CHAPTER 1
INTRODUCTION

The study of human growth is one of the most fascinating areas of biological anthropology which gives us a clear understanding of all the concepts, principles, processes and interpretation of patterns of human growth and development. A series of orderly and irreversible changes that every organism undergoes during its life span are collectively known as growth and development. It is a fundamental characteristic of all living organisms. Growth refers to changes in size and dimension including differentiation and alterations in the form that an organism undergoes with advancing age. Maturity or development is an increase in functional ability of an individual. Development is broadly defined as a sequence of changes either quantitative or qualitative that lead from undifferentiated or undeveloped state to a highly organised, specialized and matured state (Bogin 1999). Children inherit their growth potential from their parents but this potential is fully exploited only under various favourable conditions including social, economic and environmental conditions. Individuals not only vary considerably in body size, physique or composition but also in tempo of growth i.e. the speed at which they reach maturity. Human growth is the outcome of interaction between genes and environment. The sensitivity of growth process to the environment is one mechanism by which human beings adapt.

Normal growth promotes good health. With infection, inadequate nutrition, hormonal deficiency or other environmental stresses, growth can be impaired. Growth retardation due to inadequate nutrition and infection is reported to be common in developing countries especially during early stages of growth and development. The degree of growth faltering becomes a reliable measure of environmental quality. In the history of the study of human growth, Prof. James Mourilyan Tanner (1981), a pioneer in growth studies called this effect “auxological epidemiology” and traced its beginnings to survey of the growth of British factory children in the 19th century. In 1986, he stated that growth may be described as "mirror of the conditions of the society" and height as a proxy for health. Human growth is an organized and multifaceted process which leads to morphological and functional changes. It proceeds in a
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nonlinear fashion displaying the greatest rate immediately after birth. There is a general deceleration throughout childhood, except for a juvenile mid-childhood growth spurt and a prominent adolescent growth spurt, after which the epiphyses close and maximum height is attained. Adolescence is a period of rapid growth and maturation in human development.

The regulation of growth is a complex phenomenon determined by biological factors that show a high degree of sensitivity to environmental stimuli which in turn can temper the expression of genetic potential (Thomis and Towne 2006; Ulijaszek 2006). There are a number of environmental factors, such as climate, altitude, migration and urbanization, socio-economic status and psycho-social factors that affect human growth but of all the factors nutrition influences on retardation or acceleration of hereditary potentials of individuals (Mlyńska 2002). In addition, hormonal factors significantly affect the process of growth and maturation. Maternal nutrition during pregnancy also influences birth weight of the child. In general, lower birth weight is associated with higher risk or morbidity. At a population level, groups with lower mean birth weight often have higher infant mortality, whereas, large birth size may predict increased risk of obesity, diabetes and some cancers (Risnes et al. 2011).

There are well known population differences throughout the world in human growth and nutritional status. Numerous earlier studies have shown significant differences in the growth rates of children from different populations due to differences in their health and nutritional status, environmental conditions and genetic makeup (Eveleth and Tanner 1990). It was traditionally believed that growth patterns differ among different ethnic groups; on average African-Caribbean groups are taller and heavier, and Asian and Chinese groups are shorter and lighter when compared with Caucasians (Gatrad et al. 1994). More recently, the Multicentre Growth Reference Study group refuted this belief showing that variability in infant growth was greater within population groups than between the different country groups (De Onis 2006). Thus, pattern of growth of populations change with passage of time is well documented by the secular trends in height, weight and reduction in age of puberty associated with rapid urbanization and modernization. Perhaps the most concerning are the effects of childhood obesity on health in both
childhood and adulthood. India is facing dual burden of undernutrition and over nutrition. The challenge lies in curbing all kind of malnutrition to achieve sustainable development.

Growth assessment depends on accurate measurements. Anthropometry is the simplest and best tool to measure growth status. Anthropometric measurements are taken on an individual, child or on a group of children to ascertain the growth status, which in turn is one of the most sensitive and commonly used indicators of child health and nutrition (WHO 1981). Anthropometric parameters provide a lot of information about body composition and nutritional status, regardless of the fact whether they relate to obesity or malnutrition (Freedman and Perry 2000). Therefore, growth assessment is important, not only for epidemiological purposes but also for the follow-up of childhood disorders and diseases. Growth standards/charts are used as a dynamic usable tool to educate and motivate health workers and parents to take action to improve or maintain the child’s growth and to screen for growth faltering and targeting of appropriate interventions.

Improving dietary patterns and monitoring nutritional status throughout the growing period requires addressing not only individual-level influences on health, but also examining these factors within the environmental context in which people live.

1.1 ADOLESCENCE

Adolescents currently account for approximately 20% of the world's population and the numbers are growing (UNICEF 2012). Adolescence has been defined by the World Health Organisation (WHO) as the period of life from 10 to 19 years. Adolescence refers to a critical stage in the human life cycle, a transition period between childhood and adulthood that is characterized by rapid development due to adolescent growth spurt (Cordeiro et al. 2006; Maiti et al. 2011). Physical changes occur simultaneously with hormonal (Delisle 2005); cognitive (Whaley et al. 2003; Cordeiro et al. 2006; Kristjansson et al. 2009)) and emotional development (Delisle 2005). Onset of puberty signifies the beginning of biological growth and development during adolescence. In other words it is responsible for overall physical transformation of a child into an adult.
For children who experience nutritional deficits in their early life, adolescence is known to be a “second opportunity” for growth as it facilitates catch-up growth among them (Rao 2001). During adolescence with onset of puberty, dramatic changes take place among boys in height, weight, body proportions, skeletal mass, fat mass, bone mass, somatotype components, leading to completion of sexual maturation, changes in physique and body composition. Muscle accumulates slowly throughout infancy and childhood, with a dramatic rise at adolescence. Body size exerts a profound influence on a variety of physiological functions including blood pressure. Blood pressure, vital capacity and grip strength during adolescence among boys show regular increase with age. The number of red blood cells and the ability to carry oxygen from the lungs to the muscles increases in boys.

All individuals pass through this succession, however, they differ from each other in the age of onset, duration, and tempo of these events between and within individuals. Thus, adolescents of the same chronological age can vary greatly in physical appearance. This difference is directly related to their nutritional status besides the genetic differences. The nutritional requirements of an adolescent in terms of calories and micronutrients play a very important role in bringing about this difference. The phenomenal growth that occurs in adolescence, second only to that in the first year of life, creates increased demands for energy and nutrients. Total nutrient needs are higher during adolescence than any other time in the lifecycle. Nutrient needs parallel the rate of growth, with the greatest nutrient demands occurring during the peak velocity of growth. At the peak of the adolescent growth spurt, the nutritional requirements may be twice as high as those of the remaining period of adolescence (Forbes 1992).

Adolescents who experience normal growth due to optimal nutrition and unconstrained environment attain the adult status as per their genetic potential after completion of linear growth spurt associated with puberty and completion of skeletal growth. Early matures are ahead of their counterparts of the same age in physical growth as well as skeletal and sexual maturity. Consequently, in place of chronological age, sexual maturation should be used to ascertain the degree of biological growth and development and the
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individual nutritional needs of adolescents (Stang and Story 2005). Failure to consume an adequate diet at this time can result in delayed sexual maturation and can arrest or slow linear growth.

1.2 MALNUTRITION

Impairment of health arising either from deficiency or excess or imbalance of nutrients in the body is known as malnutrition. Malnutrition is one of the most important global health problems which affects all countries with one in three people on the planet. According to Global Nutrition Report (2015) nearly half of all countries face multiple serious burdens of malnutrition such as poor child growth, micronutrient deficiency, anemia and adult over weight. The figures show that 161 million children under age 5 are stunted; 51 million are wasted and 42 million are overweight. None of these children are growing healthy (UNICEF/WHO/ World Bank 2015). 2 billion people suffer from micronutrient malnutrition (WHO 2015a); 1.9 billion adults are overweight (WHO 2015b) and 1 in 12 adults worldwide have Type 2 diabetes (WHO 2015c) and 795 million people are calorie deficient (FAO 2012). Forty-five percent of all mortality of children under age 5 is linked to malnutrition (Black et al. 2013).

India is a country which is undergoing transition in life style and dietary habits and as a consequence is suffering from already existing undernutrition along with over nutrition. Indian undernutrition data plays a very important role in shaping global statistics. In India there are about 40 percent of the world’s stunted children under the age of 5 and nearly 50 percent of the wasted children (UNICEF 2013). A recent National Survey—the Rapid Survey on Children (RSOC), conducted in 2013–2014 by the government and UNICEF provides new data. The preliminary data found that stunting in India had fallen from 48 percent in 2005–2006 to 39 percent in 2014.

According to this survey report, nearly all states in India showed significant declines in child stunting between 2006 and 2014. However, three states with very high rates in 2006—Bihar, Jharkhand, and Uttar Pradesh—showed some of the slowest declines. Changes in wasting rates are found to be more variable across states. For wasting, results show declines in most of the states except for Arunachal Pradesh, Maharashtra, Andhra Pradesh, Goa,
and Mizoram where increases in wasting are reported. Although the increases for the first two states are marginal, yet, these figures need to be viewed with caution because of effect of season on wasting rates. The preliminary findings suggest that India has accelerated its progress on stunting, wasting, and exclusive breastfeeding compared with results from the previous two surveys.

1.3 UNDERNUTRITION

Undernutrition is a condition associated with weakened immune systems and increased susceptibility towards diseases. Deficiency of calories and certain micronutrients is known to cause growth faltering in children among developing nations (Srihari et al. 2007; Best et al. 2010; World Health Organization 2011). In such nations including India, the relationship between malnutrition, morbidity, mortality, and child development is well recognized, and the efforts are being made to curb all kinds of malnutrition. Effects of intervention are an ongoing area of research these days to monitor the progress in undernutrition. Malnutrition among school age children is also one of the major public health concerns. More than 200 million school age children are stunted and underweight; about one billion school children will be growing up by 2020 with impaired physical and mental development (UNICEF 2011).

School age is the active growing phase of childhood (UNICEF 2004); it represents a dynamic period of physical growth as well as cognitive development of the child. Children are particularly vulnerable to undernutrition and environmental stresses as the priority in nutrition interventions is often to prevent malnutrition during fetal development and the first years of life (Bundy et al. 2009). Despite substantial progress in the fight against undernutrition in many regions of the developing world, Sub-Saharan Africa remains the only region challenged with increasing rates of undernutrition (FAO 2015).

In India, stunting has fallen from 48 % to 39 % but not much change is seen in wasting. Primary casual factors of malnutrition in developing countries are poverty and ignorance (Odunayo and Oyewole 2006). Overpopulation can reduce food adequacy, leading to inadequate food intake or intake of foods of poor nutritional quality and quantity. Moreover, unsafe drinking water and open defecation, lack of medical facilities, poor maternal health status are
other contributory factors of undernutrition in India. It is more prevalent in low and lower-middle income countries (UNICEF 2007). Chronic undernutrition has both short-term and long-term implications for physical growth (Powell et al. 1998; Whaley et al. 2003; Kristjansson et al. 2009), mental development (Whaley et al. 2003; Kristjansson et al. 2009) and productivity in adulthood (Kristjansson et al. 2009; Delisle 2010). Numerous studies have examined the relationship between contextual factors and undernutrition (Pongou et al. 2006; Wamani et al. 2007; Linnemayr et al. 2008; Olalekan 2008; Masibo and Makoka 2012; Kandala et al. 2011; Macassa et al. 2012; Nikoi and Anthamatten 2012). These factors include community food security (Haering and Syed 2009), geographic (UNICEF 2012) location (Kandala et al. 2011; Macassa et al. 2012; Nikoi and Anthamatten 2013), community socio-economic status (Fotso and Kuate-Defto 2005), infrastructural development (Masibo and Makoka 2012; Macassa et al. 2012), as well as institutional and organizational structures (Pongou et al. 2006; Linnemayr et al. 2008; Macassa et al. 2012) and health care services (Smith et al. 2005). Undernutrition in India is not only prevalent among infants and children (IIPS 2007, UNICEF 2009) but it also exists among adolescents (Bisai et al. 2012) and adults (IIPS 2007). According to WHO (2002) report, 32% adolescents were stunted and 53% adolescents were thin or underweight. These findings raise concerns for adolescents in developing countries where undernutrition in this age group is a significant but often overlooked problem (Delisle 2005).

In recent decades, the majority of programs and intervention studies designed to improve nutrition and health status focused mainly on children below five years of age and pregnant women, neglecting the health and nutritional vulnerability of adolescents. Adolescents from resource constrained communities have limited access to and availability of healthy foods and health care services, which puts them at higher risk for poor nutritional health (Nikoi and Anthamatten 2012). They encounter numerous health risks, many of which will affect the length and quality of their adult lives (Singhal et al. 2003; Delisle 2005; Cordeiro et al. 2006). Therefore, this study focuses on adolescents, a group that has typically been considered less vulnerable to poor health, and has received less attention in research, in spite of the fact that many health problems which occur later in life can be mitigated by...
adopter healthy lifestyle habits during adolescence (Sawaya et al. 2003; Lazzaretti et al. 2012).

**1.4 OVERNUTRITION**

During the past two decades a worldwide significant change in the nutritional status of adolescents has been witnessed because of global economic development and urbanization (Wang et al. 2009). Childhood obesity is rapidly emerging as a global epidemic that will have profound public health consequences as overweight children tend to be overweight as adolescents and young adults. In developing countries such as India, malnutrition and excess energy intake have been recognized to coexist simultaneously (Sawaya et al. 2004; Nandy et al. 2005) with an increasing prevalence of adolescent obesity (Mohan et al. 2003; Khongsdier et al. 2005; Marwaha et al. 2006; Premnath et al. 2010; Kaur and Mehta 2012). Obesity is not only prevalent in urban populations but it is also seen in rural and tribal populations.

Nationwide surveys were conducted to assess growth status of Indian children e.g. ICMR survey from 1956-1965 followed by Agarwal et al. (1992, 2001); Khadilkar et al. (2009); Marwaha et al. (2011) and Khadilkar et al. (2015) on affluent Indian children. These surveys have shown that children today are taller and heavier than their counterparts four decades ago. Similarly, affluent children, more specifically at younger ages today, are already taller and heavier than their counterparts fifteen years ago studied by Agarwal et al. (1992). It is, therefore, important to evaluate the nutritional status of adolescents to identify both under and overnutrition.

**1.5 NUTRITIONAL STATUS**

Nutritional status has been defined by Dwyer (1991) as “the condition of the body resulting from the intake, absorption, and utilization of food as well as from factors of pathological significance. Its full assessment requires anthropometric, dietary and biochemical data in addition to clinical observations.”

Nutritional status in different populations has been assessed using different methods. The simplest method involves the use of anthropometric variables of height and weight (Deurenberg et al. 1991; Hines and Dietz 1994).
Anthropometric indices of weight, height (Body Mass Index; BMI), skinfold thicknesses and circumferences are simple, easily obtainable, non invasive and inexpensive measures of assessing nutritional status. Body Mass Index (BMI) has been widely used to assess the nutritional status of children and adolescents. The accuracy of BMI varies according to the degree of body fat. Among relatively fat children, BMI is a good indicator of excess adiposity, but differences in the BMI of relatively thin children can be largely due to fat-free mass.

Body fatness is usually standardized for body weight and expressed as percent body fat [Fat mass (kg)/body weight (kg)], but an alternative is to express fat mass relative to height squared. This leads to the use of Fat Mass Index (FMI) and the Fat Free Mass Index (FFMI) (VanItallie et al. 1990 and Wells 2001). The cut off points for Centers for Disease Control and Prevention (Kuczmarski et al. 2000) were based on a US reference population. The 85th and 95th percentiles of BMI for age have been used as international standard cutoffs to define overweight and obesity and under the 5th percentile as underweight in the United States (Barlow and Dietz 1998; Kuczmarski et al. 2000), while alternative international cutoffs of overweight and obesity for children corresponding to adult BMI of 25.0 and 30.0 kg/m2 using data from other countries have also been proposed (Cole et al. 2000).

The use of IOTF criteria is applicable to Asian children (WHO/IOTF 2000) as an alternative to measure adiposity by BMI. Percentiles and Z -scores are often used to assess anthropometric measures to help evaluate children’s growth and nutritional status (Wang and Chen 2012). WHO released another set of growth reference for children and adolescents aged 5–19 years in 2007 (de Onis et al. 2007). The references were derived based on the same US dataset as for the 1977 WHO/NCHS growth references but used different growth curve smoothing techniques. The references include three indicators: BMI-for-age, weight-for-age, and height-for-age. For each indicator, charts and tables for percentiles and Z -scores were provided. Regarding Z -scores of these three indicators, the curves for 0, ±1, ±2, ±3 Z -scores from median were shown on charts, and the values for these cut points were provided in tables. Revised Growth charts were published by Indian Academy of
Paediatrics IAP (Khadilkar et al. 2015) to evaluate the nutritional status of Indian children and adolescents from 5 to 18 years. For the BMI; however, using (IOTF) approach 3rd, 5th, 10th, 25th, 50th, 23 adult equivalent (as overweight cut-off), and 27 adult equivalent (as obesity cut-off) percentiles were generated as per recent recommendations for Asian Indian overweight and obesity cutoffs (Cole and Lobstein 2012 WHO 2004). The 3rd percentile was used to define thinness (WHO 2007).

1.6 NUTRITIONAL STATUS OF INDIAN TRIBES

India has several socially disadvantaged communities among which Scheduled Tribes are the most deprived ones. The tribal population constitutes 10.43 crore, (8.6%) as per 2011 census of India, out of which 89.97% of them live in rural areas and 10.03% in urban areas. The tribal population often lives in the unique physical, socio-economic and cultural environment. In view of their habitat and food habits, they form a distinct group compared to other populations. Their food intake is influenced by large seasonal variations, depending upon availability of agricultural and forest produce. Several studies have documented a close relationship between the tribal ecosystem and their nutritional status (Rao et al. 1994; Rao et al. 1996). They live under horrific circumstances like poverty, illiteracy, malnutrition, lack of safe drinking water and unhygienic living conditions, which are contributing factors to dismal health conditions (Rath 2004). Inadequate health care facilities and ecological degradation further aggravate the situation (Rao et al. 2006).

Numerous research studies on growth and nutritional status of children and adolescents of various tribal populations residing in different parts of India have been conducted and found them to be undernourished, socially and economically disadvantaged (Malik and Singh 1978; Singh 1980; Reddy and Rao 2000; Bhasin et al. 2008; Mitra et al. 2002; Khongsdier and Mukherjee 2003; Rao et al. 2005; Rao et al. 2006; Tiwari et al. 2007; Bhasin and Jain 2007; Singh et al. 2007; Bhasin et al. 2008; Chakrabarty and Bharti 2008; Das and Bose 2011; Singh and Mondal 2014; Mondal and Terangpi 2014; Sen et al. 2015; Sahani and Das 2015). Moreover, growth pattern of high altitude children and adolescents has been found to be different from their
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counterparts living at low altitude and plains. Therefore regular monitoring of growth and nutritional status of the tribal population is necessary to study recent trends in these parameters with respect to other communities.

1.7 GROWTH AND NUTRITION AT HIGH ALTITUDE

The regions on the earth’s surface that are high above mean sea level are referred to as high altitude. High altitude is sometimes defined to begin at 2,438 meters i.e. 8000 ft (Webster’s New World Medical Dictionary 2008; Cymerman 1994). High-altitude exposure to hypoxia, nutritional stress, cold or a combination of these factors affect growth and development, infants born at high altitudes are smaller in size as compared to the infants from low altitude (Wilcox 2001).

Previous studies looked at the effects of altitude on human growth exclusively from biological or physical anthropological perspectives. Although, the high altitudinal zones of the world present very difficult and harsh weather conditions for the animals and humans to survive, yet these environmental conditions have long been inhabited. Surviving and procreating in such regions virtually requires marvellous adaptive flexibility of the organisms.

The common stresses of all high altitude regions include low barometric pressure, cold climate, high velocity winds, increased intensity of UV radiation, rugged terrain, increased precipitation (snow, hailstorm, sleet), isolation, limited energy production, desert and arid conditions. The survival in these regions is difficult, and so is the case with the growing and developing phenomena. All these conditions affect the growth and development of children in such a way that it slows down the process of maturation and depresses the overall growth. Andean, Alps and Himalayan high altitude zones have been extensively studied by various authors to explore the growth and development of children and adolescents. The growth-retarding effects of high altitude hypoxia are well known with several studies reporting healthy, well-nourished high-altitude children shorter and lighter than their age-matched low altitude counterparts (Haas et al. 1977; Giussani et al. 2001).

The findings from different high altitude zones have generally indicated that the children have a prolonged period of growth, late and poorly defined adolescents spurt, relatively bigger chests and calf muscles, greater lung
capacity and relatively thinner fat folds than those inhabiting sea level or lower altitudes (Frisancho and Baker 1970; Clegg et al. 1972; Hoff 1974; Beall et al. 1977; Miklashevskaya 1977; Malik and Singh 1978, 1979; Basu and Gupta 1984; Malik and Hauspie 1986; Singh 1980, 1989; Greksa 1990; Bhasin and Singh 1992). The only exception seems to be that of the Ethiopian highlands where the high altitude children grow favourably to their lowland counterparts (Harrison et al. 1969). Age-related increases in blood pressure throughout adulthood have been commonly observed in industrialized and developing populations. Based on studies in the Andes, Tien Shan, Pamir and US highlands, Blood Pressure values are generally lower in high than low altitude populations. Low and high altitudes may reflect the effects of other variables on blood pressure. Measures of adiposity like skin fold thickness, body mass index and upper arm circumference have a significant effect on blood pressure.

Many studies have also looked at the Andean populations and found different results. Even though a few studies showed that individuals living at high altitudes were smaller than the ones living at low altitude (Frisancho and Baker 1970; Haas 1976; Beall et al. 1977; Mueller et al. 1978) a significant group of studies could not reveal such a clear relationship (Clegg et al. 1972; Hoff 1974; Frisancho et al. 1975; Pawson 1977). In general, the consensus seems to exist only with regard to the increased chest size of high altitude populations. There are many ways through which altitude can have an effect on child health. Higher altitude is often associated with more difficult transportation, which, on one side, can lead to higher food prices and have an impact on the diet of the children and, on the other side, to more difficult access to health facilities. Moreover higher altitude can be associated with worse crop outcomes and have an impact on the diet of the population and on their available resources. Understanding the role of altitude can shed some light on the effects of other factors on anthropometric outcomes.

Several morphological and demographic studies have been carried out in different high altitude populations worldwide to study the pattern of growth and development, sexual maturation, structural, compositional, and physiological

Many people who live at high altitudes are shorter than their lowland counterparts (Pawson 1977; Singh 1980; Haas et al. 1982; Majumder et al. 1986; Leonard 1989). However, well-nourished children from diverse ethnic groups will attain a height within international reference ranges (Habicht et al. 1974; Martorell et al. 1978). Therefore, the short stature of children living at high altitudes should not be attributed to factors such as genetics and altitude when it may represent growth failure due to chronic undernutrition. Stunting of growth as a consequence of chronic malnutrition is often associated with irreversible neuro-developmental delay and increased morbidity and mortality (Garn 1973; Chen et al. 1980; Victoria 1992; Allen 1993; Burger et al. 1993; DeLong 1993; Pelletier 1994).

1.8 RATIONALE OF THE STUDY

Tribal studies have been traditionally pioneered by anthropologists over the last hundred years. However, there are still many tribes living on high altitudes which have not been studied. Shin tribe; a high altitude population residing in Gurez valley near the line of control in the state of Jammu and Kashmir, India is one of them. Due to disturbances after the eruption of militancy in Kashmir Valley in late 1980’s and harsh climatic conditions during winters, the valley was closed for researchers for several decades.
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As per literature survey, there is no information on growth and nutritional status of adolescent boys belonging to Shin tribe of Gurez valley. The strength of the study lies in the fact that this happens to be the first anthropological study of its kind, which has been undertaken with a view to examine the growth trends and evaluate the nutritional status of adolescent boys living in three zones of Gurez valley and to highlight the effect of high altitude if any, along with other factors, on their growth performance. This study will provide baseline data on growth pattern and nutritional status of adolescent boys of an unexplored tribe that could be used by researchers for future comparisons. Thus, the main aim of this study is to collect baseline data on physical growth and nutritional status of adolescent boys (10-19 years of age), belonging to Shin tribe, a high altitude population residing in three zones of Gurez Valley, on whom data of such nature are completely nonexistent.

1.9 OBJECTIVES

The proposed study has the following objectives:

- To study the growth trends in morphological and physiological variables among adolescent boys of Shin tribe (10-19 years) residing in three zones of Gurez Valley.

- To assess their nutritional status.

- To compare the growth and nutritional status of adolescent boys belonging to three zones of Gurez valley.

- To compare their growth status with international and national standards.

- To compare their growth status with other populations living at low, moderate and high altitudes.