

The mean value for body adiposity index of Kanzalwan boys at 10 years is 22.09% which decreased to its lowest value of 18.26% at 19 years with minor fluctuation at 15 years. Dawar boys registered 21.69% body fat at 10 years which decreased to 18.20% at 19 years. Boys from Tulail showed 22.21% fat at 10 years which decreased to 17.44% till 17 years, thereafter, it increased at 18 years followed by decline till 19 years. Tulail boys exhibited considerably minimum values of body adiposity index than their counterparts from Kanzalwan and Dawar at 16 and 17 years. Pooled sample exhibited an overall decreasing trend with fluctuation at 18 years. p-value showed significant differences at 17 and 18 years. BAI as compared to percentage body fat seems to overestimate fat among Shin boys.

A body shape index of Tulail boys exhibited greater values for this index than Dawar and Kanzalwan boys. The distance curve for a body shape index for pooled sample showed an overall decreasing trend where the mean values ranged from 0.75 at 10 years to 0.69 at 19 years. However, statistically
significant differences among the boys of three zones were observed at 10, 11, 12 and 16 years only.

Systolic blood pressure showed an increasing trend with the advancing age in these three zones. The maximum annual gain in systolic blood pressure in boys of Kanzalwan, Dawar and Tulail occurred between 14 to 15 years i.e. 2.43 mmHg, 2.20 mmHg and 3.13 mmHg respectively. Pooled sample for systolic blood pressure showed an overall increasing trend till 19 years with maximum annual gain of 2.59 mmHg between 14 and 15 years. p-value clearly depicted significant differences in systolic blood pressure through the time span of 10 years under study.

The maximum annual gain in diastolic blood pressure among boys of Kanzalwan, Dawar and Tulail occurred between 14 and 15 years i.e. 2.06 mmHg, 2.14 mmHg and 2.93 mmHg respectively. Diastolic blood pressure for pooled sample also showed an overall increasing trend till 19 years, with maximum annual gain of 2.38 mmHg between 14 to 15 years. Significant differences have been observed for diastolic blood pressure among boys of three zones through the time span of 10 years under study.

Pulse pressure showed a fluctuating trend with an initial increase at 11 years it decreased till 14 years, followed by a regular increase till 16 years, among Kanzalwan and Dawar boys a decline till 19 years was witnessed thereafter. In case of Tulail boys there was regular increase till 19 years. The distance curve showed a fluctuating trend with an initial increase at 11 years, followed by decreased till 14 years, thereafter, a regular increase till 17 years followed by decrease till 19 years among boys of pooled sample. F-value clearly depicted significant differences in pulse pressure at the ages 10, 12, 13, 18 and 19 years.

The distance curve of pulse rate of Shin boys showed a decreasing trend with the advancing age in the all three zones. The maximum annual decline in pulse rate among boys of all the zones occurred between 13 and 14 years but
the magnitude of decline varied. Kanzalwan boys showed a decrease 0.76 beats per minute while Dawar boys showed a decrease of 0.81 bpm and the lowest annual decrease of 0.64 bpm was recorded among Tulail boys. The maximum annual decrease in pulse rate of pooled sample is 0.74 bpm between 13 and 14 years. The distance curve showed an overall decreasing trend till 19 years. F-values did not reveal any significant differences between boys of three zones for pulse rate.

Vital capacity showed an increasing trend with the advancing age in all the three groups. Maximum annual gain of 523.34cc was witnessed by Dawar boys followed by Kanzalwan (456.67cc) and Tulail boys (453cc) between 13 and 14 years. The distance curve of the pooled sample for vital capacity showed an increasing trend with the advancing age with maximum annual gain of 477.78cc from 13 to 14 years. p-value clearly depicted no significant differences in vital capacity of all the three zones with advancing age except for the age of 14 years. Vital capacity among Shin boys increased rapidly till 15 years when they add a total of 1465 cc, where after till 19 years, they add only 714cc suggesting early and rapid development of lung capacity. Altitude seems to be probably affecting Shin boys more during earlier years of adolescence.

Grip strength of right hand showed an increasing trend and similar pattern with the advancing age in all the three groups. The maximum annual gain in grip strength among boys from all the three zones occurred between 13 and 14 years. The magnitude of gain was 5.30 kg for Kanzalwan boys; 6.80 kg for Dawar boys and 8.17kg for Tulail boys. The distance curve of grip strength of right hand showed an increasing trend with the advancing age in pooled sample. The maximum annual gain (6.76 kg) in grip strength among boys from Gurez valley occurred between 13 to 14 years. ANOVA depicted significant differences in grip strength among boys of all the three zones at 10, 14, 16, and 19 years only. The maximum annual gain in grip strength of left
hand among boys of all the three zones i.e. Kanzalwan (4.96 kg), Dawar (6.90 kg) and Tulail (7.86 kg) occurred between 13 and 14 years. The distance curve of grip strength of left hand showed an increasing trend with the advancing age in pooled sample. The maximum annual gain (6.57 kg) in grip strength among boys from Gurez valley occurred between 13 and 14 years. p-value depicted significant differences in grip strength among boys of all the three zones at age 10, 14, 15, 16, and 19 years only.

To identify the relationship between different anthropometric and physiological variables correlation coefficient (r) was calculated. Body mass index correlated positively and significantly with all the anthropometric measurements including skinfolds. Body mass index was found to be positively and significantly correlated with weight (0.853**) followed by chest circumference (0.718**), hip circumference (0.702**), upper arm circumference (0.690**), calf circumference (0.670**), thigh circumference (0.666**), waist circumference (0.665**), humerus bicondylar diameter (0.634**), femur bicondylar diameter (0.576), height (0.560**) and various skinfolds. It also yielded significant and positive association with FFMI (0.967**); FFM (0.841**); FM (0.790); and FMI (0.786**). However BMI correlated negatively with ABSI (-0.608**); and WHR (-0.167**). It is evident from the results of correlations that BMI of Shin boys is more strongly correlated to FFMI (0.967**) than with FMI (0.786**). Thus, age wise increase in BMI among Shin boys is largely due to greater fat free mass than fat mass.

The findings of present study, revealed a positive and significant correlation of SBP and DBP with FFM (0.826**, 0.830**) followed by FM (0.684**, 0.689**); BMI (0.605**, 0.611**); FFMI (0.554**, 0.562**); FMI (0.527**, 0.528**); %Fat (0.415**, 0.414**) and GMT (0.293**, 0.296**). SBP and DBP also correlated positively and significantly with grip strength, (0.894**, 0.893**); vital capacity (0.881**, 0.885*8) and pulse rate (0.590**, 0.596**). BMI was also found to be positively correlated with grip strength of right hand
(0.577**), grip strength of left hand (.576**), vital capacity (0.563**) and pulse rate (0.374**).

Multiple regression analysis was performed to evaluate the best predictor of SBP and DBP. It clearly indicated significant prediction of systolic blood pressure by FMI, BMI, ABSI and WC. Variance of approximately 53% was explained by FMI and BMI which was followed by ABSI (48.00%) and WC (40.00%). Thus FMI and BMI were found to the best predictor of systolic blood pressure among Shin boys. Regression analysis revealed that significant prediction of diastolic blood pressure by FFMI, BMI, ABSI and WC. Variance of approximately 55.00% was explained by FFMI which was followed by BMI (54.00%), ABSI (50.00%) and WC (40.00%). Thus the independent variable (FFMI) statistically significantly predicted the diastolic blood pressure.

Significant prediction of pulse rate was shown by FFMI, BMI, ABSI and WC. Variance of approximately 25.00% was explained by FFMI and BMI which was followed by ABSI (22.00%) and WC (17.00%). Significant prediction of grip strength was shown by FFMI, BMI, ABSI and WC. Variance of approximately 62.00% was explained by FFMI and BMI which was followed by ABSI (53.00%) and WC (42.00%). In case of vital capacity significant prediction was observed with CC, FFMI, BMI and ABSI. Variance of approximately 73.00% was explained by chest circumference (CC) followed by FFMI and BMI 64.00% and ABSI (54.00%).

Nutritional status of adolescent boys of the present study was evaluated with the help of Body mass index using three reference standards. 1) Z scores using References developed by WHO (2007) for 5 to 19 years. 2) Growth charts developed by Centers for Disease Control and Prevention (CDC) (Kuczmarski et al. 2000). 3) Revised Growth charts by Indian Academy of Paediatrics IAP (Khadilkar et al. 2015). Height for age was assessed using references developed by WHO (2007) for 5 to 19 years.
When nutritional status of boys of three zones was compared according to classification of WHO (2007) it was observed that boys from Kanzalwan showed maximum stunting (62.67%) followed by boys from Tulail (61.00%). Minimum stunting was seen among Dawar boys (53.00%). Maximum underweight (64.61%) was witnessed among Tulail boys followed by Dawar (56.00%) and Kanzalwan boys (54.67%) respectively. Similar trend for underweight was seen using CDC classification according to which 38.30% boys from Tulail were underweight followed by boys from Dawar (34.00%) and minimum (31.30%) underweight was reported among Kanzalwan boys. As per IAP growth charts also Tulail boys showed maximum percentage of underweight (6.30%) followed by Dawar boys (3.70%) and Kanzalwan boys (2.60%). It is apparent from the above results that out of three zones maximum percentage of underweight was reported from Tulail zone and maximum stunting was exhibited by boys from Kanzalwan zone.

On the basis of height for age 58.89% of boys were found to be stunted as per WHO (2007) standards. Out of which 37.67% boys were mildly stunted, 16.44% showed moderate stunting and only 4.75% boys were severely stunted. The results based on BMI for age revealed that 37.67% boys were mildly underweight, 14.78% boys were moderately and only 6.00% boys were severely underweight.

As per CDC classification for BMI, 64.4% boys were found to be normal; 34.6% were classified as underweight and only 1% were overweight. Using IAP growth charts (Khadilkar et al. 2015), nutritional status of 810 boys from Gurez from 5 to 18 years was assessed. According to this classification, 91.7% boys were in normal category 4.2% boys were underweight and 4.1% boys were overweight.

A comparison of three criteria was made with the aim to determine the most appropriate classification for assessing underweight, overweight and obesity. Since growth charts by Indian Academy of Pediatrics are till 18 years therefore, all the classifications were compared till 18 years. A comparison of
three revealed that maximum percentage of underweight (37.67%) is reported by WHO (2007) standards. Followed by CDC (34.6%) and minimum percentage of underweight is reported by IAP standards.

The present study also investigated the effect of socio-demographic and lifestyle variables on the nutritional status of Shin boys. Dietary pattern and dietary habits of Shin boys were studied with respect to meals per day (twice, thrice, four times a day); frequency of non-vegetarian food (once in two weeks, once in a week, twice in a week, and thrice in a week), frequency of vegetables (once, twice, thrice a week); fruit consumption (daily, alternate days, once in a week); consumption of milk and milk products (Daily, alternate days and once in a week) and type of lunch (mid day meal, homemade, fast food and both MDM/homemade). Frequency of meals per day, frequency of vegetables, consumption of fruits and type of lunch revealed non-significant differences in various categories as is exhibited by $\chi^2$ values ($\chi^2 = 2.199$, $p = 0.333$; $\chi^2 = 0.200$, $p$-value = 0.905; $\chi^2 = 3.549$, $p$-value = 0.170 and $\chi^2 = 9.335$, $p$-value = 0.25). However, frequency of non-vegetarian food and consumption of milk and milk products showed significant differences among Shin boys as is clear from $X^2$ values ($\chi^2 = 118.71$, $p$-value=0.000 and $\chi^2 = 53.624$, $p$-value=0.000).

Chi square values suggested significant differences in percentage prevalence of underweight and normal subjects with respect to modes of transport used by children to reach their school. Duration of physical activity was inversely correlated with their nutritional status. The maximum percentage of underweight boys was reported among boys who had physical activity for more than four hours.

Non significant differences were found in the nutritional status of boys with respect to type of residence (pucca or kutchha) ($\chi^2 = 0.001$, $p$-value = 0.972); source of electricity supply ($\chi^2 = 0.647$, $p$-value=0.724) and presence/absence of toilets in the house ($\chi^2 = 0.029$, $p$-value = 0.986). But source of drinking water ($\chi^2 = 6.042$, $p$-value = 0.049) showed significant differences in their nutritional status. Family type ($\chi^2 = 79.988$, $p$-value = 0.000*), size of house
hold \( (15.558, \ p-value = 0.000) \) and sib ship \( (\chi^2 = 7.789, \ p-value = 0.020) \) affected significantly the nutritional status of Shin boys. Socio-economic status of boys of Gurez valley exhibited significant differences in their nutritional status as is revealed by the value of chi square \( (\chi^2 = 52.357, \ p-value = 0.000) \).

It can be concluded from above that Shin boys of Gurez valley are taller and heavier between 17 and 19 years than their counterparts from moderate and low altitude but considerably lighter and shorter as compared to national and international standards. They have a definite and early growth spurt in height, weight and BMI unlike many high altitude populations. BMI among sample boys increased with greater pace between 13 and 19 years because of overall better growth, the contribution of fat free mass was greater towards their BMI than fat mass. Waist hip ratio decreased with advancing age there by indicating more thickening of hip region as compared to waist region. Waist height ratio was considerable less than 0.5. Body adiposity index showed decrease in percentage fat. However, from the values of BAI, it seems as if it overestimates fat as compared to percent fat. ABSI values declined with the advancing age reflecting smaller values for waist circumference among them. Tulail boys from upper zone of Gurez valley showed minimum values for all the skinfolds as compared to boys of other zones and depicted higher values of systolic and diastolic blood pressure than them. Ratio of central to peripheral skinfolds and upper to lower skinfolds among Shin boys revealed redistribution of fat away from extremities towards the trunk region during adolescence.

Shin boys possessed thinner fat folds, greater developed calf muscles and showed prolonged growth in chest circumference a characteristic of high altitude due to hypoxia. It seems that well developed calf muscles help Shin boys to carry load uphill and thinner fat folds contribute towards increasing efficiency. They also exhibited higher values of SBP and DBP than many high
altitude populations but have lower ventilator capacity than them. Thus, altitude is a multi stressing environment where interaction of adaptive and genetic factors plays an important role in bringing about differences in morphological and physiological traits among different populations due to different mechanism of adaptation to the same set of environment.

Overall the poor growth and nutritional status of Shin adolescents seems to be more due to low socio-economic status, inadequate nutrition and increased physical activity due to rough terrain and environmental stresses and partially due to hypoxia. This part of Jammu and Kashmir needs immediate attention where scheduled tribes are living under tremendous harsh conditions, facing poverty, food scarcity, lack of modern medical facility and provisions for normal growth and development of children and adolescents.