CHAPTER I

INTRODUCTION

'Malnutrition' is prominent in developing countries like India. Substantial reduction in the infant and early childhood mortality have been achieved throughout the world in recent decades. Unfortunately, this achievement has not been paralleled in developing countries like India.

Malnutrition is present in all age groups, but pre-school children suffer most and is therefore considered most vulnerable group. Reported prevalence of severe Protein Energy Malnutrition (PEM) either Kwashiorkar or marasmus as 0.7% to 7.6% in children below 5 years and prevalence of moderate PEM, though varied from country to country, of the order of 4.4% to 43.1% in this age group (WHO, 1971).

Substandard stature and low body weights of adults are attributed to widespread malnutrition in early years of life. For example, Satyanarayana *et al.* (1989: 289-300) found that adult stature is highly correlated with height at fifth year's age, among rural Hyderabad children. Similarly, Tanner *et al.* (1956: 372-381) have noted that almost all dimensions could be predicted from measurements taken at 3^{+} year for children in developed countries. Such observations

were supported by Mills *et al.* (1986: 543-547) and Martorell *et al.* (1992: 143-149). Recently, Kanade A.N. (1993: thesis) also demonstrated importance of maintaining height in pre-school years for better adolescent growth performance for Indian rural children. Such long term investigations are however, difficult and rare as they need to cover entire phase of growth from childhood to adulthood.

Issues investigated over short-term growth phase especially over pre-school age span are of special importance for several reasons. For example, it is in this period growth stabilization is believed to take place that ultimately confirms to the growth in later years. As a consequence, malnutrition during this rapid phase of growth produces profound influences on growth of individuals. Secondly, it is in this age group, attempts to combat malnutrition can be undertaken through intervention.

Consequently, considerable research on pre-school children has been documented in literature addressing several issues. One of the major problems studied is that of comparison of children from rural-urban (Choudhry M. *et al.* 1983: 18-29, Phadke M.V. *et al.* 1973: 387-390) or high and low socio-economic groups (Datta Banik *et al.* 1970: 438-447,

Quinn *et al.* 1995: 66-72, Datta Banik 1982 : 353-359, Dhamija *et al.* 1976:209-218, Cameron 1992: 223-224, Khurana *et al.* 1971: 331-335, Rao S. *et al.* 1993: 129-135). The weights and heights of children from better-off classes are found to be higher than the children from lower classes, but no comment is offered with regard to observed variability in measurements among the individuals from such groups.

Another issue often studied among pre-school children is the use of several anthropometric indices (viz. weight for age, height for age, weight for height etc.) for grading malnutrition among children. Several classificatory systems (Gomez *et al.* 1956:77-83, Waterlow 1972:566-569, Seoane and Latham 1971 :98-104, Dugdale 1979:53-56) thus were established, which enabled comparisons of various communities for studying the extent of malnutrition, and associated factors (Vishweswara Rao 1978: 233-244, Martorell *et al.* 1988: 57-73, Gopalan C. *et al.* 1989: 69-100). These studies too overlooked the between individual variability in weight or height deficits among children from respective communities.

Growth is mainly affected by genetic and environmental factors. But Martorell *et al.* (1988: 57-73) who studied relative importance of these factors reported that variations

that could be attributed to environmental factors were several times greater than that attributed to genetic factors. Further, among the two major environmental factors infection and nutrition have been largely studied among pre-schoolers.

The effect of infection has been studied by several researchers. Thus while Scrimshaw *et al.* (1968), James (1972: 690-694) and Gorden *et al.* (1964: 9-20) described the relationship of poor nutritional status with morbidity, Mata *et al.* (1977: 1215-1227) and Rowland *et al.* (1977: 441-450) reported that morbidity, especially gastro-intestinal infections, predisposes the risk for malnutrition. Further, Nabarro *et al.* (1988:165-184) investigated variations in linear growth among Nepali children and noted that infections could partly explain the variation in growth though larger part in variation remained unexplained.

The studies examining influence of nutrition on growth are not many, as assessment of nutritional intakes of pre-schoolers is difficult unlike that in case of adults. Most studies therefore only attempts to study the group of infants and correlates breast feeding practices in infant growth. (Rao S. *et al.* 1992: 1533-1539, Sidhu *et al.* 1981: 75-79). Among the few studies which examined the

nutritional intakes of pre-school children in relation to growth reported that height is affected most by protein deficiency (Ashworth *et al.* 1986:157-163, Malcolm 1978:361-371) whereas weight is more sensitive to low energy intake (Malcolm L.1978: 361-371, Waterlow J.C. 1978:455-460). These observations were then confirmed by Dagnelie P.C. *et al.* (1994 : S103-S112). In view of the difficulties of assessing the nutritional intakes of pre-schoolers the problem is often tackled by giving nutritional supplement and examining its impact on growth.

Consequently, supplementary feeding programmes were used as main weapon to tackle the problem of malnutrition. Many studies (Devadas *et al.* 1979: 335-341, Soman C.R. 1982: 215-222, Sail *et al.* 1972 : 185-193, Manjarekar *et al.* 1986:404-407) evaluated these programmes by longitudinal data, but often using the initial and final measurements only without considering intermediate observations . Such approach not only leads to underutilization of the data but also loses the opportunity of examining the enormous variation in growth between different children and also within the same child. Infact it has been observed that similar children did not show similar gains in weights and heights even with the same amount

of supplementary intake, nor did the same individual show similar gain over equal time intervals in a given feeding trial. Secondly, in response to the feeding received, some children may improve their heights while other children may improve their weights. Therefore it is equally essential to study such variation in muscular or skeletal growth observed in feeding trials while evaluating these programmes (Rao S. *et al*. 1992:45-52). The implication is that proper understanding of the growth process especially, with reference to the variations, is necessary.

Thus the above discussion reveals that reported studies have not given due attention to the observed variation in growth, between as well as within children. In the absence of this many comparisons based on averages alone would lower its importance. Investigations on between as well as within variations in growth would infact help in understanding the biological variability in growth and therefore would facilitate understanding of the growth process. The present study therefore, attempts to investigate several aspects of such variations in growth among rural Indian children.

Growth alterations can be due to extrinsic as well as intrinsic factors. Formar mainly contributies to between

individual variation while latter contributes to within individual variation. Most of the studies reported were of cross-sectional nature and do not allow examination of within individual variation. Although there are few longitudinal studies reported they seem to have dismissed within variation as errors of measurements. It is perhaps worth mentioning here that while between individual variation is affected by environmental factors, within individual variation is likely to be due to biological variations. Infact it has been described as reflection of responses of an individual to the environmental stimulus (Sukhatme 1982: 11-63) and highlights the importance of within variability. Therefore, systematic longitudinal studies are required to examine between as well as within variation.

Growth can be measured either in the form of distance traveled or velocity. Physical growth characteristics like weight, height of an individual when compared with standards show whether child is growing within expected normal range, but if velocities are compared it will reveal if child is growing with expected growth rate for his age-sex.

Harrison *et al.* (1989: 45-51) have observed larger values of Coefficient of variation (C.V.) for incremental data than

for attained values. This variation in increments between children was further observed to be larger in case of poor Sudanese children (Zumravi *et al.* 1987:383-395) than that observed for children under better condition, when weights were recorded over the period of two weeks. Further, this was also observed to be true in case of height increments when observed over the period of four weeks.

Thus it shows that the between individual variability appears to be higher in malnourished children both with regard to attained weights and heights as well as their increments when compared to children from better-off families. Is it by corollary that one should expect within variability in growth among children from poor communities to be lower than children from better-off communities? In that case it means that malnourished children have lower capacity to interact with the environmental stimulus considering the interpretation of within variability offered by Sukhatme P.V. (1982 : 11-63). Unfortunately, this issue can not be studied with the reported longitudinal data sets and needs investigations with the help of systematic follow-up data.

There are few longitudinal studies that noted variation in incremental data. Roche & Himes (1980:2041-2052) showed that

it was common for children (0-36 months age) to grow at rates which are outside the 90th and 10th percentile of the median weight reported for respective children. Thus children changed paths of development over a fairly wide range depending upon the location in time and the momentum they receive. Yet they have not offered the biological interpretation of this wide variation encountered among normal healthy children of same age-sex.

Recent study by Butler *et al.* (1990:177-198)is perhaps unique in its nature as it attempts to examine the intra-individual variation or time related variation in growth of individuals by analysing the longitudinal data sets reported in literature. They examined serial observations on heights of children from 3 years onwards and noted wide variation in height velocities and which were further seen to be of cyclical nature. They therefore, suggested that growth is perhaps rhythmical in its nature. However, this study did not elaborate this rhythmical nature in terms of mathematical or statistical test such as serial correlations, although they felt the existence of the periodicity in the growth. Second major limitation of this study is that they have studied only height measurements. Healy *et al.* (1988: 41-55) have analysed

height incremental data (4 weekly and 8 weekly) of infants for a period of one year in order to detect early growth retardation to initiate intervention. In their analysis although they attempted computations of serial correlations, they did not find correlations in successive height increments to be significant and this was attributed to measurement errors. Therefore, longitudinal data was not further examined to study within variation and its nature in the skeletal growth. However, it may be noted here that the increments over short periods (such as 4 weeks or 8 weeks) are likely to be exceedingly small with respect to the sensitivity of the height measurement and this might be the reason for getting non-significant correlation. It would have been possible for them to compute serial correlations of successive increments over larger periods such as 12 weeks or 16 weeks before dismissing the intra-individual variation as arising from errors of measurements. These authors too analysed only height incremental data. As weights and heights are known to be correlated in all communities simultaneous examination of weight and height increments will be more helpful than studying them in isolation for understanding variation in growth.

Lastly, longitudinal data is also useful to fit mathematical models to individual growth data and information about growth process can be extracted and condensed in the form of parameters. Such parameters would be of use to compare growth of different individuals or different populations by comparing the averages of these parameters. But here again there are several issues which need critical investigations. For example, though various models were described in literature for describing growth of pre-school children, most of the models were tested on healthy children living in optimum favorable conditions. Thus Jenss model (Jenss *et al.* 1937: 556-563), Count model (Count 1943: 1-32) and Reed model (Berkey *et al.* 1987: 973-987) were reported for describing growth of healthy pre-school children. Therefore, testing the suitability of these models for describing growth of children from populations of developing countries where malnutrition is prevalent is necessary.

Secondly, conventional models used the data over the whole age span of 0-6 years. However, in reality longitudinal field studies for such long period are rare due to well-known difficulties, in field surveys. Therefore, testing the adequacy of these models for short-term age ranges of two or three years

is essential to enhance their utility in practice.

Thirdly, most of the studies are of cross-sectional nature. Therefore, applicability of these models for average weights and heights (i.e. for grouped data) will be even more beneficial to many researchers. It will facilitate the comparison of different communities or groups, in terms of model parameters, rather than simple means.

All these important aspects of growth modelling along with its use to differentiate growth pattern of normal and malnourished children are addressed in the present study. Children from rural area exhibit wide spectrum of malnutrition, therefore examining variations in growth pattern of rural preschool children forms the main objective of the study.

Initially, 376 pre-school (1-5 years) rural children were observed. A continuous morbidity data and periodical anthropometric measurements (every three months) on weight and height were recorded for a period of two years. Thus at the end of the study period 277 children had 9 serial observations on weight and height. This longitudinal growth data is analysed for various issues related to variability in growth, brought out above, using simple biometrical methods.

Analysis is presented into different chapters. The second chapter offers detailed information about subjects included in the study and methodological details related to data collection.

Description related to preliminary analysis for identifying critical age of growth retardation is offered in chapter III. It also deals with relationship between nutritional status and morbidity.

Since malnutrition in these rural children is considerable, extensive analysis for examining variations in growth pattern of normal and malnourished children is described in chapter IV. Different techniques used to examine nature of within variation are also discussed in detail in this chapter.

A distinct use of growth modelling for comparing the variation in growth of normal and malnourished children is attempted in this study. Thus extensive review of growth modelling along with the actual application of these popular models has been illustrated in chapter V with the help of longitudinal data collected in this study.

Finally, the summary of major findings is presented in last chapter along with its implications .