1.1 GROWTH AND DEVELOPMENT

The evolutionary history of all organisms is a saga of the gradual development of survival mechanisms. The most fundamental survival mechanism is growth. The process of growth in the life cycle of a human being is fascinating. It comprises of fetal growth and the growth of the neonate into an adult. The fetus grows and develops inside the uterine environment which is extremely stable and provides a protective niche for the developing fetus. At birth, the fetus leaves this niche and gets delivered into the external environment. Human growth starts from this point of time. This is called postnatal phase of growth which differs completely from the fetal growth.

The external environment has a wide range of varying physiochemical stimuli that impose extreme physiological demand for the infant. To cope up with these demands, for the sake of survival, the infant undergoes several adaptive changes. These changes are brought about by the process of growth and development. Growth and development is a process that involves a desirable level of morphologic, cognitive, functional, metabolic and nutritional development which are fundamental for achieving an optimal level of health. Therefore, growth is considered as an indicator of health.

Health is a multidimensional concept. It is defined as a "state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"[1]. This implies that health encompasses several domains. The domain of physical well-being represents the state of physical health of an individual. It indicates the status for morphologic and functional development. Morphological development reflects the physical growth status of an individual.

1.1.1 PHYSICAL GROWTH

Physical growth is a complex and continuous process of physical developmentin terms of physical size and morphology and functionality, by which an infant develops into an adult. Physical growth commences through different phases which are described as growth during infancy, childhood, and adolescence. The pattern of growth and development is mostly determined by the genetic makeup of an individual. However, other than genetic factors, a complex interaction between nutritional, hormonal and environmental factors also influence the growth process.

Growth also depends on gender; boys have different growth pattern as compared to girls.

1.1.2 HEIGHT AND WEIGHT

Height and weight are considered as the two most fundamental anthropometric measurements that reflects physical growth.Each phase of development has its own characteristic features and pace of development, and in each phase depending upon the interaction between different factors, the height and weight increases at a particular pace. These are reflected in a measurable increase in body shape and size.

The increase in height and weight at different phases of growth are described in terms of growth velocity and growth spurt. Growth velocity is the measurable increase in height and weight at a fixed period of time. Growth spurt refers to the maximum gain of height and weight during a growth phase.

1.2 GROWTH MONITORING

The normal growth pattern continues with a standard level of gain in both height and weight with chronological age. This is associated with age and sex specific development of secondary sexual characters including the patterning of muscle and fat mass. The characteristics of normal growth and development in different growth phases, i.e., during infancy, childhood and adolescence and the growth spurts and velocities in each phase have been established by decade long scientific studies.[2]

Normal pattern of growth requires optimum health condition. Therefore, the growth standards are considered as the barometric measure of overall health condition. Health conditions of infants, children and adolescent's population are considered as indicators of the well-being of the society as they represent the future generation of any society.

Growth patterns can be evaluated through growth monitoring. It helps to understand growth standards and any potential growth problem. Therefore, growth monitoring is considered as an important clinical and public health practice to assess whether a child from a particular country, state or community is developing normally.

Food provides nutrition and promotes growth and development. Thus, the standard of growth is directly influenced by the level of nutrition. Poor nutrition hinders optimal growth with negative health outcomes, theseconditions are termed as malnutrition.

Growth monitoring can assess physical growth profile for a group of population in terms of presence and extent of growth problem and thereby reveals conditions of malnutrition. Subsequently, this provides an opportunity to take preventive and supportive actions to promote proper nutrition for betterment of health and well-being.

1.3 GROWTH STANDARDS AND GROWTH REFERENCES

In nutritional studies, for the purpose of growth monitoring and to determine the level of growth standards, the height and weight of a study population at a particular age are compared with certain growth criteria. According to WHO two types of growth criteria are used for assessment purpose; the growth standard and growth reference[3].

The growth standard represents the pattern and standard of normal growth of children under conditions of optimal nutrition and health. The growth standards of height and weight are available as charts or tables which gives the growth pattern of these children from 5 to 19 years of age in terms of their height, weight and BMI at different age group separately for males and females. Growth standard charts are prepared by the World Health Organization[4]following a worldwide survey across several nations and therefore allow to compare the growth pattern of children of all countries, races, and ethnicity against a single standard**.**

Although growth standards are used worldwide to assess the overall health condition of the community, it is however proposed that comparing the growth status of a particular study population against the WHO growth standard can overestimate the prevalence of malnutrition of apparently normal children particularly, in the context of developing countries like India[5-6].

As an alternative solution to this problem, growth references are used to assess normal growth. Growth references describe the existing growth pattern of children for a particular community, country or population at a particular period of time growing in the best possible state of nutrition and health in a given community. However, the best possible state of nutrition might not represent the optimal condition, and therefore, unlike the growth standards the growth references may not represent an optimal level of growth. Growth curves obtained from growth references, known as reference curves therefore need to be updated at least once a decade and with the recent rising incidence of obesity, as they are likely to define overweight children as normal[7].

1.4 GROWTH INDICES

Height and weight, although considered as the two most sensitive anthropometric indicators of physical growth, do not help to detect various clinical and sub clinical forms of growth deficiencies and malnutrition alone, and therefore need to be transformed to suitable growth indices. An index is defined as a combination of variables[8].

Growth indices also called growth indicators, are constructed by combining height and weight with age and sex of the individual. They indicate age and sex specific normal level of height and weight. Objectively, they compare the height or weight of a child or adolescent (study population) with the expected value of height or weight of a child or adolescent of the same age from a reference population. The reference population is considered as the population of children and adolescent with normal growth pattern. Such comparisons, help to detect any growth deficiencies among the study population.

Growth deficiencies is the inability to gain normal height at a particular age, or the inability to attain a normal weight for a particular height. Given the fact that nutrition determines growth, these indices, by detecting growth deficiencies, serve as important proxy measures of nutritional standard and detect conditions that evolves from nutritional imbalance or deficiencies. Simply stating, these indices detect conditions and levels of malnutrition. So, these growth indicators are also termed as nutritional indicators. In public health and epidemiological studies, these indices are used as a valuable tool to assess the nutritional status of a given population and to compare nutritional standards between populations. Three sex and age specific indices are most commonly used for the evaluation of growth and nutritional status in children's and adolescents up to 19 years of age. They are height - for - age (HAZ), BMI - for - age (BMIAZ), and weight-for-age (WAZ)[9]**.**

1.4.1 HEIGHT- FOR AGE

The Height – for – Age (HAZ) is a height- based indicator and indicates linear growth. It compares whether a child or adolescent has achieved the expected level of height as compared to a child from healthy well-nourished reference population of same age. A low HAZ indicates age related short stature condition known as stunting. This indicates linear growth retardation which means a child has failed to achieve a standard linear growth at a particular age.

Height increases over years and inadequate nutrition over a long period of time leads to failure to attain an expected stature at a particular age. Therefore, stunting reflects a state of chronic malnutrition.

1.4.2 BMI-FOR-AGE

Body mass index (BMI) is a quotient which is used to identify if an individual has an abnormal weight in proportion to their height. It is calculated as weight divided by height and expressed in kg/m^2[10]. BMI gives an indication of the relative amount of body fat. Worldwide data on BMI reveals that increased BMI is related with physical inactivity, and consumption of high calorie food and increased BMI is associated with the risk of chronic diseases[11].

BMI is transformed to an index called BMI - for - age (BMIAZ) which is considered as a weight- based index. It compares the BMI of a child at a particular age with the BMI of a child representing the reference population of similar age group. Given that the BMI reflects relative fatness of the body, early studies on BMI for age were mainly used to identify conditions of overnutrition that includes overweight and obesity. In practice, using BMI and transforming it to BMIAZ, has been successfully used in nutritional studies to assess the risk for overweight, and obese conditions[12]. Both overweight condition and obesity are considered as chronic state of malnutrition.

More recently, the importance of low BMI has also been recognized to identify undernutrition. In accordance, low BMIAZ scores indicate condition of under nutrition termed as “thinness”. BMIAZ has been recognized as the best direct indicator of thinness during adolescence[13]. Thinness is considered as a direct indicator of acute state of malnutrition [14].

1.4.3 WEIGHT-FOR-AGE

The weight-for-age index determines if one is underweight or not, where underweight can be defined as inadequate weight related to age. This index indicates both chronic and acute malnutrition. Weight for-age is inadequate for monitoring growth beyond childhood due to its inability to distinguish between relative height and body mass, hence the use of this indicator is restricted for use in children up to 10 years of age[9].

1.4.4 CUT-OFF VALUES FOR DEFINING STUNTING, THINNESS, OVERWEIGHT AND OBESITY

The nutritional indices, the HAZ and BMIAZ, are expressed quantitatively either as percentiles or Z- score values. While the percentiles represent ranks, the Z scores are considered as continuous variables and represents standard deviations of the parameter concerned, for example, the height in case of HAZ, or BMI for BMIAZ[15].

Z – scores are considered as standardized measure which could be compared across age and sex for the assessment of the nutritional status of children and adolescents up to 19 years of the age. According to the World Health Organisation (WHO) stunting and thinness should be defined against certain Z-scores, which are considered as cut-off values. A cut off value represents a standard Z score of height and BMI of the reference population[16]. According to WHO, a standard deviation of -2 of the reference population should be considered as the cut- off z score. This means that if a subject's height or BMI is less than the – 2SD value of height or BMI of the reference population of the same age group the subject will be considered as stunted and thin (wasted) respectively. Furthermore, if the height and BMI of the subject from study population, is less than the – 3SD score of the reference population of same age group, it will be considered as a case of severe stunting or severe wasting respectively[4,16]. The Z scores of – 2SD or -3 SD are lower cut-off values which define conditions of poor or under nutrition represented by stunting and wasting (thinness).

Overweight and obesity also represent malnutrition and more specifically, they are considered as conditions of overnutrition. They are defined by higher cut-off values. Conventionally, percentile scores of the reference population are used instead of z scores, to define overweight and obesity conditions. Overweight is defined by a cut-off value of BMI of > 85^{th} to < 95^{th} percentiles and obesity is defined by a cut- off -value of BMI ≥ 95th percentile of the reference population of the same age.[17].

More recently, the overweight has been defined as a BMI > 1 SD and obesity as a BMI > 2 SD, of the WHO reference population[9,18].

1.5 DIET AND DIETARY PATTERNS

Nutrients are essential to maintain growth and physiological functions. We obtain nutrients from the daily intake of different variety of foods. The combination of different kinds of food is called diet. The daily pattern of food and beverage intake in

terms of variety, quantity, quality and the frequency with which they are habitually consumedis called dietary pattern[19].

As the foods vary widely in their nutrient content, food combinations determine the nutrient content of the diet which is important for the health consequences of the food. It determines the standard of nutrition**.** For positive health outcome and adequate nutrition, the dietary pattern must be sufficient from its nutrient content. On the other hand, inappropriate diet pattern and food habits can fail to provide the daily nutritional requirements and can cause both under nutrition and over nutrition.

This adverse pattern couples with the physical activity and affect systemic health as reported in various studies[20-22].

Evaluation of the dietary standard includes adequacy of diet, dietary contents and their appropriate and inappropriateness, the pattern for daily meal intake, and spacing's between meals, eating behaviour and preferences for food. Various socio-cultural, economic and environmental factors influence food preference. They include food related beliefs, the availability of foods, the ability to purchase and prepare food, promotion of food by advertisement. Healthy dietary patterns can be induced by efforts from different government, non-governmental agencies and nutrition communities to promote healthy diet[23].

Evaluation of dietary pattern and subsequent determination of nutritional sufficiency provide evidences to formulate dietary guidelines. Dietary guidelines are the evidence-based statements on food choices to meet the nutritional requirement and to reduce the risk of malnutrition and chronic diseases[24].

1.6 EFFECT OF GLOBALIZATION ON DIETARY PATTERN

Over the last few decades global scenario of dietary patterns has changed. Populations are moving from traditional diets to more highly processed diets. Traditional diets are high in fibres and micronutrients, but processed foods are usually high in sugar, low in fibre, fat, salt, and less nutrient dense. Therefore, these changes are leading to nutritional inadequacies. This pattern of change is described as the 'nutrition transition[25].

Nutritional transition is progressing with a rapid pace and affecting people of all age groups across countries, communities and socio-economic status. These transitional patterns are outcome of socio- cultural, economic and technological transformation

and are more prominent in lower- and middle-income countries. These dietary and activity shifts have direct implications for non-communicable diseases, which are more aptly termed as nutrition-related non- communicable diseases.

With the ongoing nutritional transition there is also a rising trend of obesity. Children and adolescents are suffering from both under nutrition (stunting and thinness) and overnutrition (overweight and obesity). The simultaneous existence of both these extremities of malnutrition is more prevalent in the communities of the developing and underdeveloped countries, this condition has been termed as the double burden of malnutrition which has become an important public health issue worldwide[25].

Worldwide data available on adolescent nutrition and dietary pattern point towards low consumption of fruits and vegetables, meal skipping habits, consumption of substantial amount of fast food in diet and not having family meals[26-29].

India is undergoing nutritional transition which has been triggered by diverse sociocultural, economic and marketing policies[30]. This resulted in a significant change in the lifestyle and dietary habits especially of the urban population of India[31-33].

Nutritional transition among Indian population is conspicuous too. The traditional culture specific home-cooked meals are getting rapidly replaced with read-ready-to - eat and processed fast food in the urban community[34-35]owing to the simultaneous introduction of western culture and opening of multinational food companies, the Indian food market has experienced a paradigm shift in the last few decades with transition in nutritional status within the various Indian populations.

1.7 BACKGROUND OF THE STUDY

1.7.1 THE IMPORTANCE OF ADOLESCENT PERIOD

Adolescents are the persons within the age group of 10-19 years[36]. They are the largestcohorts in today's world than ever before[37]. Adolescent comprises 16% of total world population[38]. Asia has more than half of the world's adolescents. Most of these adolescents (90%) live in low-and- middle- income countries (LMICs)[4,39]. According to the census 2011, 20% of population of India are adolescents[40-41].

The adolescent period is divided into 2 phases- early adolescence which span from 10 to 14 years and late adolescence period which is between 15 to 19 years[37].The adolescent period of life is seen as second window of opportunity for "catch up growth"[42] and a significant period of growth and maturation in human development.

This period is characterized by rapid physical growth, and psychological development. A substantial amount of adult height, weight, and bone mass is gained during this period. Moreover, this is a period of significant deposition of muscles in boys and fat in girls.

To meet these growth requirements and rapid growth spurt, the physiological need for nutrients during adolescent period is immense, in fact this period of life has the highest nutritional demand. Therefore, dietary adequacy in this phase of life is of utmost importance to achieve optimum growth & development. This can be fulfilled by the consumption of a high-quality nutritional diet coupled with good lifestyle and hygienic practice coupled with a planned physical activity for improving & maintaining physical fitness.

During adolescent an individual undergo extreme psychosocial cultural- emotional changes which influence their lifestyle, food habits, food preferences, and other health related behaviours. This may lead to erratic nutritional pattern affecting both nutrient intake and need. Therefore, adolescent period is also considered as a period of nutritional vulnerability[43]. Studies have identified various sociocultural and economic factors as determinants of adolescent malnutrition[44].

Food habits developed in adolescent period have several long-term nutritional implications and consequences. It has been reported that the food habit and pattern that develops during adolescence influence the food related behaviours of adulthood[45]. Therefore, providing healthy nutrition during adolescent period can have significant long-term health benefits and on the contrary, adverse nutritional condition in this period of life can make the adolescents prone to sub clinical cardiovascular disease, type II diabetes and obesity[46].

The domain of adolescent's health and nutrition condition bear immense importance for community health as the adolescents are the future workforce and bearers of next generation. In addition, the nutritional standards of the adolescents girls who are future mothers contribute significantly to the nutritional status of the community and improvement in Adolescent nutrition of girls can also break intergenerational malnutrition cycle and improve the pregnancy outcome[47-48]. Identification of health and nutritional status of adolescents also can predict the future development of illness. It has been reported that inadequate nutrition during this period can potentially retard

the growth and sexual maturation and can also increase the risk of chronic diseases at a future age.[4,39,49].

1.7.2 THE IMPORTANCE OF NUTRITIONAL STUDIES

It has been reported in international literatures that there is a paucity of data on how the nutritional status is affected by different health related behaviour, nutritional preferences, everyday life context and sociocultural and economic factors when one transit through the age of adolescent[44].

Examination of the patterns of diet and preference for different kinds of food is critical for understanding the nutrition transition among different populations and communities, which also holds true for adolescents and adults. It is essential for the development of appropriate health policy and programmes

Nutritional studies worldwide, have reported the prevalence of anthropometric indicators like underweight, stunting, overweight and obesity, which are often indicated as proxy measures of changes in dietary habits and food consumption pattern[50]. Although these prevalence data on nutritional standards make important contribution to the understanding the overall nutritional conditions, these findings need to be complemented and substantiated by data on actual pattern of food consumption and preferences is necessary for a fuller understanding of the drivers of dietary change. These studies are not only important for formulating nutritional policies in a broader public health context, but can also provide guideline for development of improved methods and metrics for agri-health research[51].

1.7.3 SOCIO-CULTURAL AND DEMOGRAPHIC CONDITIONS OF HIMACHAL PRADESH

Himachal Pradesh (HP) is a hilly state in Northern India. The state is bordered by four Indian state and also by the autonomous Tibet region. The unique geographical feature of the state has influenced the socio-economic, and cultural pattern of the state population. The state has a population of 68,84,602[41] with a large majority (90%) living in rural areas. It consists of 12 districts, 123 tehsils spread over 55,673 sq km area. Youth constitute about one third of the total population.

Himachal Pradeshis considered to be the most progressive hilly state of India and has made remarkable socio-economic development during the last few decades owing to the remarkable efforts that was taken to reduce poverty and establishing the state with

the best human development outcome in India. There has been a significant drop in the poverty level which has benefitted all social group across rural and urban areas of the state.

The state has also undergone transformation and development in its agriculture, horticulture and animal husbandry sector[52]. Himachal has also made tremendous improvements in various demographic indicators such as life expectancy, infant mortality rate and crude death rate. Between 1981 and 2011, Himachal's literacy rate has almost doubled and is one of the most literate states of india with a literacy rate of 83.78%. According to Human Development Report 2018, Himachal ranks as the third best[41]performing states in the country after Kerala and Goa.

However, there is still a concern for the nutritional status of Himachali children and adolescents. A health survey report on adolescents and youths of Himachal Pradesh reported that 44 percent prevalence of underweight and 5 percent prevalence of overweight and obesity among the surveyed population[53].

Given the fact, that Himachal Pradesh is a home to about 1.5 million adolescents in the age group of 10-19 years, that constitute 22 percent of Himachal Pradesh's total population and that the effect of socio cultural economic and technological developments in Himachal will open avenues for infiltration of global nutritional trends among the Himachali communities, it is expected that such transformations will also affect the adolescents of Himachal.

However, there is a paucity of data on nutritional standard and dietary pattern of Himachalischool going adolescent population. In the last decade only, three studies have reported about the dietary adequacy and dietary pattern including junk food consumption of Himachali adolescents and children[54-56]. Other three studies have reported on the anthropometric profile of Himachali children and adolescents[57-59].

1.8 SCOPE OF THE PRESENT STUDY

The physical growth standards of children and adolescents are considered as the markers of the progress of human societies. Therefore, the domains of children and adolescent nutrition, health and physical development have always gained academic importance. Investment in adolescent nutrition with the aim of development of health and nutritional status of school age children and adolescents is associated with positive health outcome of the future society. Adolescent nutrition and health research

can provide insights into the extent of growth and nutritional related problems of this population. Such efforts can also address their health and developmental needs which could be taken into consideration in order to achieve improved health and development outcomes for the population as a whole.

In view of the above background and scope, the present study has been conducted with the following aims and objectives.

1.9 AIMS OF THE STUDY

1. Estimation of the growth standards of Himachali adolescent boys and girls
2. Assessment of malnutrition of Himachali adolescent boys and girls
3. Evaluation of dietary pattern of Himachali adolescent boys and girls

1.10 OBJECTIVES OF THE STUDY

1. To determine the mean height, weight and BMI of the Himachali adolescent boys and girls for all age groups from 10 to 17 years.
2. To estimate the Z scores of different growth indices viz, height – for – age and BMI for age to assess malnutrition in terms of the growth standards.
3. To estimate the prevalence of different categories of malnutrition separately for boys and girls in relation to different age groups and adolescent categories.
4. To report the dietary pattern in relation to the intake frequencies of different food groups consumed during meal and snacks.
5. To study the breakfast habits and vegetarian and non-vegetarian pattern of the boys and girls
6. To study the relationship of dietary patterns with different nutritional categories.

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