Academic Report of the Project "Physical Growth, Body Composition and Nutritional Status of Bengali School aged Children, Adolescents and Young adults of Calcutta, India: Effects of Socioeconomic Factors on Secular Trends" (ID 158)

Sponsors: **Neys-van Hoogstraten Foundation**
The Netherlands
and
Indian Statistical Institute
Kolkata, India

Principal Investigator: Parasmani Dasgupta
Professor
Biological Anthropology Unit
Indian Statistical Institute
203, B.T. Road
Kolkata 700108, India

Collaborators: Dr. Maarten Nube′
Nutritionist
Centre for World Food Studies
Amsterdam, the Netherlands

Debasis Sengupta
Professor
Applied Statistics Unit
Indian Statistical Institute
203, B.T. Road
Kolkata 700108, India

Dr. Mercedes de Onis
Growth Assessment and Surveillance Unit
Department of Nutrition for Health and Development
World Health Organisation
Geneva
Switzerland

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Dedicated to the memory of J. M. Tanner for his interest, encouragement and support in all three growth studies presented in this report

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SUMMARY OF THE STUDY

In the backdrop of the countrywide ongoing economic transition, a cross-sectional growth study has been carried on children of Bengali population aged 7.0-21.0 years, living in Kolkata city, India. The first objective of the study is to enquire whether secular trends phenomena are operating in the measures of body size and mass, different body segments, body shape, body composition, nutritional status and in the biological parameters of adolescent growth spurt of urban children when the results of the study are compared with the results of two earlier studies (Sarsuna-Barisha growth study of 1952-1966 for both sexes and Kolkata growth study 1982-83 for boys) carried out around this place during pre transition period of the country. The second objective is to investigate the occurrence of secular trends phenomena in mean age at onset of menarche of contemporary urban Bengali girls during the transitional period of Kolkata city. The third objective of the study is to evaluate the effects of probable socioeconomic factors responsible for the observed secular trends and subsequently to analyse their influences on several individual measurements, body shape/form, body composition and nutritional status of contemporary urban children and on age at menarche of contemporary Kolkata girls.

The sample for this cross sectional growth study constitutes 1,999 Bengali boys and 2,195 Bengali girls selected from predominantly middle class families, sampled from 66 schools and colleges from the city of Kolkata, India. Students from these academic institutions have participated in this study in response to the requests made by the administration of these institutes to the guardians of the students. For boys, the cross-sectional growth data have been collected in two survey phases: the first between the years of 1999 and 2002 and the second between the years of 2005 and 2011. For girls, the cross-sectional growth data have been collected from only one survey period of 2005 to 2011. Twenty one direct anthropometric measurements have been collected from 4,194 children (1,999 boys and 2,195 girls) by the well trained male and female measurers on and around birth dates of the subjects following the protocol of the International Biological Programme (IBP, 1969). From all 2,195 girls, data on onset of menarche have been collected by status quo method. From them only 444 girls have provided recalled data by interview. Socioeconomic data (fifty items) have also been collected from the participants from their households by interview. Dietary intake data have been collected by twenty four hours recall questioner method.

To measure the amount of secular trends in the percentiles of body mass index and skinfold thicknesses in comparison with the results of the earlier study periods the LMS method (Cole, 2000) has been used. To measure the amount of secular trends in means of fifteen individual anthropometric measurements (seven for both sexes and eight for boys) related to body size and mass, body segments, head and face, six indices of body shape (four for both sexes and two for boys) and six measures of body composition (for boys only) in comparison with the results of the earlier study periods, student’s t-test has been performed. To measure the amount of secular trends in four indicators of nutritional status (stunting, thinness, overweight and obesity) in comparison with the results of the earlier study periods, z-statistics has been performed on the data. To measure the amounts of secular trends in adolescent growth spurt, three biological parameters, namely, mean ages of maximum increment, mean peak velocity and final/mature size (estimated from Preece-Baines model 1) of seven studied anthropometric traits have been compared with the results of the earlier study periods. Mean and median ages at menarche of urban Bengali girls of Kolkata city have been estimated by Probit, Turnbull and Kaplan Meier methods and secular trend in this measure of sexual maturation has been observed in comparison with the results of the earlier study periods. To

measure the effects of several socioeconomic factors, like parental education, father's occupation, per capita monthly family expenditure, size of sib ship and birth order of the subject on standing height, body weight, sitting height, subischial leg length, sitting height/subischial leg length index, body mass index percentage of body fat mass, triceps skinfolds, subscapular skinfolds and body fat distribution index ANOVA/MANOVA has been performed on the data of the contemporary children. To measure the effects of some of these socioeconomic factors on stunting and thinness in both sexes and age at menarche of girls logistic regression model and Cox proportional hazards regression model respectively have been performed on the data of contemporary children.

Results show that notable positive secular changes have taken place in the higher percentiles of body mass index (in both sexes) and skinfold thickness (in boys) between the comparing study periods which are evident from the LMS values. Other results have also produced primary evidences supporting the positive trends which are observed to have occurred in most of the age specific means of seven individual somatic traits of the contemporary children. They are standing height, sitting height, subischial leg length, biacromial diameter, bi-iliocristal diameter, total arm length and body weight. Moreover, significant increase in means for upper arm circumference, bicondylar femur, calf circumference, head length, head breadth, head circumference and bizygomatic breadth of contemporary boys (between 7.0 and 16.0 years) confirmes the occurrence of positive secular trends for these traits as well. However, the magnitude of the increased means varies according to age, sex and time interval between the study periods under comparison. As exception, morphological facial height has manifested a significant negative secular trend by lowering age specific means of contemporary boys. The mean final/mature size (estimated from Preece-Baines model 1) of five of the seven studied traits (standing height, sitting height, subischial leg length, biacromial diameter and body weight) have also increased between the comparing study periods which is more pronounced in boys to reveal the occurrence of positive trends. But for increase of mean standing height between the comparing study periods, the lower segment (subischial leg length) has contributed more than the upper segment (sitting height) which is notable for males only. Moreover, it is observed that the amount of all increases in final/mature size, are lower in magnitude than the amount of increase recorded during the years of adolescence. On the contrary, negative secular trends are also observed for two traits, namely, bi-iliocristal diameter and total arm length, which perhaps has resulted due to methodological reason.

The trend of age specific increased standard deviation values in standing height and related linear traits have provided conclusive evidences for an earlier onset of adolescent growth spurt in children of contemporary Bengali population.

Among the investigated six measures of body shape or proportion, body mass index has manifested significant positive secular trends in both sexes with increased means observed over the comparing study periods to imply greater increment in body weight than standing height. Two other related indices of linear body shape like sitting height/standing height index and sitting height/sub-ischial index have not manifested any consistent pattern due to change of time. But it is interesting to note that when these two indices are derived from the adult values (obtained from Preece-Baines model 1) and are compared between the study periods, the results show a larger gain in sub-ischial leg length than sitting height which is observed in males particular. More interestingly the means of bi-iliocristal/bi-acromial diameter index in males as well as in females have shown a significant decline between the comparing study periods both during growth and at adulthood to suggest a greater secular increase in shoulder width than hip width in both sexes. Out of the two cephalofacial indices studied for boys only, the head shape has not manifested any trend of brachycephalisation (larger head breadth than length). However, the increase of mean facial index has suggested a more consistent increase in face breadth than length.

Among the measures of body composition, a greater deposition of subcutaneous fat in upper limbs, upper and lower trunk of contemporary boys are found to be significant in most of the studied age classes. By the same way, the percentage of body fat mass in both contemporary pre pubertal and pubertal boys are significantly greater by 2.6% and 1.9% due to change of time. All are therefore, suggesting the occurrence of positive secular trends in the form of elevated adiposity level of the contemporary boys. Finally, the fat distribution index of boys in particular, tends to show little change towards a more truncal pattern.

Two indicators of nutritional status, namely prevalence of stunting and thinness have under gone significant declines over time with varied magnitudes according to age and sex. On the contrary, the other two indicators namely, prevalence of overweight and obesity have increased in both sexes with varied magnitudes between the same comparing study periods. Therefore, the trend of overall changes in all four indicators of nutritional status confirms that urban Bengali population is living in an early stage of transition stage.

Among the investigated measures of adolescents growth spurt, the mean age at maximum increment (estimated from Preece-Baines model 1) of all studied seven traits (standing height, body weight, sitting height, subischial leg length, biacromial diameter, bi iliocristal diameter and total arm length) have declined in boys with varied magnitudes. But in girls, such declines are restricted to only five measures (sitting height, sub ischial leg length, biacromial diameter, bi-iliocristal diameter and body weight) while for other two traits, namely, standing height and total arm length, the mean ages of maximum increment cannot be determined due to methodological reason. The overall declining pattern of this parameter therefore suggests that a positive secular trend in the form of faster rate of physical maturation is operating on the children of contemporary Bengali population. The other measure of adolescent growth spurt, namely, mean peak velocity has not manifested any consistent pattern of trends in both sexes over all the comparing study periods.

The one studied measure of sexual maturation in girls i.e. the mean age at menarche has been observed to have declined in this sample in about four decades of time interval. It suggests a slow rate of change in the timing of sexual maturation in contemporary girls.

A notable increase in the literacy rate and per capita monthly family expenditure level in association with decreased household members and size of sibship as manifested by the population of Kolkata city over the last five decades may be held as the responsible socio economic factors for the observed positive secular trends. However, as exception, only a few cephalofacial traits of boys have manifested negative secular trends for which further investigation is recommended.

The socio-economic factors which are attributed to be responsible for the manifestation of positive secular trends have also affected different growth measures of contemporary urban Bengali children. Two such primary socio-economic factors namely, parental education and per capita monthly family expenditure level have significantly influenced several traits like standing height, subischial leg length, body weight, body mass index, triceps and sub scapular skinfold, percentage of body fat mass, prevalence of stunting and thinness in both sexes. In addition, per capita monthly expenditure of family has also influenced the prevalence of stunting in girls. Thus taken together, improved parental education with higher standard of living appear to be the probable causative factors for manifestation of taller and heavier children with longer body segments and higher adiposity level in association with decline in prevalence of stunting and thinness. The early onset of menstruation of contemporary urban Bengali girls has resulted mostly from the families with higher educated parents living in smaller sib ship size. But father's occupation has not influenced any of the studied traits in both sexes and therefore its unsuitability as a socio-economic variable is suggested for this sample under study.

The household variable like size of sib ship has significantly influenced the measures of adiposity in particular i.e. percentage of body fat, triceps and sub scapular skinfolds, body weight and body fat distribution in both sexes and body mass index and prevalence of thinness in girls only. But its influence on any of the linear traits (standing height, sitting height etc.) has not been observed. Another household variable, namely, birth order of the subject (parity) has also influenced adiposity related traits like percentage of body fat mass, triceps, sub scapular thickness and prevalence of thinness in both sexes. Further, its significant effect on body weight and body mass index is also notable. Therefore, to summarize, the first born children who are living in a smaller household have manifested a higher adiposity level and improved nutritional status. It clearly implies that the body compositional traits are also sensitive to changes in the household composition which perhaps has resulted due to socio economic transition in the population of Kolkata city.

The analysis of the data so far performed to prepare this report seems to be still inadequate in unfolding many unknown aspects of auxology of Bengali population. For example, the relative influences of the studied socioeconomic factors in different measures of physical growth, nutritional status, body composition etc. remain to be attempted. Finally, monitoring the rates of major transitional processes responsible for manifestation of secular phenomena in growth of children living in highly stratified Indian society should emerge as one of the important research agenda in future.

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CHAPTER 1

INTRODUCTION

1.1 Economic globalisation and transition in India

In the early nineties India implemented an economic globalisation program which refers an integration of the national economy into international economy through trade, direct foreign investment, capital flows, migration and the spread of technology (Jagdish, 2004, Ulijaszek et al., 2012). This process implies a worldwide shift towards market liberalization and a decline in government regulation in financial flows in part to maximize poverty reduction and to increase food security (World Bank, 1990, Marchione, 1999).

Rapid changes in the form of liberalisation of Indian Economy have had profound impacts with an upsurge in the rate of industrialisation and urbanisation in the country in a faster rate to initiating the process of transition, a term, used specially in the context of South East Asia (Omran, 1971). Transition involves all processes that ensure a country's economic growth and social development in the long run (Rosegrant and Hazell, 2001). In low to middle income countries transition results in increased urbanization, increased material consumption and affluence in at least certain sections of society (urban in particular) as lifestyles become more westernised (Poskitt, 2009). Since the implementation of the economic globalisation programme, the contemporary Indian population is passing through multiple distinct but linked transitional processes namely nutritional, epidemiological, demographical and socio-economical transitions. Manifestation of the nutrition transition is observed through a major shift in dietary composition (from a traditional diet to a diet high in calories, saturated fats and refined carbohydrates with less fibres) which in association with reduced physical activity and increased sedentary nature change body composition and consequently affects their overall health. In urban areas a substantial increase in the consumption of fats, saturated fats, sugars, salts and vegetable fats have been reported for people of high income groups (Griffiths and Bentley, 2001, Shetty, 2000). As a result, the coexistence of stunting with overweight and obesity has been found to be increasing as a double burden among children and adolescents (Popkin, 1999, Chatterjee, 2002). Simultaneously a transition in the epidemiological profile of the population has been noticed with a shift in mortality resulting from infectious diseases to life style related chronic diseases (NRCD: Nutrition Related Chronic Diseases) (Hoffman and Klein, 2012). In the Indian population a considerable increase in the prevalence of diabetes mellitus and cardiovascular disease support an epidemiological transition (Misra et al., 2011). In terms of a demographic transition there has been an increase in life expectancy in association with decreased crude birth, death and total fertility rates. According to a projection of Shetty (2002) over the periods of 1996 to 2016 the population in age range 15-59 years will increase from 519 to 800 million, those aged less than 15 years will decline from 353 to 350 million and those aged greater than 60 years will increase from 62 to 113 million reflecting a demographic transition. The state of Kerala has manifested the highest rates of both demographic and epidemiological transition in terms of perceived health status, physical mobility and morbidity level (Mini, 2009). Several consequences of socioeconomic transition in India may be highlighted with a decline in the number of people lying below poverty level (BPL) and with increasing inequality between rural and urban areas with respect to access to health services and infant mortality (Thankappan, 2001). An increase has also been noticed in the inequality between the rural and urban population and between poor and rich people with respect to health services, occurrence of disease and prevalence of infant mortality (Gopalan, 1998).

In the economic sphere, the reform resulted in an increase of India's Gross National Product (GNP) from INR 5,034 billion in 1990-91 to INR 42,970 billion in 2007-08 (Purchasing Power Parity or PPP). India's real Gross Domestic Product (GDP) at current prices has moved up from INR 6,383 in 1990-91 to INR 33,283 in 2007-2008. As far as two engines of growth are concerned Gross Domestic Savings (GDS) and Gross Domestic Capital Formation (GDCF), both calculated as a percentage of GDP, it has been observed that while the former has gone up from 24.3% (in 1990-1991) to 41.2% (2007-2008), the latter has increased from 27.7% in 1990-91 to 42.7% (at current prices) in 2007-2008 (Government of India, 2011).

Shetty (2002) has schematically presented the nature of the relationship between the four transitional processes while Hermanussen (2013) has recently argued that socioeconomic transition leads to the three important transitions like nutritional, demographic and epidemiologic as outcome. Both the authors however have highlighted the integrated effects of these transitional processes in changing the future public health profile of the population of the third world countries (e.g. India) and accordingly have drawn serious attention of the researchers of health sciences working in these specific areas. It is important to note that besides India, Brazil and China are the other two fastest transitioning countries in the world that have emerged out of the Economic Globalisation Process. The features of transition as stated before are distinctly observed among population of many other third world countries as well though with varied nature of manifestations (Monteiro, 2013).

1.2 Transition as a social impulse in auxology research: secular trends and socioeconomic factors

In the western countries research in human auxology has been initiated out of social impulse especially during the time of rapid industrialisation and urbanisation (Tanner, 1981). Two main areas, namely monitoring secular trends phenomena and measuring social gradients in growth of children have been the primary focus of investigation (Bielicki, 1986). Dramatic changes in environmental sanitation, rates of infection, food consumption and nutrition pattern occurring during this time are responsible for improvements in the socioeconomic and hygienic condition of the people. This situation has motivated the auxologists and public health scientists in particular to undertake a prolific number of growth studies on children (Hauspie et al., 1997, Martorell et al., 1988, Bodzsar and Susanne, 1998) with the ultimate goal of evaluating the socioeconomic progress of the respective countries due to industrialisation (Eveleth and Tanner, 1990). Similarly the ongoing process of transition in third world countries has emerged as a very important social impulse for conducting growth and nutrition related studies focusing on trends and gradients. In the industrialized areas of Europe, America and Japan, however these secular phenomena appear to have stopped or slowed down due to the improvements in the socioeconomic and hygienic environment. On the other hand in many countries in Asia, Latin America and Africa, these phenomena are at an early stage particularly in those regions currently undergoing different transitions. These phenomena have been interpreted as the product of continuous and often non additive interactions between genes and the changing socioeconomic environment (Ji and Chen, 2008, Thomis and Towne, 2006). The researchers working in this area have established the existence of secular phenomena in a number of measures like overall body size, body segments, body shape, body composition, parameters of the adolescent growth spurt, pubertal maturation, nutritional status, cephalofacial traits etc. In the present context a few of these need closer attention.

Body height of the Oaxaca children from Mexico has been studied from 1970 to 1999 in relation to different transitional processes (Malina et al., 2008). It has been found that 30 years of epidemiological transition from stage 1 to stage 2 (changes in age and causes of death) has occurred concurrently with significant secular increase in the body height of the children, adolescents and young adults in the community who are in the early stage 2 of demographic transition. In another study carried out on the same place Little et al. (2008) have calculated that the lead time from the onset of demographic transition phase 2 to the beginning of a secular trend in increasing height is approximately twenty five years. Together all these transitions have worked synergistically to promote a secular increase in growth and development of children in this community resulting from improvements in overall health, nutrition and living conditions (Malina et al., 2004). In this Mexican population a close relationship between the transitional processes and the secular phenomena in child growth is established. Moreover, besides height, in two decades the average sitting height of the Oaxaca boys and girls aged 10-13 years have increased by 2.6 cm. and 2.3 cm. respectively and these values are less than the increments in leg length (3.1 cm. and 3.2 cm. respectively). However for other traits like biacromial and bi-iliocristal diameters, secular phenomena are reported mostly from the industrialised countries of Europe. For example, the mean biacromial diameter of German boys aged 14 years has increased by 2.2 cm. in two decades (1975-1995) of time interval (Kromeyer-Hauschild and Jaeger, 2000). Similarly the average bi-iliocristal diameter of Italian boys aged 7 to 10 years is found to have increased at all ages ranging from 1.71 cm. to 1.96 cm. in two decades (1975-76 to 1996) of time interval (Sanna and Soro, 2000). Again the average total arm length of the Italian boys aged 7-10 years has increased with range from 0.01cm. to 1.06 cm. over the same time span (Sanna and Soro, 2000).

Sitting height/standing height ratio (an indicator of body shape or proportion) of Mayan children aged 5-12 years from USA measured in 1999-2000, has been compared with Mayan children of Guatemala measured in 1998. The results have shown that the children living in USA, in addition to their increased total standing height are also longer legged by 6.83 cm. (due to a lowering of the average ratio). Improvement in the quality of the environment is reported to be responsible for this change in body shape (Bogin et al., 2002). Among the Bengali boys aged 7.0-16.0 years from Kolkata (formerly Calcutta), India, in about two decades of time interval the ratio is found to have declined considerably (Dasgupta et al., 2008**).** In a transitional country of the European continent, namely Slovenia, a positive secular change with increased mean body mass index of boys aged 19 years is reported between 1960 to 1980 to 2000 in the order of 22.8 to 23.2 to 23.4 kg./m.^{2} (Kotnik and Golja, 2012). Between 1992-2000, a statistically significant increase in body mass index of Vietnamese urban children aged 6-15 years in the order of 0.28 kg./m.^{2} is reported with a rising prevalence in the proportion at risk of overweight (Dang et al., 2010). In Poland, size of sibship is more important than the socioeconomic status in explaining the increments in average body mass index of the conscripts due to economic transition in the country (Koziel et al., 2004).

Secular changes in two important measures of body composition, namely total body fat percentage and body fat distribution have been studied among Spanish adolescent boys and girls aged 6.0 to 14.9 years. In this West European transitional country, the percentage of body fat in children has increased from 2.46% (at 13.5 year) to 6.03% (at 11.5 year) over a 15 year time interval (1980-1995). In addition, there is a notable change in the form of the central pattern of body fat distribution among boys and girls aged 6.5-11.5 years and 6.5 -7.5 years respectively over the same time interval. Body fat distribution has been assessed by two ratios namely, i) averages of summation of biceps and triceps skinfolds/averages of summation of subscapular and suprailiac skinfolds and ii) averages of trunk skinfolds/averages of summation of four skinfolds. Both ratios are found to have declined over time. Lifestyle associated factors such as sedentary habits associated with decreasing physical activity levels are responsible for these two changes in body composition (Moreno et al., 2001a, 2001b). According to Olds (2009), these two manifestation are the worst possible combination in terms of potential for metabolic and cardiovascular disease in later age which are considered to be one of the common features of epidemiological transition.

A considerable decrease in the prevalence of stunting and thinness in association with an increase in the prevalence of overweight and obesity in children, adolescents and young adults are the primary features of changes in nutritional status of populations undergoing transition. A remarkable example of this comes from a study conducted in the Latin American country of Chile where among children aged 6.5 years the prevalence of stunting has declined by 4.7% (8.4% to 3.7%) over an eight year period (1997-2005). During the same time interval, the prevalence of obesity has increased by 5.7% (from 11.8% to 17.5%). The authors have concluded that a decline in poverty levels in the country is the most probable cause of this dual change (Bustos et al., 2009). Among South African children aged less than 6 years, prevalence of stunting has declined from 24.6% to 4.9% between 7-10 years of time interval from the year 1994 to 2004. During the same time span the prevalence of overweight and obesity has also increased by 12% and 1% respectively (Armstrong et al., 2011). In our previous study the prevalence of thinness among the middle class Bengali boys of Kolkata (formerly Calcutta) aged 9-16 years has declined by about 29% (from 50.5% to 21.9%) with a time span of about two decades (Dasgupta et al., 2008**).** Among grade 0 to grade 10 school boys from the Seychelles, a transitional country in Africa, overweight and obesity prevalence have increased by 4.8% and 3.1% respectively from 1998-2004 while for the girls the respective increases in prevalence are 6.8% and 3.1% for which decrease in physical activity is found to be the responsible factor (Bovet et al., 2006).

Among the biological parameters of the adolescent growth spurt, the decline in mean ages at peak height velocity of Chinese boys and girls from Taiwan is reported to be 0.044yr./yr. and 0.050 yr./yr. respectively over a 25 year time period (from 1964 to 1988) (Huang and Malina, 1995) while over two decades (1964-66 to 1983-84) the mean ages at peak height and weight velocities of Nunoa Children from Peru are found to have declined by one year on average (Leatherman et al., 1995). In Japan between the periods of 1950 to 2000 the mean ages of peak velocity of height in boys has declined from 14.1 year to 12.0 year, for weight from 14.4 year to 12.3 year, for sitting height from 14.4 year to 12.4 year and for subischial leg length from 13.6 year to 11.6 year. The corresponding declining values for these traits in girls are 12.0 year to 9.9 year, 13.2 year to 10.7 year, 12.6 year to 10.2 year and 11.3 year to 9.6 year (Kagawa and Hills, 2011). Thus lowering of mean age of peak velocity as an indicator of faster rate of physical maturation of contemporary children has been associated with the overall economic progress of the respective country observed during transition (Malina et al., 2004).

A decline in the average age at onset of menarche of South African girls by 0.34 years and 0.73 years per decade for rural and urban areas respectively has occurred over a span of forty years from the year 1943 onwards. According to the authors (Cameron et al., 1995), this consistent decline is due to improved socioeconomic conditions in the country as a whole. A further decline in the difference of average age at onset of menarche between the black and the white girls over the last 48 years is also attributed to these improvements (Jones et al., 2009). Obese girls from Thailand have attained menarche 0.9 years earlier than the normal weight girls to indicate the association between these two phenomena which characterizes the features of transitional population (Jaruratanasirikul et al., 1997).

The cephalofacial traits like other somatic traits are also observed to have undergone notable secular changes although the reported studies are mostly carried out on the children of European origin and Japan (Saha and Dasgupta, 2006). For example, while the average head length of the German boys aged 7-14 years has increased by 0.47 cm. in two decades (1975-1995) of time interval (Jaeger, 1998), the average head breadth of Italian children has also increased (Cresta et al. 1982-83). On the contrary, absence of secular trend in head circumference is also reported for German boys (Zellner et al., 1998). Among the facial measures average morphological facial height of the Italian boys has increased (Cresta et al. 1982-83) and the average bizygomatic breadth of the adult Australian aborigines has also increased by 0.2 cm. between the year 1930-1960 (Brown and Townsend, 2001). The measures of cephalofacial shape like average cephalic index has declined among the Hungarian children over a seven decade time interval (Eiben and Panto, 1984). The average facial index too has manifested a decline among the Italian children over two decades of time interval (Sanna and Soro, 2000). Socioeconomic status, nutrition and changes in diet are attributed as some of the responsible factors for these changes (Palsson and Schwidetzsky, 1973, Kouchi, 2000).

All these reviewed measures of body size, body shape, body composition, nutritional status, physical and pubertal maturation and cephalofacial characters etc. which have individually or collectively responded to the secular trends phenomena are also found to be linked with each other in their manifestation (e.g. increase in average height of children and adults with decrease of average age at onset of menarche). The factors responsible for their changes over time are found to be principally socioeconomic and socio-hygienic in origin and they have undergone substantial transformation in accordance with the speed of transition of the respective countries.

Bielicki (1986) has remarked that auxological data for a country has a great potential when it looks at secular trends and social gradients simultaneously. Prolific studies are available from the industrialized countries that measured the magnitude of variability in different auxological traits between the social groups and their changes over time (Eveleth and Tanner, 1990). Social groups have been determined by the level of parental education, parental occupation or profession, economic condition of family (by income-expenditure level), rural-urban residence etc. in association with demographic variables like size of sibship, birth order of the child etc. However for monitoring socioeconomic transition in the third world countries a small number of investigations have been carried out on the ascertained social groups to measure the magnitude of variation in child growth and nutrition. For example, a study from Brazil has revealed that a dramatic reduction in age at menarche is more noticeable among the women living in the worse socioeconomic conditions which have resulted due to their improvements in living conditions (Junqueira Do Lago et al., 2003). The elevated subcutaneous fatness level of children from Columbia (Cameron et al., 1992) and

Papua New Guinea (Ulijaszek, 2003) is strongly associated with the higher socioeconomic strata. Other studies have investigated individual or joint effects of various household socioeconomic factors in growth and nutrition of children during the transitional phase. In our two small scale growth studies performed in the city of Kolkata, India, average height, weight and body mass index of the middle class Bengali boys aged 7.0-16 .0 years is found to be related with improved maternal education and escalated per capita monthly expenditure of the family (Dasgupta et al., 2008). Mothers' education and sib size are also the two important socio economic factors in determining increased height and body mass index of the Polish boys (Suliga, 2009). In Bangladesh, besides family income, water supply, sewerage facilities and cultural background have equal importance in the growth of urban school children (Ahmed et al., 1991). Higher prevalence of overweight and obesity among Palestinian boys aged 13-15 years are associated with higher standard of living while stunting is negatively associated with fathers' education and urban residence (Mikki et al., 2009). In Iran, a transitioning country of West Asia, overweight in girls aged 14-17 years is more common in those with less educated mothers than with more educated mothers (Maddah, 2007). From a recent analysis of Demographic and Heath Survey data of the Turkish girls it has been found that the mean age at onset of menarche has declined from 13.44 years (from 1959-1968 periods) to 13.17 years (from 1989 to 1993) for which the size of sib ship, as a quantitative factor and childhood place of residence, education of the girl and their welfare status as several qualitative factors, are significantly associated with this decline (Adali and Koc, 2011). To the best of our knowledge studies concerning the effects of socioeconomic factors on the measures of body shape or form (anthropometric indices or ratios) and physical maturation (e.g. biological parameters of the adolescent growth spurt) of children are relatively less from the transitional countries. Several researchers (Rousham, 1996, Floyd, 2000) have suggested that there is a continuous need to analyse the relationship between growth and various indicators of socioeconomic and demographic origin in different populations as these factors determine the level of a population's well being as a part of a transitional process and thereby play significant roles in influencing the pattern of child growth and development (Dasgupta and Weale, 1992).

India, being an ethnically and environmentally heterogeneous country with huge landmass offers numerous scopes and opportunities to undertake studies on secular trends and socioeconomic factors in child growth for monitoring country's ongoing transition. Unfortunately, comprehensive growth studies on children from different transitioning ethnic groups of this country encompassing the measures of body size, body shape (or form), body composition, nutritional status, physical and pubertal maturation etc. are still inadequate in number. On the other hand such prolific auxological studies are reported from two other leading transitional countries of the world, namely China and Brazil. However, several small scale growth studies among different ethnic groups from India have been carried out during the pre-transition period of the country. All these growth data can be used as a reference for monitoring the secular trends in physical growth and related variables of contemporary children of transition period (Roche and Towne, 2001, Virani, 2005). Consequently, the outcome of these investigations will have significant impact in judging the overall socioeconomic development of the nation during various stages of its transition (Dasgupta et al., 2008).

1.3 Present study and its objectives

The present study has been conducted among Bengali Hindu urban children of the Kolkata city, India, using a cross-sectional method. Twenty one anthropometric measurements and a battery of fifty socioeconomic items have been collected from the households of 4,194 children (1,999 boys and 2,195 girls), aged 7.0-21.0 years belonging to predominantly middle class families. In addition, data onset of menarche have been collected from contemporary girls and qualitative data on twenty four hours dietary intake have been collected from all children by questionnaire interview.

The first objective of the study is to investigate whether secular trends phenomena are operating in the measures of body size and mass, different body segments, body shape, body composition, nutritional status and in the biological parameters of adolescent growth spurt of urban children when the results of the study are compared with the results of two earlier studies (Sarsuna-Barisha growth study of 1952-1966 for both sexes and Kolkata growth study of 1982-83 for boys) carried out around this place during the pre transition period of the country. The second objective is to investigate the occurrence of secular trends phenomena in mean age at onset of menarche of contemporary urban Bengali girls during the transitional period of Kolkata city. The third objective of the study is to evaluate the effects of probable socioeconomic factors responsible for the observed secular trends and subsequently to analyse their influences on several anthropometric traits, body shape/form, body composition and nutritional status of contemporary urban children and on age at menarche of contemporary Kolkata girls.

CHAPTER 2

MATERIALS AND METHODS

2.1 Launching of the project

This project on physical growth of children of contemporary urban Bengali population has been sponsored by the Neys-van Hoogstraten Foundation, the Netherlands which has been launched in the Indian Statistical Institute, Kolkata, West Bengal, India, in the year 2004. Subsequently the cross-sectional growth survey on children has been initiated in June, 2005 and has been completed in February, 2011.

2.2 Physical and cultural attributes of Bengali population

The Bengali Hindu population is an ethno linguistic group native to the historic region of Bengal (now divided between Bangladesh and India). They speak Bengali (Bangla), which is an Indo-Aryan language of the East Indian subcontinent. In their native language, they are referred by the term *Bangali* and they primarily belong to the Indo-Aryan stock (http://en.wikipedia.org/wiki/Kolkata) and are mostly concentrated in India (the state of West Bengal and Tripura) and in Bangladesh. A number of Bengali communities are scattered across the country and abroad.

Ethnically, the Bengali population is a heterogeneous group comprising of the Caucasoid, Proto Australoid and Mongoloid strains (Risley, 1891 and 1908). The populations living in the northern parts of the state of West Bengal show Mongoloid affiliation whereas the people of the Southern region show affinities especially with the Proto-Australoids and Caucasoid elements (Roychowdhury, 1992). Average stature of adult Bengali population from the state of West Bengal combining both sexes ranges from 1676 mm. for Brahmins to 1577 mm. for tribal populations. The cephalic index ranges from 75.4 to 78.8, which implies that the population includes both brachycephalic and dolichocephalic individuals (Sur, 1988).

The Bengalis constitute numerous endogamous subpopulations with different hierarchical status known as caste. The higher caste groups show greater frequency of tall-dolichocephalic-leptorrhine people compared to the scheduled caste groups (Rakshit, 1969). Recent studies on mitochondrial DNA and Y chromosome have shown that upper castes are more similar to the Europeans while the lower castes show greater affinity with the Proto-Asians (Bamshed et al., 2001).

Two major religions practiced in Bengal are Hinduism and Islam. In West Bengal, the Hindus are the majority with 71% of the population while the Muslims comprise 27%. In Bangladesh 88.3% of the population follow Islam (US Department of State, 2007) while 9.2% follow Hinduism. Other religious groups include Buddhists and Christians and they are present in both West Bengal and Bangladesh. The location of the state of West Bengal in India is shown in fig 2.2 (see page 142).

2.3 Kolkata city and some of its transitional features

The metropolis city of Kolkata, the capital of the state of West Bengal, is about 300 years old, 185 square km. in area, with a population of 44,86,679 (Census of India, 2011). It is situated at the latitude of 22 degree and 82 minutes in the north and longitude of 88 degree 32 minutes in the east. The city is 5.3 meters above sea level and it stands on the eastern bank of the river Hooghly about 128 km. north of the Bay of Bengal. It experiences a subtropical climate, i.e. winters are pleasant with a temperature ranging from 12-27 Celsius and summers are hot and humid when the temperature varies 24-40 degree Celsius. The city receives an average annual rainfall of 1,582 mm. (en.wikipedia.org/wiki/Kolkata). Environmental pollution is a very important concern of Kolkata city. According to the Central Pollution Control Board (2008-2009) although the levels of sulphur dioxide and nitrogen dioxide are below the national average, the level of suspended particulate is excessively high which is directly responsible for the recent increase in the prevalence of respiratory disease among the city people. Kolkata is a cosmopolitan city having a very high density of population. The citizens belong to different religious groups like Hindus, Muslims, Christians, Jains, Sikhs and others. Kolkata is one of the most crowded cities in the world where 70% of the population are native Hindu Bengalis, the remaining 30% hail from the neighbouring states like Bihar, Assam, Orissa etc. (Chatterjee et al., 1999). The population of the city is multilingual with 66% speaking Bengali, the native language of the area and the rest speaking Hindi, Urdu and other languages. About 84% of population are Hindu by faith while Islam accounts for 14% of the population and other religions including Sikh, Jainism and Christianity collectively account for 2% of the population (Chatterjee et al., 1999). Of all households in the city only 19% remain below the poverty line. With respect to housing 50% of the residents have their own houses and 38% have rented houses. About 37.5% of the households have toilets with sewerage while 62% have a septic tank. With respect to the supply of drinking water, 85% of the households get their potable water from the taps while 15% get their waters from tube wells (Chatterjee and Ghose, 2001). According to the National Sample Survey Organisation, Government of India and Indian Statistical Institute, the average household expenditure of city population is found to be INR 1,822 per person per month (Dutta, 2009).

In accordance with the countrywide implementation of the economic globalisation programme the city of Kolkata is also undergoing rapid transition in all aspects of human lifestyles. Although recent data on all these aspects are not yet widely known for use in research but some earlier results have confirmed the trend. For example, in the demographic sphere the infant mortality rate is reported to have decreased from 44 to 25 from 1981 to 1991 (Dutta Roy, 2002). The average per capita income of city population per year has increased from INR 10,464.88 (1993-1994) to INR 31,986.66 (2000-2001) to INR 46,883.65 (2003-2004) (http://wbplan.gov.in/ HumanDev/DHDR/24%20pgsSouth/Chapter%2003). The overall literacy rate of city population has increased from 77.6% in 1991 to 81.3% in 2001. The percentage of adult literacy rate has also increased from 71.1% in 1981 to 76.6% in 1991 (Dutta Roy, 2002). On the epidemiological aspect prevalence of metabolic syndrome among urban females is reported to be 56.2% compared with 36.4% for rural females. In addition, the risk factors due to Cardiovascular Disease (CVD**)** are about to increase markedly to warrant further intervention (Das et al., 2008). Although dietary transitional data of the city population are not widely accessable for use in research, but the trend appears to be in conformity with the patterns reported from different parts of urban areas of India noticed especially for children, adolescents and young adults of higher socioeconomic strata. For the city as a whole, the value of the Composite Human Development Index (Anand and Sen,

1999) has shown a trend of rise from 0.737 in 1981 to 0.780 in 2004 (West Bengal Human Development Report, 2004).

2.4 Organisation of the cross-sectional growth survey on Bengali children of Kolkata city between the year 2005 and 2011

The current cross-sectional growth survey of 2005-2011 has been carried out in the households of Bengali school and college going students (boys and girls) sampled from sixty six academic institutions of Kolkata city. In the beginning the Principal investigator of this project has explained the content of the project activities to the personal secretary of the former Education Minister of the state of West Bengal. The secretary of the concerned minister subsequently has made verbal requests to the administrations of these Kolkata based schools and colleges to co-operate with the Principal investigator by providing the sample of students required for this growth survey. Subsequently, the Principal investigator has contacted the respective administrations of these institutions and accordingly has submitted all relevant official documents related to this project.

A uniform procedure has been followed to organise the growth survey on school boys, college boys and girls. For them the primary data base has been supplied to the Principal investigator by the administrations of the respective academic institutions. From the given data base the students have been selected by the following criteria: i) Whether the student has authenticated birth certificate ii) Whether the student is free from any growth affecting disease during or before giving measurements iii) Whether the student is physically fit during the time of giving measurements iv) Whether the student belongs to the middle class socioeconomic group v) Whether the student is brought up in the household environment under parental care and is living in the city for a fairly long period of time. On fulfilment of these criteria, an intimation letter has been sent to the guardians of the respective students by the administration of the respective academic institutions through Indian Statistical Institute for giving body measurements and socioeconomic data as and when required. Those students, who have sent their consent of participation in the growth study, have subsequently been contacted by the data collectors to fix up the date and time of data collection. But for school girls (Class I to XII) the organisational procedure of the survey is different. Several girls' schools have been selected by the Principal investigator and accordingly, the respective administrations of these schools have given their initial consent to carry out the survey on the girl students. Simultaneously, on behalf of Indian Statistical Institute, the administrations of these girls' schools have also canvassed an appeal letter, a consent form and a schedule (on primary information of socioeconomic status of the family) for the guardians requesting participation of the students in the study. Those who have responded to this appeal and have submitted these three filled up canvassed forms to the school administration have only been considered for inclusion in the study following a short scrutiny of these forms. The requisite criteria for inclusion of school girls in the survey are same as followed for school boys, college boys and girls. Those students who have fulfilled the requisite criteria are finally selected for the survey and subsequently have been contacted for collection of data. The school administration in the mean time has made a request to the parents of the willing students to cooperate with the data collectors in the households during collection of data as and when asked for. For this purpose, a prior appointment has been made with the parents through telephonic confirmation. All school and college girls who have participated in this study are unmarried and non pregnant during the time of data collection.

2.5 Names of the academic institutions from where the sample of students have been collected

2.5a For boys: The boys sample has been collected from thirteen north Kolkata based schools and sixteen colleges where the students are predominantly from middle class families. The names of the schools are: Scottish church collegiate school, Park institution, Metropolitan institution, Hindu school (primary and secondary sections), Hare school (primary and secondary sections), Sanskrit collegiate school (primary and secondary sections), Bidhannagar government high school (primary and secondary sections), Labanhrad vidyapith (primary and secondary sections), Shyambazar AV school, Sailendra sarkar vidyapith, AD block primary school, Central modern school and Dumdum KK hindu academy. The names of the colleges are: Bangabasi college, Surendranath college, Manindra college, Scottish church college, S. A. Jaipuria college, Srish chandra college, Vidyasagar college (day and evening sections), Gurudas college, Rabindra bharati university, Prafulla chandra college, Techno india, Prasanta chandra mahalanobis maha vidyalaya, Herambachandra college, South calcutta law college, City college of commerce and Ananda mohan college.

2.5b For girls: The girls sample has been collected from twenty eight schools and nine colleges located in both southern and northern parts of Kolkata city. The names of the schools are: Beltala girls' high school (primary and secondary sections), Binodini girls' school (primary and secondary sections), Lake school for girls, Pathabhaban (primary and secondary sections), Jadavpur vidyapith (primary and secondary sections), Kamala girls' high school (primary and secondary sections), Muralidhar girls' high school, Bethune collegiate school for girls, Baghbazar multipurpose girls' school, Arya kanya vidyapith, Harimati girls' high school, Khanpur girls' high school, Jadavpur sammilita balika vidyalaya, Nava nalanda, A. K. Ghose memorial school (primary and secondary sections), Better high school (primary and secondary sections), Sakhawat memorial girls' school, Alipur multipurpose government girls' school, Dolna day school (primary and secondary sections), Kolkata public school (primary and secondary sections), Gangapuri sikhsha sadan for girls, Adarsha balika sikhshayatan, Tollygunge girls' school, Saraswati balika vidyalaya and Shilpa shiksha sadan, Ramjoy seal shishu pathshala, Amiya devi balika vidyalaya, Nafar chandra girls' high school and Baghajatin girls' high school.

The names of the girls' colleges are: Basantidevi girls' college, Muralidhar girls' college, Sivanath Sastri college, Deshabandhu college for girls, Jadavpur university, Gokhale memorial girls' college, Dinabandhu andrews college, Jogesh chandra choudhury college and South Calcutta girls' college.

The residential area of the male students ranges from Belgharia to Sealdah in the north-south direction and from Jyangra to Belgachhia in the east-west direction. For the female students location of the field area ranges from Garia in the south to Belgharia in the north and Park Circus in the east to Alipur in the west (fig 2.5 in page 143).

2.6 The sample

The total size of the sample covered in this study is 4,194 of which, 1,999 are boys (collected between two survey periods of 1999-2002 and 2005-2011) and 2,195 are girls (collected from one survey period of 2005-2011) and their age distribution from 7.0-21.0 years is shown in table 2.6.iii. All subjects are Bengali Hindus and are from predominantly middle class families who have participated in the survey in response to the appeal made by the administrations of the respective academic institutions.

Although the total number of boys sample constitutes 1,999 individuals but during the current survey period of 2005-2011, data from only 847 boys aged 7.0-21.0 years have been collected. This is therefore observed to be significantly smaller in number than the girls sample (2,195) covered, which has occurred due to the following reason. Between the years 1999 and 2002, a cross-sectional growth survey has already been conducted by Parasmani Dasgupta from Indian Statistical Institute on 1,152 Bengali boys of Kolkata city aged 7.0 to 16.0 years. This sample has been drawn purposefully from one particular school, named Scottish church collegiate school, Kolkata. This is because in the year of 1982-83, the first cross-sectional growth survey on Bengali boys of Kolkata aged 7.0 to 16.0 years has been carried out by Parasmani Dasgupta on the students from this particular school and this study has been referred as Kolkata growth study (see section 2.10b). These two growth studies have been carried out on the students of the same school with a span of about two decades to investigate whether any secular phenomena are operating in different measures of physical growth, nutrition, body composition etc. during the transition period of the city. A comparison of the results of these two growth surveys has revealed that positive secular trends have taken place in several measures of body size, body shape, body composition, nutritional status etc. of Bengali boys (Saha, 2005, Dasgupta et al., 2008) between the time intervals of the two comparing study periods. However such an interpretation from these two small scale growth surveys has been found to have several important limitations. Firstly, the students sampled from one particular school do not represent the entire Bengali population and to overcome this biasness, it has been decided later to include additional sample of boys from few other neighbouring institutions as well. Secondly, it is to be noted that the performed two small scale growth surveys on boys (1982-83 and 1999-2002) are restricted for the age periods of 7.0-16.0 years and therefore, for planning future growth studies on boys, it has been decided to extend the age periods from 17.0 to 21.0 years, so as to accommodate the entire period of adolescence to the completion of growth phase. Thirdly, since a relatively larger sample is usually recommended for performing cross-sectional growth studies, therefore, it has also been considered as one of the important criteria as well for collecting additional number of boys in the total sample (at least 100 subjects per age class) for this study. Thus, in consideration of these three important issues, in the current growth survey of 2005-2011, an additional sample of 847 boys aged 7.0-21.0 years has been collected from different neighbouring academic institutions. Thus pooling of the two samples of growth data collected for boys (1,152+847) from two different phases of the survey, as stated before, has resulted into a total sample size of 1,999 (between the years 1999-2011). It may further be noted that from these additional 847 samples of boys collected in phase 2, only 177 samples have been collected for the age periods of 7.0 to 16.0 years while 670 samples have been drawn for the age periods of 17.0 to 21.0 years. Therefore, growth data on boys for ages 7.0 to 16.0 years in particular, have been collected in two phases (both in 1999-2002 and 2005-2011) and accordingly the distribution of boys sample for this particular age periods (7.0 to 16.0 years) with percentage covered in both phases of the survey, is shown in table 2.6.i.

Table-2.6.i: Sample distribution of boys (aged 7.0-16.0 years) collected in two phases of the survey

Age (yrs.)	Sample			Percentage of the sample		
	Phase 1 (1999-2002)	Phase 2 (1999-2002)	Total	Phase 1 (1999-2002)	Phase 2 (1999-2002)	Total
7.0	100	23	123	81.30	18.70	100.00
8.0	101	24	125	80.80	19.20	100.00
9.0	109	21	130	83.85	16.15	100.00
10.0	98	19	117	83.76	16.24	100.00
11.0	121	3	124	97.58	2.42	100.00
12.0	136	13	149	91.28	8.72	100.00
13.0	154	5	159	96.86	3.14	100.00
14.0	132	5	137	96.35	3.65	100.00
15.0	105	22	127	82.68	17.32	100.00
16.0	96	42	138	69.57	30.43	100.00

Accordingly, the possible heterogeneity in the data set of boys in view of the time lag (1999-2002 and 2005-2011) is an impotant issue. In order to test whether the collected measurements vary from phase 1 (1999-2002) to phase 2 (2005-2011), one way Analysis of Variance (ANOVA) for each of these measurements has been carried out on the phase indicator. Table 2.6.ii exhibits the p-values of the corresponding F tests. The results have been reported by age class, for ages 7.0 to 16.0 years. Since the reported p-values have corresponded to multiple tests of significance conducted simultaneously, some small p-values are expected. For example, 5% of the p-values are expected to be smaller than 0.05. In reality 14% of the p-values are below this threshold. This indicates some degree of heterogeneity between the two phases of growth data. The small p-values have tended to cluster in a few rows (e.g. for biacromial diameter, bi-iliocristal diameter, total arm length, upper arm circumference, bicondylar humerus, log values of biceps, subscapular and abdominal skinfolds, bizygomatic breadth, morphological facial height). Other variables have appeared to be relatively free from this type of heterogeneity. Two variables namely biacromial diameter and abdominal skinfold, which have shown significant heterogeneity in more than 5 out of 10 age classes (table 2.6.ii) between 7.0-16.0 years are indicated in table of which the former has been used for secular comparison (excluding abdominal skinfold). For the remaining 8 variables (bi-iliocristal diameter, total arm length, upper arm circumference, bicondylar humerus, biceps and subscapular skinfolds, bizygomatic breadth and morphological facial height) heterogeneity has been noticed in ≤5 age classes out of 10 between ages 7.0-16.0 years, are also indicated in the same table and therefore has been used for secular comparison.

Table-2.6.ii: Test of heterogeneity between the variables in boys sample collected in two phases of survey (1999-2002 and 2005-2011)

Variables	p-value of F test for dependency of variables on Phase for ages 7.0-16.0 years									
	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0
SHT(cm)	0.234	0.551	0.909	0.564	0.285	0.412	0.760	0.569	0.062	0.490
WT(kg)	0.912	0.533	0.058	0.542	0.071	0.935	0.325	0.620	0.147	0.209
SH(cm)	0.371	0.786	0.633	0.087	0.259	0.957	0.265	0.714	0.788	0.608
BAD(cm)	*	*	0.003	*	0.706	0.004	0.105	0.258	0.001	0.604
BID(cm)	*	*	0.035	0.006	0.564	0.020	0.708	0.164	0.373	0.371
TAL(cm)	0.002	0.034	0.260	0.031	0.797	0.651	0.659	0.413	0.027	0.998
UAC(cm)	0.229	0.030	0.023	0.153	0.020	0.291	0.316	0.193	0.005	0.057
BH(cm)	*	0.542	0.858	0.030	0.634	0.134	0.222	0.008	*	*
BF(cm)	0.447	0.105	0.154	0.736	0.547	0.805	0.767	0.581	0.595	0.398
CC(cm)	0.110	0.972	0.123	0.926	0.336	0.619	0.427	0.475	0.209	0.376
log TS	0.998	0.268	0.247	0.262	0.154	0.841	0.225	0.165	0.318	0.531
log BS	0.552	0.009	0.035	0.041	0.084	0.279	0.635	0.134	0.004	0.225
log SSS	0.343	0.059	0.013	0.033	0.111	0.692	0.456	0.043	*	0.017
log SIS	0.491	0.666	0.940	0.550	0.470	0.472	0.401	0.013	0.075	0.926
log MCS	0.386	0.427	0.497	0.727	0.662	0.422	0.772	0.135	0.174	0.163
log ABS	0.013	0.002	*	0.005	0.276	0.044	0.581	0.516	0.010	0.001
BB(cm)	*	0.004	*	0.195	0.006	0.019	0.088	0.069	0.094	0.257
MFH(cm)	0.027	*	0.073	*	0.968	0.025	0.276	0.414	0.071	0.655
HC(cm)	0.348	0.038	0.674	0.030	0.787	0.771	0.909	0.565	0.816	0.347
HB(cm)	0.630	0.733	0.984	0.042	0.452	0.863	0.795	0.039	0.394	0.900
HL(cm)	0.801	0.257	0.222	0.990	0.538	0.854	0.522	0.284	0.658	0.869

* p value <0.001

SHT = Standing Height, WT = Body Weight, SH= Sitting Height, BAD= Biacromial Diameter, BID= Bi-iliocristal Diameter, TAL= Total Arm Length, UAC = Upper Arm Circumference, BH = Bicondylar Humerus, BF= Bicondylar Femur, CC= Calf Circumference, TS = Triceps Skinfold, BS = Biceps Skinfold, SSS = Subscapular Skinfold, SIS= Suprailiac Skinfold, MCS= Medial Calf Skinfold, ABS=Abdominal Skinfold, BB= Bizygomatic Breadth, MFH = Morphological Facial Height, HC = Head Circumference, HL = Head Length and HB = Head Breadth.

Since the entire data set on boys for the age periods 17.0 to 21.0 years has been collected in the current survey period of 2005-2011, therefore, the question of heterogeneity for this specific age periods has not arisen. By the same way, since total sample of 2,195 girls aged 7.0 to 21.0 years has been collected in one phase (2005-2011) only, therefore, the question of heterogeneity due to time lag has also not taken into consideration.

Table-2.6.iii: Distribution of sample of the current study (1999-2002-2005-2011) by age and gender

Age (years)	Sample (n)		Total
	Boys	Girls	
7.0	123	155	278
8.0	125	156	281
9.0	130	151	281
10.0	117	161	278
11.0	124	143	267
12.0	149	145	294
13.0	159	140	299
14.0	137	141	278
15.0	127	148	275
16.0	138	135	273
17.0	143	139	282
18.0	128	136	264
19.0	132	146	278
20.0	135	158	293
21.0	132	141	273
Total	1999	2195	4194

2.7 Data collection through fieldwork

After completion of the fieldwork organisation activities related the date and time of data collection for the current growth survey of 2005-2011 have been fixed up in consultation with the subjects and their parents. Both anthropometric and socioeconomic data have been collected from the households of the students. Two teams are formed for collection of data. One team has been asinged to collect data from boys which is constituted by four members namely, the male measurer, the field assistant, the field porter cum guide and male/female socioeconomic data collector. The other team has been asinged for collecting the data from girls which consists of the female measurer, the female field assistant, the male field porter cum guide, the female socioeconomic data collector with female field guide. The data collectors have visited the respective households of the subjects with prior appointment. On an average in one day four households have been visited for collecting anthropometric data while five households for collecting socio-demographic data. Anthropometric data have been collected only during day time whereas the socioeconomic data have been collected both during day time and in the evening hours.

2.7a Collection of anthropometric data

The following twenty one direct anthropometric measurements have been attempted on all subjects:

2.7a.1 Direct measurements

i. Standing Height (SHT)
ii. Sitting Height (SH)
iii. Biacromial Diameter (BAD)
iv. Bi-iliocristal Diameter (BID)
v. Total Arm Length (TAL)
vi. Bicondylar Humerus (BH)
vii. Bicondylar Femur (BF)
viii. Upper Arm Circumference (UAC)
ix. Calf Circumference (CC)
x. Head Length (HL)
xi. Head Breadth (HB)
xii. Head Circumference (HC)
xiii. Morphological Facial Height (MFH)
xiv. Bizygomatic Breadth (BB)
xv. Triceps Skinfold (TS)
xvi. Biceps Skinfold (BS)
xvii. Subscapular Skinfold (SSS)
xviii. Suprailiac Skinfold (SIS)
xix. Medial Calf Skinfold (MCS)
xx. Abdominal Skinfold (ABS)
xxi. Body Weight (WT)

2.7a.2 Derived measurement

22. Subischial Leg Length (SLL) has been derived by subtracting the value of sitting height from the value of standing height (when both measurements are available).

2.7a.3 Measuring equipments and technique of measurements

The equipments used to take the measurements are Anthropometer (GPM Swiss made), Sliding caliper, Spreading caliper, Lange skinfold caliper, Steel tape and Portable weighing machine (LIBRA). Measurements have been taken following the recommendation of the IBP (International Biological Programme, 1969). A single trained female measurer, named Rituparna Das has taken the measurements from all girl subjects with the help of one female field assistant cum recorder. Two ladies named Sangeeta Kundu and Namita Bhattacharya have worked alternately with her. They are responsible for holding and positioning the subject during measurements and recording the measurements in the data schedule. One male field porter named Uttam Nandi has been responsible for locating the households and for carrying the fieldwork related equipments during house visit. Two trained male measurers named Rana Saha and Samrat Paul (one of them worked at a time) with the help of two field assistants cum recorder named Bhagirath Mandal and Partha Pratim Panja (one of them worked at a time) have taken the measurements from boys. One field porter named Raju Saha has been included in the field team. The Principal investigator has trained all measurers through one month of training in anthropometry before they are engaged in taking the final measurements from the subjects. The measurements have been taken on and around birth dates (± 3 days) of the subjects, verified by the authenticated documents (Birth certificate, Hospital discharge certificate etc.) which the subjects have submitted to the field workers during the time of the house visit. Since birth day is the target date of taking measurements, measurement sessions have been continued throughout the year. The time for collecting the measurements is usually between 7 am to 2 pm. The subjects have been requested to wear minimal clothing during the time of measurements. For girls a specially designed gown has been supplied for wearing during the measurement session. Skin marking pen or pencil has been used to locate the landmarks on the subject's body and thereafter the measurements have been taken in presence of the parents or guardians. A few measurements, like total arm length, bicondylar humerus and bicondylar femur, skinfolds and circumferences have been taken from the left side of the subject. On an average, about forty five minutes has been spent to take the full set of measurements. From girls, in addition to anthropometry, information on age at onset of menarche has been collected by both status quo and recollection methods (where possible) by interviewing the subject and her mother.

The Photographs for collecting the anthropometric measurements from the male and female subjects are shown in figs 2.7.ia to 2.7.xxib (see pages 144 to 153).

2.7a.4 Reliability of the anthropometric measurements

Since in the current study the male and the female measurers have taken all anthropometric measurements duly trained by Parasmani Dasgupta (the Principal investigator as well as the measurer of the 1982-83 Kolkata growth study), therefore, both intra and inter observer errors of the measurements (within a single measurer and between the two measurers respectively) have been calculated by the following formulae:

$$\text{TEM (Technical Error of Measurements)} = \sqrt{(\Sigma D^2/2n)}$$

Where D=Difference between the measurements taken on two occasions with two hours apart and n=Sample size.

Double measurements (twenty one in number) from the same number of subjects (n=9) have been taken by both male and female mesurers with six hours of difference. The corresponding calculated values of TEM (both intra and inter observer) are presented in table 2.7a.4, from which it appears that most of the measurements are within the normal range of errors reported in literatures (e.g. Malina et al., 1987, Frisancho, 1990).

Table-2.7a.4: Intra and inter observer errors of anthropometric measurements

Measurements	Intra observer error				Inter observer error	
	Male measurer		Female measurer			
	n	Values	n	Values	n	Values
Standing height (cm.)	9	0.071	10	0.074	10	0.095
Sitting height (cm.)	9	0.078	10	0.059	10	0.105
Bi-acromial diameter (cm.)	9	0.058	10	0.045	10	0.107
Bi-iliocristal diameter (cm.)	9	0.041	10	0.102	10	0.095
Total arm length (cm.)	9	0.053	10	0.039	10	0.175
Upper arm circumference (cm.)	9	0.033	10	0.055	10	0.152
Bicondylar humerus (cm.)	9	0.024	10	0.050	10	0.087
Bicondylar femur (cm.)	9	0.000	10	0.055	10	0.110
Calf circumference (cm.)	9	0.024	10	0.063	10	0.114
Triceps skinfold (mm.)	9	0.289	10	0.158	10	0.806
Biceps skinfold (mm.)	9	0.236	10	0.250	10	0.524
Subscapular skinfold (mm.)	9	0.204	10	0.194	10	1.135
Suprailiac skinfold (mm.)	9	0.118	10	0.274	10	0.671
Medial calf skinfold (mm.)	9	0.456	10	0.316	10	0.814
Abdominal skinfold (mm.)	9	0.167	10	0.224	10	0.418
Bizygomatic breadth (cm.)	9	0.024	10	0.045	10	0.077
Morphological facial height(cm.)	9	0.000	10	0.045	10	0.186
Head circumference (cm.)	9	0.105	10	0.055	10	0.150
Head breadth (cm.)	9	0.024	10	0.039	10	0.089
Head length (cm.)	9	0.053	10	0.071	10	0.084
Body weight (kg.)	9	0.204	10	0.158	10	0.194

2.7b Collection of household socioeconomic data

The names of the socioeconomic data collectors are Soma Aich, Rana Saha, Sukanta Das and Debanjana De who are responsible for collecting data from the households of the male students. The names of the socioeconomic data collectors from the households of the female students are Chitrita Banerjee, Jahanabi Banerjee, Nabanita Das, Mousumi Bose, Shubhasree Bhadra and Namrata Sinha Roy. It may be noted that only one person from these two given lists, has worked at a time.

The items of collected data on socioeconomic condition of the family of subjects include parental education, parental occupation and per month total expenditure of the family (INR). Data on household demography constitute parental age and marital status, family type, number of household members, birth order of the subjects, size of sibship, number of younger and elder siblings, religion, ethnicity and caste or social group. The data on health condition of the subjects constitute the items like the general state of health of the subject along with guardians' assessment. In addition, data on eyesight, physical exercise or physical activity habit, participation in outdoor games, aptitude for fine arts etc. have also been recorded. The data on household particulars include the duration of the stay in the city, type of possession of the household, household assets, nature of dwelling unit, total covered area of the residential plot, total number of rooms including kitchen and excluding toilet, number of toilets with type and nature of ownership, sources of potable water and its distance from the households with adequacy, type of kitchen, fuel used for lighting and cooking. Data on the public health aspects include community facilities like area of open space, proximity to park or play ground, location of primary and secondary schools, hospitals or health centres and private nursing homes, use of mosquito net at night and intensity of water logging during rainy season.

Qualitative data on twenty four hours dietary recall have been recorded via questionnaires which include information on kinds of food and drinks taken with frequencies in early morning, during breakfast, lunch, school hours and post school hours, in the evening and at dinner. Frequencies of food items taken per week have accordingly been recorded.

The photographs for collecting socioeconomic data by the data collectors from the households of male and female subjects respectively are shown in figs 2.7.xxiia and 2.7.xxiib (see page 154).

The anthropometric, socioeconomic and dietary recall data collection protocol has been approved by the Ethical Committee for research risks to human subjects, Indian Statistical Institute.

2.8 Sample distribution by age and anthropometric measurements

Although twenty one anthropometric measurements have been attempted from all subjects but due to various unavoidable circumstances it has not been possible to collect the full set of measurements from all of them. Therefore, the subjects with incomplete number of measurements have also been included in the study sample and accordingly the collected incomplete data sets have also been analysed. Tables 2.8.i and 2.8.ii show the distribution of the sample according to the measurements in both sexes between age classes 7.0 to 21.0 years. Table 2.8.iii and 2.8.iv show the numbers (with percentages) of boys and girls sample collected from different academic institutions.

Table-2.8.i: Distribution of sample of the currentt study by measurements and age: Boys

Anthropometric measurements	Age in years														
	7.0	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**	**15.0**	**16.0**	**17.0**	**18.0**	**19.0**	**20.0**	**21.0**	**Total**
SHT(cm)	123	125	130	117	124	149	159	137	127	138	143	128	132	135	132	1999
SH(cm)	122	119	126	114	123	146	159	135	122	131	123	109	121	127	120	1897
SLL(cm)	122	119	126	114	123	146	159	135	122	131	123	109	121	127	120	1897
BAD(cm)	123	124	130	117	123	134	149	136	126	138	141	128	131	135	132	1967
BID(cm)	123	124	129	117	123	134	149	135	125	138	142	127	129	134	129	1958
TAL(cm)	122	123	130	116	123	140	153	136	126	138	141	128	131	135	132	1974
UAC(cm)	122	124	130	117	123	145	158	137	126	137	142	128	132	135	132	1988
BH(cm)*	123	124	130	116	123	146	158	137	126	138	142	128	132	135	132	1990
BF(cm)	123	123	130	117	123	145	158	137	126	138	142	128	132	134	132	1988
CC(cm)	123	124	130	117	123	145	158	137	126	138	142	127	132	134	132	1988
TS(mm)	123	123	126	117	121	120	136	134	124	136	143	127	130	135	132	1927
BS(mm)	123	123	126	117	121	120	136	134	124	136	143	127	129	135	132	1926
SSS(mm)	123	123	126	117	121	120	136	134	124	136	143	125	127	133	132	1920
SIS(mm)	123	123	125	115	119	120	136	134	121	132	139	123	118	125	121	1874
MCS(mm)*	122	123	125	116	120	116	133	133	121	134	134	120	127	133	131	1888
ABS(mm)*	96	95	90	72	76	80	93	106	92	84	132	117	113	120	118	1484
BB(cm)	123	125	129	117	124	149	159	137	127	138	143	128	132	135	132	1998
MFH(cm)	123	125	130	117	124	149	159	137	127	138	143	128	132	135	132	1999
HC(cm)	123	125	130	117	124	149	159	137	127	138	143	128	132	135	131	1998
HB(cm)	123	125	130	116	124	149	158	137	127	137	143	128	131	135	131	1994
HL(cm)	123	125	130	117	124	149	159	137	127	138	143	128	131	135	132	1998
WT(kg)	123	125	130	117	124	149	159	137	127	138	143	128	132	135	132	1999

***Measurements taken but not analysed for this report**

Table-2.8.ii: Distribution of sample of the current study by measurements and age: Girls

Anthropometric measurements	Age in years														
	7.0	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**	**15.0**	**16.0**	**17.0**	**18.0**	**19.0**	**20.0**	**21.0**	**Total**
SHT(cm)	154	155	150	160	143	143	140	140	147	135	138	135	146	157	140	2183
SH(cm)	151	141	141	149	135	134	131	131	134	126	126	127	134	139	126	2025
SLL(cm)	151	141	141	148	135	134	131	131	134	126	126	127	134	139	126	2024
BAD(cm)	150	145	145	151	133	137	132	136	136	130	129	125	128	135	122	2034
BID(cm)	150	148	146	152	136	137	132	136	136	130	129	125	129	138	122	2046
TAL(cm)	150	147	144	148	132	133	130	134	134	130	128	124	126	133	121	2014
UAC(cm)*	150	146	145	150	134	135	130	136	134	128	128	124	128	133	121	2022
BH(cm)*	155	153	147	157	142	142	136	138	145	132	137	133	142	154	135	2148
BF(cm)*	154	151	145	156	139	135	135	137	139	130	130	129	130	142	129	2081
CC(cm)	155	152	144	153	137	135	134	134	137	130	127	126	128	139	128	2059
TS(mm)*	150	150	145	151	134	137	133	138	135	129	128	124	128	135	123	2040
BS(mm)*	149	150	145	148	134	137	133	138	136	129	127	124	128	135	122	2035
SSS(mm)*	151	151	146	149	137	139	132	138	136	130	128	124	128	136	123	2048
SIS(mm)*	150	150	143	144	136	136	131	138	134	128	128	124	128	133	122	2025
MCS(mm)*	152	148	143	144	136	132	132	132	133	128	126	126	127	131	120	2010
ABS(mm)*	150	149	144	146	136	137	130	137	134	129	127	125	128	130	122	2024
BB(cm)*	154	154	150	157	143	141	138	138	147	134	138	136	146	156	140	2172
MFH(cm)*	155	154	150	156	143	141	138	138	147	134	137	136	146	156	140	2171
HC(cm)*	155	154	149	157	143	140	137	138	146	133	137	136	144	156	138	2163
HB(cm)*	155	154	149	157	143	141	138	138	147	134	138	135	144	156	138	2167
HL(cm)*	155	154	149	157	143	141	138	138	147	134	138	135	145	156	138	2168
WT(kg)	154	156	150	161	143	144	140	141	148	135	139	136	146	158	140	2191

***Measurements taken but not analysed for this report**

Table-2.8.iii: Institution wise distribution of the sample: Boys

Sl.No.	Names of schools	n	%	Names of colleges	n	%
1	AD block primary school	15	0.8	Ananda mohan college	1	0.1
2	Bidhannagar govt. high school	44	2.2	Bangabasi college	202	10.1
3	Central modern school	2	0.1	City college of commerce	1	0.1
4	Dumdum KK hindu academy	1	0.1	Gurudas college	3	0.2
5	Hare school	61	3.1	Herambachandra college	3	0.2
6	Hindu school	85	4.3	Manindra college	4	0.2
7	Labanhrad vidyapith	19	1.0	Prafulla chandra college	3	0.2
8	Metropolitan institution	130	6.5	PCM maha vidyalaya	1	0.1
9	Park institution	9	0.5	Rabindra bharati university	1	0.1
10	Sailendra sarkar vidyapith	48	2.4	S. A. Jaipuria college	21	1.1
11	Sanskrit collegiate school	16	0.8	Scottish church college	24	1.2
12	Scottish church school	1166	58.3	South calcutta law College	1	0.1
13	Shyambazar AV school	7	0.4	Srish chandra college	20	1.0
14				Surendranath college	87	4.4
15				Techno india	1	0.1
16				Vidyasagar college	23	1.2
Total	13	1603	80.2	16	396	19.8

% - percentage of the total sample

Table-2.8.iv: Institution wise distribution of the sample: Girls

Sl.No.	Names of schools	n	%	Names of colleges	n	%
1	A. K. Ghose memorial school	39	1.8	Basantidevi college	30	1.4
2	Adarsha balika sikhshayatan	43	2.0	Deshabandhu college	7	0.3
3	Alipur multipurpose	55	2.5	Dinabandhu andrews college	7	0.3
4	Amiya devi balika vidyalaya	2	0.1	Gokhale memorial college	13	0.6
5	Arya kanya vidyapith	5	0.2	Jadavpur university	7	0.3
6	Baghajatin girls'	5	0.2	JC choudhury college	15	0.7
7	Baghbazar multipurpose	21	1.0	Muralidhar college	42	1.9
8	Beltala girls'	327	14.9	Sivanath Sastri college	303	13.8
9	Bethune school	22	1.0	South Calcutta college	9	0.4
10	Better high school	27	1.2			
11	Binodini girls'	326	14.9			
12	Dolna day school	36	1.6			
13	Gangapuri girls'	3	0.1			
14	Harimati high school	57	2.6			
15	Jadavpur sammilita	21	1.0			
16	Jadavpur vidyapith	97	4.4			
17	Kamala girls'	264	12.0			
18	Khanpur high school	114	5.2			
19	Kolkata public school	35	1.6			
20	Lake school	58	2.6			
21	Muralidhar high school	85	3.9			
22	Nafar chandra high school	1	0.1			
23	Nava nalanda	24	1.1			
24	Pathabhaban	54	2.5			
25	Ramjoy seal pathshala	9	0.4			
26	Sakhawat memorial school	26	1.2			
27	Saraswati balika vidyalaya	4	0.2			
28	Tollygunge girls'	2	0.1			
Total	28	1762	80.3	9	433	19.7

% - percentage of the total sample

2.9 Difficulties faced during organisation of the survey and field work

During organisation of the fieldwork and collection of data several difficulties have been encountered by the Principal investigator as well as the data collectors. Initially the attitude of the parents of the girl students in particular has not been very positive for their participation in the survey unless convinced by the administrative authorities of the respective academic institutions. This has happened due to the conservative nature of the middle class Bengali families where the parents generally hesitate to allow their girl children to participate in such kind of surveys. Moreover, lack of their awareness about the importance of growth studies (which are rarely performed) is one of the other reasons for this non-cooperating attitude. However, the extent of their co-operation, when obtained, depends on to what extent the administrations of the respective academic institutions are able to convince the guardians about the importance of the study.

A few subjects, even after giving their consent of participation, have withdrawn from the study with the excuse of appearing in the forthcoming examinations, attending classes, unsuitability with the timings of giving measurements etc. Some female subjects have refused to give the full set of measurements due to several reasons like feeling of headache, nervousness, menstrual pain in the abdomen etc. Skinfold thickness measurements from the abdominal, suprailiac and medial calf sites in particular, have not been possible to take from several subjects (both sexes) due to the problems of tickling and excessive deposition of subcutenious fat in the respective sites. In some households, sitting height has not been measured from the subjects due to unavailabily of wooden table required for taking this measurement. Due to all these reasons, an unequal distribution of sample between the sexes has resulted for some measurements (see tables 2.8.i and 2.8.ii). In some households there has been a shortage of space required for taking all measurements. In some days scheduled dates for fieldwork, the field vehicles can not be operated in accordance with the timings due to acute traffic problems in the city. Among other important constraints that have badly affected the data collection process are natural calamities, religious festivals, vacations, general strikes for socio-political reasons and state-wide entrance examinations. These are some of the notable constraints that the data collectors have faced and thereby, have failed to collect the data on the target dates. As a result, some targeted samples of both sexes required for data collection, have been missed. Moreover, it has been very difficult to make an appointment with the parents for collection of socioeconomic data in particular, due to their hectic daily schedule.

2.10 Overview of two earlier growth studies performed on the children of Bengali Hindu population during the pre transition period of the country

It has been mentioned in the first chapter that during the pre transition period of India two notable growth studies have been performed on the children of Bengali Hindu population which are known as the Sarsuna-Barisha growth study and the Kolkata growth study. To prepare this report the data from these two important growth studies have been reanalysed and presented for secular comparison. Therefore, these two studies require a brief introduction in the following two sections.

2.10a Sarsuna-Barisha Growth Study (study 1 for both boys and girls)

This mixed-longitudinal family based growth study (of twenty two anthropometric traits) has been conducted by late S. R. Das from the Anthropological Survey of India between the years 1952 to 1966 on Bengali Hindu children aged 6 months to 21.0 years (Das, 1985). This fourteen year long growth study has been performed on children from middle class Bengali families living within about 20 km. south from the heart of Kolkata city in an area known as Sarsuna-Barisha. All measurements on all occasions have been taken from the subjects by S. R. Das on birth dates or half birth dates of the siblings from their households following the technique of Martin (Martin, 1928). The study has generated an enormous amount of results on various aspects of auxology of Bengali population related to gender differences in age specific height, weight, their velocities, parameters of adolescent growth spurt (Hauspie et al., 1980), sibling resemblance in several biological parameters of adolescent growth spurt (Hauspie et al., 1982), short term variation in linear traits (Hauspie and Das, 1995), sex dimorphism in several linear and transverse traits (Hauspie et al., 1984) and genetic control of adolescent growth spurt in body mass index, linear and transverse body dimensions (Rebato et al., 2005, Salces et al., 2007, 2009). This unique growth data set has been restored in the archives of three international institutes namely i) Institute of Child Health, University of London (Tanner and Cox, 1986) ii) Laboratory of Anthropogenetics, Free University of Brussels, Belgium (Hauspie et al., 1984) and iii) Department of Genetics, Physical Anthropology and Animal Physiology, University of Basque Country, Bilbao, Spain (Rebato et al., 2005). This data set can be conveniently utilised as a dependable baseline for undertaking future studies on various aspects of auxology of Bengali population (Tanner, 1985 and 2001, Roche and Towne, 2001). The distribution of total sample for this study by age and sex is shown in table 2.10a.i. Altogether twenty two measurements have been taken in this study from which only seven measurements have been found to be common with the current study for boys (1999-2011) and for girls (2005-2011). Therefore, these seven measurements have been reanalysed for presentation in this report. Age-sex distributions of these seven common measurements are presented in tables 2.10a.ii and 2.10a.iii respectively.

Table-2.10a.i: Distribution of sample of Sarsuna-Barisha Growth Study (1952-1966) by age and gender

Age (years)	Sample (n)		Total
	Boys	Girls	
7.0	107	115	222
8.0	133	108	241
9.0	141	124	265
10.0	140	126	266
11.0	146	110	256
12.0	146	123	269
13.0	142	118	260
14.0	139	123	262
15.0	141	104	245
16.0	125	99	224
17.0	120	93	213
18.0	99	72	171
19.0	93	55	148
20.0	81	51	132
21.0	29	17	46
Total	1782	1438	3220

Table-2.10a.ii: Distribution of sample of Sarsuna-Barisha Growth Study by measurements and age: Boys

Anthropometric measurements	Age in years															
	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	Total
SHT(cm)	107	132	141	140	146	146	142	127	132	117	110	95	92	80	29	1736
SH(cm)	105	129	139	134	138	140	138	128	130	112	109	92	82	71	23	1670
SLL(cm)	105	129	139	134	138	140	138	118	123	106	103	91	81	70	23	1638
BAD(cm)	107	132	141	138	144	145	141	137	139	123	118	96	92	78	29	1760
BID(cm)	104	128	134	134	142	143	137	135	134	120	114	90	88	77	29	1709
TAL(cm)	104	127	137	132	137	137	136	119	122	103	103	82	74	63	16	1592
WT(kg)	106	130	141	139	144	144	141	137	138	123	118	98	91	81	29	1760

Table-2.10a.iii: Distribution of sample of Sarsuna-Barisha Growth Study by measurements and age: Girls

Anthropometric measurements	Age in years															
	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	Total
SHT(cm)	112	106	119	119	102	113	111	105	90	90	88	60	50	41	11	1317
SH(cm)	112	108	121	120	107	118	113	108	88	86	84	59	51	40	12	1327
SLL(cm)	112	106	119	119	102	113	111	105	86	85	84	59	50	40	11	1302
BAD(cm)	115	107	122	126	110	119	117	120	102	97	89	70	53	47	15	1409
BID(cm)	107	104	116	121	108	115	113	118	94	91	88	63	51	42	14	1345
TAL(cm)	113	106	118	119	102	116	109	101	83	85	84	54	44	33	9	1276
WT(kg)	115	108	123	123	110	120	116	119	103	98	90	69	55	48	15	1412

2.10b Kolkata Growth Study (study 2 for boys)

The first population based cross-sectional growth study on urban Bengali Hindu boys of Kolkata has been undertaken from the Indian Statistical Institute, Kolkata, India, during the year 1982-83. 825 boys from predominantly middle class families aged 7.0 to 16.0 years have been selected from one particular school named Scottish church collegiate school. Twenty five anthropometric measurements, thirty three household socioeconomic items and twenty four hours dietary recall data have been collected from all boys. From this data set nineteen measurements have been found to be common with the current study (1999-2011) and therefore, these data have been re-analysed for presentation in this report. The age and measurement wise distribution of sample of Kolkata growth study are shown in tables 2.10b.i and 2.10b.ii. All measurements from the subjects have been taken by Parasmani Dasgupta, duly trained by S. R. Das, (The Principal investigator of Sarsuna-Barisha mixed longitudinal growth study) on and around birth dates of the subjects following the techniques of IBP (International Biological Programme, 1969). This study has initially generated a series of results on growth pattern of urban Bengali boys related to age changes in different measures of body dimension and body shape (Pakrasi et al., 1988., Dasgupta and Das, 1997, Dasgupta, 1989/90). Subsequently, effects of some socioeconomic factors on several selected growth measures have also been studied from this data set (Rebato et al., 2001, Dasgupta et al., 2008). Moreover, two biological parameters of adolescent growth spurt (mean age at maximum increment and mean final/mature size) of standing height have been estimated from this data set by fitting Preece-Baines growth model 1 (Preece and Baines, 1978) and changes in age specific prevalence of stunting, thinness and overweight have also been observed (de Onis et al., 2001). This archive of growth data still offers promising opportunities for undertaking further analysis.

Table-2.10b.i: Distribution of sample by age of Kolkata Growth Study on boys (1982-1983)

Age (years)	Sample (n)
7.0	64
8.0	87
9.0	97
10.0	76
11.0	98
12.0	97
13.0	98
14.0	95
15.0	76
16.0	37
Total	825

Table-2.10b.ii: Distribution of sample of Kolkata Growth Study by measurements and age: Boys

Anthropometric measurements	Age in years										
	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	Total
SHT(cm)	63	87	96	75	97	96	98	93	75	36	816
SH(cm)	59	83	93	66	93	94	93	89	70	32	772
SLL(cm)	58	83	93	66	93	94	93	87	69	32	768
BAD(cm)	59	82	93	69	92	92	93	90	71	33	774
BID(cm)	58	80	88	64	89	91	91	91	71	32	755
TAL(cm)	58	82	93	64	90	91	91	88	70	31	758
UAC(cm)	58	83	94	67	96	94	92	89	70	33	776
BF(cm)	59	84	92	68	95	93	92	89	69	33	774
CC(cm)	58	83	93	66	95	95	91	89	69	33	772
TS(mm)	62	84	91	76	97	96	95	93	76	36	806
BS(mm)	61	85	90	75	95	93	94	92	71	34	790
SSS(mm)	62	84	92	72	92	91	91	92	73	35	784
SIS(mm)	59	82	90	69	88	91	90	90	71	30	760
BB(cm)	58	83	95	67	92	93	92	89	70	32	771
MFH(cm)	59	83	93	67	94	93	92	89	69	32	771
HC(cm)	58	83	93	69	95	94	92	89	70	33	776
HB(cm)	58	83	95	67	94	93	92	89	70	32	773
HL(cm)	58	83	95	67	94	93	92	89	70	32	773
WT(kg)	63	85	97	75	97	95	98	95	75	36	816

2.10c Summary of three growth studies

Table 2.10c summarises fifteen important features of three growth studies, namely, Sarsuna-Barisha growth study of 1952-66, Kolkata growth study of 1982-83 and the present growth study of 1999-2011, from which the data have been analysed to prepare this report.

Table-2.10c: Summary of three growth studies

Features	Sarsuna-Barisha growth study	Kolkata growth study	Present study
Sponsor	Anthropological Survey of India	Indian Statistical Institute	Neys-Van Hoogstraten Foundation and Indian Statistical Institute
Phase	Pre transition	Pre transition	Transition
Year	1952-66	1982-83	1999-2011
Location	16 km from Kolkata	1 km from Kolkata	10 km from Kolkata
Social status	Middle class	Middle class	Middle class
Gender	Boys and girls	Boys	Boys and girls
Age group	Birth-20 years	7-16 years	7-21 years
Sample size	3220 (B-1782 and G-1438)	825	4194 (B-1999 and G-2195)
Type of study	Mixed-longitudinal	Cross sectional	Cross sectional
Protocol followed	Martin 1928	International Biological Programme 1969	International Biological Programme 1969
Measurer	S. R. Das	P. Dasgupta trained by S. R. Das	Students trained by P. Dasgupta
Target date of measurements	Birth day- half birth day	Birth day ± 3 days	Birth day ± 3 days
No. of measurements	25	22	21
Dietary data	Not collected	24 hours questionnaire	24 hours questionnaire
Socio-economic data	Not collected	24 items	50 items

2.11 Analysis of data

In the previous section the two growth studies carried out on Bengali population during the pre transition period of the country have been designated by study 1 (both for boys and girls) and study 2 (for boys only). Subsequently, the current growth study carried out on boys has been designated by study 3 and on girls, by study 2. Therefore, the data collected in the current study (in two phases of 1999-2002 and 2005-2011) have been analysed on the following two primary aspects (i and ii) for both sexes:

i. To generate summary statistics of socioeconomic, demographic and household characteristics of contemporary Bengali boys and girls.

ii. To generate summary statistics on the frequencies of food items consumed by contemporary boys and girls.

The basic growth data sets of study 1 (Sarsuna-Barisha growth study of 1952-1966 on boys and girls) and study 2 (Kolkata growth study of 1982-83 on boys) have been re-analysed for making secular comparison with the results of the current growth study (study 3 for boys for the year 1999-2011 and study 2 for girls for the year 2005-2011 respectively). Therefore, to perform analysis, growth data on boys are available for three time points (studies 1, 2 and 3) and on girls for two time points (studies 1 and 2). From these five sets of growth data (three on boys and two on girls) obtained from three studies (Sarsuna-Barisha growth study for both sexes, Kolkata growth study for boys and current study for both sexes) the following sixteen types of analyses (i to xvi) have been performed to investigate the occurrence of secular changes in several measures of body size and segments, body mass, body shape or form, body composition, nutritional status and parameters of adolescent growth spurt:

i. Secular changes in LMS values (Cole, 1988) of body mass index in boys over three study periods and in girls over two study periods have been calculated. The LMS method converts measurements for a child of known age and sex (Y) to an SDS (Standard Deviation Score) using the formula**:**

$$SDS = \frac{(Y / M)^{L} - 1}{LS}$$

where the values of L, M and S are read off smooth sex specific curves plotted against age. The M curve defines the median of the measurement, the S curve is the measurement's coefficient of variation, and the L curve is the power of the Box-Cox transformation needed to make the measurement normally distributed. Each curve is estimated as a cubic spline using maximum penalized likelihood (Cole, 1998).

ii. Secular changes in 10^{th}, 50^{th} and 97^{th} percentiles of body mass index in boys over three study periods and in girls over two study periods have been calculated by the LMS method (Cole, 1988).

iii. Secular changes in LMS values (Cole, 1988) of triceps skinfold thickness in boys over two study periods have been calculated.

iv. Secular changes in the 10^{th}, 50^{th} and 97^{th} percentiles of triceps skinfold thickness in boys over two study periods have been calculated by the LMS method (Cole, 1988).

v. Secular changes in the LMS values (Cole, 1988) of subscapular skinfold thickness in boys over two study periods have been calculated.

vi. Secular changes in 10^{th}, 50^{th} and 97^{th} percentiles of subscapular skinfold thickness in boys over two study periods have been calculated by the LMS method (Cole, 1988).

vii. Secular changes in age specific means and standard deviations of standing height, sitting height, subischial leg length, biacromial diameter, bi-iliocristal diameter, total arm length and body weight in boys over three study periods and in girls over two study periods have been examined. The statistical significance of difference in means has been evaluated by student's t test.

viii. Secular changes in age specific means and standard deviations of upper arm circumference, bicondylar femur, calf circumference, bizygomatic breadth, morphological facial height, head circumference, head breadth and head length in boys over two study periods have been calculated. The statistical significance of difference in means has been evaluated by student's t test.

ix. Secular changes in age specific means and standard deviations of body shape like sitting height-standing height index, sitting height-subischial leg length index, body mass index, bi-iliocristal-biacromial diameter index in boys over three study periods and in girls over two study periods have been calculated. The statistical significance of difference in means has been evaluated by student's t test.

x. Secular changes in age specific means and standard deviations of cephalofacial shape like bizygomatic breadth-morphological facial height index and head breadth-head length index in boys over two study periods have been examined. The statistical significance of difference in means has been evaluated by student's t test.

xi. Secular changes in age specific means and standard deviations of triceps skinfold thickness, biceps skinfold thickness, subscapular skinfold thickness and supra-iliac skinfold thickness in boys over two study periods have been calculated. The statistical significance of difference in means has been evaluated by student's t test.

xii. Secular changes in percentage of body fat mass have been assessed in prepubertal and pubertal boys over two study periods by three ways: Firstly, from the sum of log transformed values of biceps and triceps skinfold thicknesses, secondly, from the sum of log transformed values of biceps, triceps, subscapular and suprailiac skinfold thicknesses (Deurenberg et al., 1990) and thirdly, from summation of untransformed values of triceps and subscapular skinfold thicknesses (following the equation of Slaughter et al., 1988). The six equations therefore, are stated as follows:

Prepubertal (Deurenberg et al., 1990)

$= -14.61 + 26.51 \times \log(\text{bicep} + \text{triceps})$

$= -22.23 + 26.56 \times \log(\text{biceps} + \text{triceps} + \text{subscapular} + \text{suprailiac})$

Pubertal (Deurenberg et al., 1990)

$= -9.78 + 21.9 \times \log(\text{bicep} + \text{triceps})$

$= -11.91 + 18.7 \times \log(\text{biceps} + \text{triceps} + \text{subscapular} + \text{suprailiac})$

Prepubertal (Slaughter et al., 1988)

$= 1.21 \times (\text{triceps} + \text{subscapular}) – 0.008 \times (\text{triceps} + \text{subscapular}) - 3.2$

Pubertal (Slaughter et al., 1988)

$= 1.21 \times (\text{triceps} + \text{subscapular}) – 0.008 \times (\text{triceps} + \text{subscapular}) - 5.2$

The statistical significance of difference in means in percentage of body fat mass (assessed from these six equations) has been evaluated by student's t test.

xiii. Secular changes in two ratios of fat distribution (mean triceps skinfold thickness/mean subscapular skinfold thickness ratio and summation of mean triceps and mean biceps skinfold thickness/summation of mean subscapular and mean suprailiac skinfold thickness ratio) in boys have been examined over two study periods. The statistical significance of difference in means has been evaluated by student's t test.

xiv. Secular changes in three indicators of nutritional status, namely, age specific prevalence of stunting, thinness (WHO, 2007) and overweight (WHO, 1995 and Cole et al., 2000) in boys over three study periods and in girls over two study periods have been examined. The statistical significance in changes of prevalence has been tested by z-statistics.

xv. Secular changes in the fourth indicator of nutritional status i.e. age specific prevalence of obesity in both boys (over three study periods) and girls (over two study periods) have been examined by using the cut off of International Obesity Task Force (Cole et al., 2000). In addition, secular changes in age specific prevalence of obesity (WHO, 1995) have been examined only in boys. The statistical significance of changes in prevalence has been tested by z-statistics.

xvi. Secular changes in three average parameters (mean and median) of adolescent growth spurt in standing height, sitting height, subischial leg length, biacromial diameter, bi-iliocristal diameter, total arm length and body weight over five study periods (three for boys and two for girls) have been evaluated. Preece-Baines growth model 1 (Preece and Baines, 1978) has been used to estimate three parameters, namely, mean/median age of maximum increment, mean/median peak velocity and mean/median final size of seven studied traits. The corresponding values are obtained from the application of Preece-Baines model 1 on the five series of growth data (three series on boys and two series on girls) treated cross-sectionally (Tanner et al., 1982). The model stands as follows:

$$y = h_1 - \frac{2\,(h_1 - h_\theta)}{e^{s_0 (t-\theta)} + e^{s_1 (t-\theta)}}$$

Where y = size in cm. or kg. , t = age in years, and h_1 (estimated mature size), h_θ (size at age theta), θ (age at peak velocity), s_0 and s_1 (prepubertal and pubertal rate constants controlling growth velocity respectively) are the five functional parameters.

The following three types of analyses (i to iii) have been performed on the collected data on age at menarche of contemporary Bengali girls of Kolkata city (study 2 for girls):

i. The age distribution of menarcheal and non-menarcheal girls has been plotted from status quo data and the median age at menarche has been estimated by Probit Analysis (Finney, 1952).

ii. The age distribution of menarcheal girls and its histogram have been plotted from the recollection data. The mean age at onset of menarche (with standard deviation) has been calculated to measure the amount of secular trend occurred in comparison with the results of the earlier studies.

iii. Three statistical methods namely, Probit Estimate (Finney, 1952), Turnbull Estimate (Turnbull, 1976) and Kaplan-Meier Estimate (Kaplan and Meier, 1958) have been compared in estimating the median age at menarche.

The following five types of analyses (i to v) have been performed to evaluate the effects of different socioeconomic factors of households on some measures of body size, body shape, body composition, nutritional status of contemporary urban Bengali children (boys of study 3 and girls of study 2) and age at menarche of contemporay urban Bengali girls (study 2) of Kolkata city:

i. Analysis of variance (ANOVA) and multiple analysis of variance (MANOVA) have been performed to examine the effects of parental education and occupation, per capita monthly expenditure, size of sibship and parity on standing height, sitting height, subischial leg length and body weight.

ii. Analysis of variance (ANOVA) and multiple analysis of variance (MANOVA) have been performed to evaluate the effects of parental education and occupation, per capita monthly expenditure, size of sibship and parity on sitting height/subischial leg length ratio and body mass index.

iii. Analysis of variance (ANOVA) and multiple analysis of variance (MANOVA) have been performed to examine the effects of parental education and occupation, per capita monthly expenditure, size of sibship and parity on percentage of body fat mass (Slaughter et al., 1988), triceps and subscapular skinfolds thicknesses and body fat distribution ratio (triceps +biceps skinfolds/subscapular+suprailiac skinfolds).

iv. Logistic regression analysis has been performed to test the effects of parental education and occupation, per capita monthly expenditure, size of sibship and parity on the prevalence of stunting and thinness.

v. Cox's proportional hazards regression model (Cox, 1972) has been used to analyse the effects of parental education and occupation, per capita monthly expenditure, size of sibship and parity on age at menarche of girls.

All statistical analysis have been performed by using MS excel, S-Plus and SPSS packages.

CHAPTER 3

RESULTS

3.1 Socioeconomic, demographic and household characteristics of Bengali boys (for 1999 to 2011 cross-sectional growth survey) and girls (for 2005 to 2011 cross-sectional growth survey) (Tables 3.1.i to 3.1.iii)

The items of socioeconomic information which have been generated from the following three tables are self explanatory. However, since growth and socioeconomic data on boys have been collected in two phases, therefore, due to time lag between these two phases (1999 to 2002 and 2005 to 2011) the difference in expenditure level observed between the time points needs to be clarified. Thus one of the data items like per capita monthly total family expenditure in INR collected throughout the entire periods of these two mentioned studies on boys and girls (table 3.1.i) has been adjusted in accordance with the year of 2008 (Labour Bureau, GOI statistics: All India Average Consumer Price Index Numbers for Industrial Workers, Base 2001=100 for post 2006 values and 1982=100 for 1989 to 2005 values, http://www.labourbureau.nic.in/indtab.pdf). This adjustment has been made as 2008 is the mid year from 2000 to 2011. For girls, unlike boys, though data were collected in one phase only (from 2005 to 2011), yet the same procedure of adjustment has been followed. Similar adjustment has been done for another item of information like house rent amount paid per month in INR (table 3.1.iii).

Table-3.1.i: Socioeconomic characteristics of boys and girls of the current study

Socioeconomic attributes	Boys 1999-2011 survey	Girls 2005-2011 survey
	f (%)	f (%)
Fathers' education		
School	214 (10.71)	238 (10.84)
Higher Secondary	563 (28.16)	543 (24.74)
Graduate	1110 (55.53)	1275 (58.09)
Post Graduate	103 (5.15)	133 (6.06)
Not available	9 (0.45)	6 (0.27)
Mothers' education		
School	361 (18.06)	396 (18.04)
Higher Secondary	895 (44.77)	767 (34.94)
Graduate	649 (32.47)	904 (41.19)
Post Graduate	81 (4.05)	125 (5.70)
Not available	13 (0.65)	3 (0.14)
Fathers' occupation		
Service	1087 (54.38)	1318 (60.05)
Business	911 (45.57)	874 (39.82)
Not available	1 (0.05)	3 (0.14)
Mothers' occupation		
Service	111 (5.55)	193 (8.79)
Business	48 (2.40)	92 (4.19)
Housewife	1840 (92.05)	1899 (86.52)
Not available	0 (0.00)	11 (0.50)
Per capita monthly total family expenditure (INR) in accordance with the year 2008		
Up to 5000	333 (16.66)	232 (10.57)
5001-7000	553 (27.66)	415 (18.91)
7001-9000	500 (25.01)	415 (18.91)
9001-11000	219 (10.96)	347 (15.81)
11001-13000	182 (9.10)	299 (13.62)
13001-15000	91 (4.55)	145 (6.61)
15001-17000	43 (2.15)	109 (4.97)
17001-19000	30 (1.50)	87 (3.96)
19001-21000	9 (0.45)	37 (1.69)
21001-23000	13 (0.65)	20 (0.91)
>23000	17 (0.85)	62 (2.82)
Not available	9 (0.45)	27 (1.23)

Table-3.1.ii: Demographic characteristics of boys and girls of the current study

Demographic attributes	Boys 1999-2011 survey	Girls 2005-2011 survey
	f (%)	f (%)
Family type		
Nuclear	1221 (61.08)	1400 (63.78)
Joint	777 (38.87)	795 (36.22)
Not available	1 (0.05)	0 (0.00)
Size of the household		
Up to 3	580 (29.02)	709 (32.30)
4	722 (36.12)	821 (37.40)
>4	696 (34.82)	665 (30.30)
Not available	1 (0.05)	0 (0.00)
Birth order		
First Born	1387 (69.39)	1624 (73.99)
Later Born	611 (30.57)	569 (25.92)
Not available	1 (0.05)	2 (0.09)
Size of sibship		
No sib	933 (46.67)	1116 (50.84)
With one sib	964 (48.22)	996 (45.38)
With more than one sib	101 (5.05)	83 (3.78)
Not available	1 (0.05)	0 (0.00)
Caste		
General	1632 (81.64)	1954 (89.02)
Reserved	367 (18.36)	241 (10.98)

Table-3.1.iii: Household characteristics of boys and girls of the current study

Household attributes	**Boys 1999-2011 survey**	**Girls 2005-2011 survey**
	f (%)	**f (%)**
Type of possession		
Owned	1445 (72.29)	1881 (85.70)
Rented	540 (27.01)	311 (14.17)
Not available	14 (0.70)	3 (0.14)
Rent amount paid per month (INR) in accordance with the year 2008		
Up to 200	140 (25.93)	51 (16.40)
201-500	127 (23.52)	41 (13.18)
501-1000	41 (7.59)	43 (13.83)
1001-1500	16 (2.96)	34 (10.93)
1501-2000	10 (1.85)	35 (11.25)
2001-2500	7 (1.30)	32 (10.29)
2501-3000	7 (1.30)	16 (5.14)
>3000	8 (1.48)	30 (9.65)
Not available	184 (34.07)	29 (9.32)
Duration of stay in the present house		
Up to 12 years	951 (47.57)	1291 (58.82)
>12 years	1007 (50.38)	900 (41.00)
Not available	41 (2.05)	4 (0.18)
Total covered area of the household (sq. ft.)		
Up to 500	749 (37.47)	287 (13.08)
501-1000	671 (33.57)	903 (41.14)
>1000	304 (15.21)	565 (25.74)
Not available	275 (13.76)	440 (20.05)
Number of rooms in the household		
Up to 2	332 (16.61)	316 (14.40)
3	507 (25.36)	547 (24.92)
4	503 (25.16)	670 (30.52)
>4	600 (30.02)	642 (29.25)
Not available	57 (2.85)	20 (0.91)
Number of toilets in the household		
1	1358 (67.93)	1279 (58.27)
2	527 (26.36)	732 (33.35)
>2	95 (4.75)	183 (8.34)
Not available	19 (0.95)	1 (0.05)
Source of drinking water		
Owned	1855 (92.80)	1760 (80.18)
Shared	131 (6.55)	433 (19.73)
Not available	13 (0.65)	2 (0.09)
Proximity of water source		
Yes	1953 (97.70)	2194 (99.95)
No	34 (1.70)	1 (0.05)
Not available	12 (0.60)	0 (0.00)
Adequacy of water supply		
Yes	1966 (98.35)	2088 (95.13)
No	21 (1.05)	84 (3.83)
Not available	12 (0.60)	23 (1.05)

3.2 Dietary data of Bengali boys (for 1999 to 2011 cross-sectional growth survey) and girls (for 2005 to 2011 cross-sectional growth survey) of Kolkata city collected through twenty four hours recall method (Table 3.2)

Table 3.2 shows the percentages of the respondents of both sexes (participating in the present study) who have consumed the listed food items. In accordance with their response rate the percentage of the respondents are categorised into five groups which are self explanatory. Frequencies of percentage of boys' response rate differ from the girls. This is due to the fact that in 1999-2002 phase of survey the dietary data have not been collected so elaborately. Although a transition in dietary intake is now observed among a certain section of the city population, but it is mostly restricted on the children of very high socioeconomic strata. Since the objective of the present study is not aimed directly on this issue, still it is noticed that the sample of children who have participated in the study tend to consume their traditional diet to a greater extent followed by the intake of the transitional diet in a lower frequency. The questionnaire used in the study is based mostly on food items taken by the subjects within the households. Outside households food intake has not been asked during interview.

Frequencies of meals generally consumed by the subjects in a day have been categorised in accordance with several phases like early morning, breakfast, lunch, school/college tiffin, after school/college, evening meals and finally dinner. Early morning small meals constitute consumption of grams, nuts along with tea/coffee, beverages, molasses etc. The breakfast items constitute bread with butter/jam/jelly along with milk, other health drinks, cornflakes etc. The lunch (in the household), as one of the principal meals constitute the food items like rice, fish/egg/meat, pulses, vegetables and vegetable leaves, soybean, local cheese, curd, ghee (clarified butter) etc. The school/college tiffin constitutes handmade wheat bread, vegetables, machine made bread, sweets and confectioneries with the seasonal fruits etc. Post school/college/evening meals constitute mainly the confectioneries, flattened rice, puffed rice, semolina, wheat flour, milk with health drinks, beverages like tea, coffee etc. Finally, at the end of the day, the dinner items, as the second principal meal are mostly similar with the lunch items stated earlier. However, the only exception is that instead of rice many subjects prefer to take handmade wheat bread in dinner. The items like sugar, vegetable oil are consumed almost every day since these are the essentials for preparation of various types of food items. The relative frequencies of intake of various food items in a day are shown in table 3.2.

Table-3.2: Frequency of food items consumed by boys and girls of the current study

Food Items	Number of respondents		Percentage of respondents consuming the food items									
			Not at all		Less than once a week		At least once a week but not every alternate day		At least every alternate day but not everyday		Everyday	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
Rice	1999	2195	0	0.1	0	0	0	0.3	0	0	100	99.6
Wheat	605	2195	0.5	11.9	0	4.6	19.2	29.2	55.2	18.1	25.1	36.1
Maida (Wheat flour)	197	2195	2.0	2.6	0	11.3	74.6	66.4	20.3	16.4	3.0	3.2
Chira (Flattened rice)	71	2195	2.8	64.0	0	21.4	83.1	13.3	14.1	1.0	0	0.3
Muri (Puffed rice)	298	2195	0.3	25.1	0	10.9	91.3	43.6	8.1	15.7	0.3	4.6
Machine made bread	363	2195	0.6	15.4	0	17.1	77.4	52.7	19.8	11.9	2.2	2.9
Milk	790	2195	0.1	40.7	9.5	3.6	13.3	14.6	10.4	9.6	66.7	31.5
Curd	94	2195	2.1	30.5	13.8	26.8	56.4	29.0	7.4	5.4	20.2	8.2
Sweets	743	2195	0.3	12.3	34.7	16.8	35.4	45.5	10.5	14.2	19.1	10.7
Confectionery	876	2195	0	1.4	0	27.4	25.2	52.8	45.0	14.9	29.8	3.6
Fish	1042	2195	0.1	4.5	1.6	1.4	27.4	19.2	66.2	54.9	4.7	20.1
Egg	952	2195	1.1	7.1	29.5	6.7	54.9	54.2	8.9	22.6	5.6	9.3
Meat	1052	2195	0.1	2.6	33.3	22.3	66.2	71.8	0.4	2.3	0.1	0.9
Pulses	701	2195	0.4	2.6	0	1.5	0.6	24.3	0.7	16.9	98.3	54.6
Potato	796	2195	0.3	2.5	0	0.3	0.5	5.4	2.1	1.3	97.1	90.5
Vegetables	550	2195	0.4	7.6	0	0.3	3.8	16.6	4.0	5.2	91.8	70.3
Fruits	948	2195	0	7.6	23.3	4.1	30.7	33.2	12.8	23.0	33.2	32.1
Health drinks	548	2195	0.2	51.8	8.2	1.5	11.3	9.7	10.4	8.2	69.9	28.8
Cornflakes	42	2195	4.8	85.2	2.4	3.1	50.0	6.7	9.5	2.3	33.3	2.7
Tea	193	2195	1.6	47.8	1.6	2.2	9.3	16.8	1.6	3.1	86.0	30.2
Coffee	30	2195	6.7	69.6	6.7	15.3	70.0	13.0	0	1.0	16.7	1.1
Sugar	123	2195	0	0	0	0	0	0	0	2.8	100	97.2
Ghee (Clarified butter)	77	2195	2.6	45.2	6.5	9.2	71.4	30.8	14.3	10.1	5.2	4.7
Butter	155	2195	1.3	32.8	3.2	7.5	82.6	38.9	5.8	13.5	7.1	7.2
Chola (Gram)	38	2195	5.3	65.3	0	12.0	84.2	15.0	2.6	4.1	7.9	3.5
Nut	22	2195	9.1	59.8	0	12.7	86.4	22.1	0	3.4	4.5	2.0
Soyabean	32	2195	6.3	28.7	3.1	35.6	78.1	34.1	9.4	1.4	3.1	0.2
Vegetable leaves	83	2195	3.6	23.3	0	13.0	90.4	50.3	4.8	9.7	1.2	3.6
Jam/Jelly	30	2195	6.7	64.4	0	12.0	90.0	20.5	3.3	2.6	0	0.5
Vegetable oil	123	2195	0	0	0	0	0	0	0	1.0	100	99.0
Panneer (Local cheese)	32	2195	6.3	35.4	3.1	33.7	65.5	29.7	18.8	1.0	6.3	0.2
Suji (Semolina)	21	2195	14.3	53.0	0	31.2	81.0	15.3	4.8	0.4	0	0.1
Molasses	3	2195	66.7	89.7	0	4.8	33.3	4.2	0	0.7	0	0.6
Others	4	2195	50.0	100	25.0	0	0	0	0	0	25.0	0

3.3 Organisation and presentation of results on secular trends

It has already been mentioned in the previous chapter (chapter 2) that during the pre transition period of the country two notable growth studies have been carried out in Bengali population. They are, firstly, the Sarsuna-Barisha growth study of 1952-1966 (on both sexes) and secondly, the Kolkata (formerly Calcutta) growth study of 1982-83 (on boys).

Accordingly, the studies have been referred as study 1 and study 2 respectively. But the current growth survey carried out on boys in two phases (1999-2002 and 2005-2011) and on girls in one phase (2005- 2011) have been referred as study 3 and study 2 respectively. Therefore, the secular trends phenomena can be observed in boys between three time intervals of the three study periods (1 to 2, 2 to 3 and 1 to 3) and in girls between a single time intervals of the two study periods (1 to 2). Accordingly, in the following sections (from section 3.3a to 3.3l) the results are presented firstly for boys between the three mentioned time intervals and secondly, for girls between a single time interval.

3.3a Changes in the LMS values of body mass index (BMI) over time (Tables 3.3a.1 and 3.3a.2)

3.3a.1 In boys (between studies 1 and 2, 2 and 3 and 1 and 3)

Table 3.3a.1 shows that the L values of body mass index for boys in study 1 are both positive and negative while in study 2 all L values are negative from ages 7.0 to 16.0 years and this negativity continues in all ages of study 3. All age specific M values between the three comparing study intervals are in the increasing order. Between studies 1 and 2, highest increase of 1.87 kg./m.^{2} is observed at 15.0 year and between studies 2 and 3 the respective increase is 2.74 kg./m.^{2} observed at 12.0 year while between studies 1 and 3 the increased value is 4.08 kg./m.^{2} noticed also at 12.0 year. All age specific S values between the three time intervals have consistently increased, though in a lower magnitude.

Table-3.3a.1: Changes in age specific LMS values (Cole, 1988) of body mass index (kg./m.^{2}) of boys over three study periods

Age (years)	L			M			S		
	Study 1	Study 2	Study 3	Study 1	Study 2	Study 3	Study 1	Study 2	Study 3
	1952-1966	1982-1983	1999-2011	1952-1966	1982-1983	1999-2011	1952-1966	1982-1983	1999-2011
7.0	0.59	-1.67	-1.05	13.44	13.81	15.39	0.06	0.11	0.13
8.0	0.52	-1.59	-0.96	13.37	13.93	15.95	0.06	0.12	0.16
9.0	1.10	-2.32	-0.54	13.52	14.61	16.58	0.07	0.13	0.17
10.0	0.23	-1.28	-0.41	13.60	14.91	17.06	0.07	0.15	0.19
11.0	0.10	-0.78	-0.62	13.81	15.07	17.30	0.07	0.16	0.18
12.0	0.99	-1.35	-0.52	13.91	15.25	17.99	0.07	0.14	0.19
13.0	0.24	-1.29	-0.74	14.29	15.58	17.91	0.07	0.12	0.18
14.0	-0.18	-1.51	-0.70	14.69	16.05	18.55	0.08	0.13	0.17
15.0	-0.62	-0.78	-0.90	15.20	17.07	18.83	0.09	0.13	0.18
16.0	-0.04	-1.61	-0.65	15.84	17.30	19.69	0.09	0.13	0.16
17.0	0.15		-0.59	16.40		20.18	0.09		0.17
18.0	-0.48		-0.83	16.55		20.01	0.08		0.17
19.0	-0.32		-0.69	16.81		20.67	0.08		0.19
20.0	-0.27		-1.11	17.03		20.40	0.09		0.15
21.0	-0.89		-0.50	17.06		20.67	0.08		0.14

3.3a.2 In girls (between studies 1 and 2)

Table 3.3a.2 shows that in girls, most of the L values in two studies are negative. But the age specific M values have shown a consistent trend of increase between the studies with the highest value of 4.32 kg./m.^{2}, observed at 20.0 year. The age specific S values are also found to have increased between the time differences of the two study periods.

Table-3.3a.2: Changes in age specific LMS values (Cole, 1988) of body mass index (kg./m.^{2}) of girls over two study periods

Age (years)	L		M		S	
	Study 1 1952-1966	**Study 2 2005-2011**	**Study 1 1952-1966**	**Study 2 2005-2011**	**Study 1 1952-1966**	**Study 2 2005-2011**
7.0	-1.22	-0.93	13.28	15.16	0.08	0.17
8.0	-0.83	-0.44	13.47	16.04	0.08	0.17
9.0	-0.77	-0.13	13.64	16.49	0.07	0.17
10.0	0.22	-0.17	13.82	17.34	0.08	0.18
11.0	-1.08	-0.25	13.98	18.01	0.08	0.18
12.0	-1.35	-0.21	14.48	18.10	0.09	0.17
13.0	-0.38	-0.29	15.16	18.99	0.09	0.17
14.0	-1.42	0.05	15.89	19.76	0.10	0.18
15.0	-0.83	-0.40	16.68	20.46	0.10	0.19
16.0	-0.43	-0.26	17.20	21.22	0.10	0.17
17.0	-0.44	0.38	17.66	21.64	0.10	0.17
18.0	-0.12	0.17	18.09	21.95	0.09	0.19
19.0	-0.33	-0.11	17.86	21.36	0.10	0.18
20.0	-0.69	0.11	17.69	22.01	0.10	0.18
21.0	3.51	0.42	18.60	22.56	0.08	0.16

3.3b Changes in three percentiles of body mass index (BMI) over time (Tables 3.3b.1 and 3.3b4.2)

3.3b.1 In boys (between studies 1 and 2, 2 and 3 and 1 and 3)

Table 3.3b.1 shows that between studies 1 and 2, the highest increase in age specific 10th percentile rank of body mass index is 0.90 kg./m.^{2} occurs at 15.0 year. Similar increase in age specific 50th percentile rank is 1.87 kg./m.^{2}, observed at the same age. But the highest increase of 5.72 kg./m.^{2} in age specific 97th percentile rank is noticed at 11.0 year. Between studies 2 and 3 the highest increase in 10th percentile rank is 1.61 kg./m.^{2} noticed at 11.0 year while the respective increase in 50th percentile rank is 2.74 kg./m.^{2} observed at 12.0 year. In the 97th percentile rank the maximum increase of 6.15 kg./m.^{2} between two comparing studies remains at 13.0 year (table 3.3b.1). Between studies 1 to 3 the highest increase in the 10th percentile rank is 2.17 kg./m.^{2} (16.0 year) while in 50th percentile rank such increase of 4.08 kg./m.^{2} occurs at 12.0 year. But in the 97th percentile rank the maximum increase of 11.51 kg./m.^{2}, is found at 19.0 year.

In figures 3.3b.1a, 3.3b.1b and 3.3b.1c (see pages 155 and 156), three percentile lines, namely, the 10th, 50th and 97th of body mass index of boys for three respective study periods are presented for comparison. These three percentile lines of study 3 are observed to be lying much above the respective percentile lines of study 2 and study 1. Further it is observed that the magnitudes of differences are greater in higher percentiles than in the lower one (e.g. 97th versus 10th) when any two study periods are compared. Figure 3.3b.1d (see page 156) compares the 50th percentile lines of three studies on boys with the respective 50th percentile line of World Health Organisation (WHO, 2007). The comparison shows that the percentile lines of both study 1 and 2 are lying conspicuously much below than both the WHO and the study 3 lines. But the percentile line of study 3 overlaps with the WHO line up to 12.5 year and thereafter, it tends to fall a little below the WHO line up to 18.0 year.

Table-3.3b.1: Changes in age specific values of 10th, 50th and 97th percentiles of body mass index (kg./m.^{2}) of boys over three study periods calculated by the LMS method (Cole, 1988)

Age (years)	10th centile			50th centile			97th centile		
	Study 1 1952-1966	Study 2 1982-1983	Study 3 1999-2011	Study 1 1952-1966	Study 2 1982-1983	Study 3 1999-2011	Study 1 1952-1966	Study 2 1982-1983	Study 3 1999-2011
7.0	12.35	12.15	13.18	13.44	13.81	15.39	15.10	17.85	20.49
8.0	12.32	12.10	13.17	13.37	13.93	15.95	15.00	18.60	23.01
9.0	12.29	12.71	13.49	13.52	14.61	16.58	15.31	20.83	23.54
10.0	12.43	12.60	13.59	13.60	14.91	17.06	15.45	20.92	24.88
11.0	12.64	12.41	14.02	13.81	15.07	17.30	15.70	21.42	25.01
12.0	12.70	12.98	14.38	13.91	15.25	17.99	15.70	21.16	26.43
13.0	13.05	13.57	14.49	14.29	15.58	17.91	16.27	20.25	26.40
14.0	13.28	13.84	15.12	14.69	16.05	18.55	17.10	21.74	26.73
15.0	13.65	14.55	15.28	15.20	17.07	18.83	18.04	22.52	28.17
16.0	14.13	14.89	16.30	15.84	17.30	19.69	18.75	23.76	27.31
17.0	14.61		16.42	16.40		20.18	19.36		28.84
18.0	15.00		16.29	16.55		20.01	19.30		29.39
19.0	15.23		16.53	16.81		20.67	19.54		31.05
20.0	15.28		17.22	17.03		20.40	20.07		28.27
21.0	15.55		17.32	17.06		20.67	19.86		27.65

3.3b.2 In girls (between studies 1 and 2)

Table 3.4.1b shows that between studies 1 and 2, highest increase in 10^{th} percentile rank of body mass index is 2.08 kg./m.² occurs at 16.0 year. The respective increase in the 50^{th} percentile rank is 4.32 kg./m.² occurs at 20.0 year. But in the 97^{th} percentile rank the highest increase of 9.36 kg./m.² is noticed at 18.0 year.

Figures 3.3b.2a, 3.3b.2b and 3.3b.2c (see pages 157 and 158) show that in girls all three percentile lines (10^{th}, 50^{th} and 97^{th}) of study 2 are lying much above the respective percentile lines of study 1. Further the magnitude of difference between these two comparing studies increases in the higher percentiles than in the lower one (e.g. 97^{th} versus 10^{th}). In both sexes, the magnitude of increments in three percentile lines (10^{th}, 50^{th} and 97^{th}) vary between studies 1and 3 for boys and studies 1 and 2 for girls. Figure 3.3b.2d (see page 158) shows that in girls, the 50^{th} percentile line of the study 2 almost coincides with the WHO line in most of the ages. These two lines, taken together, are lying much above the 50^{th} percentile line of study 1.

Table-3.3b.2: Changes in age specific values of 10^{th}, 50^{th} and 97^{th} percentiles of body mass index (kg./m.²) of girls over two study periods calculated by the LMS method (Cole, 1988)

Age (years)	10^{th} centile		50^{th} centile		97^{th} centile	
	Study 1 1952-1966	**Study 2 2005-2011**	**Study 1 1952-1966**	**Study 2 2005-2011**	**Study 1 1952-1966**	**Study 2 2005-2011**
7.0	12.12	12.47	13.28	15.16	15.51	22.01
8.0	12.18	13.08	13.47	16.04	15.88	22.47
9.0	12.49	13.29	13.64	16.49	15.71	22.88
10.0	12.48	13.82	13.82	17.34	15.99	24.61
11.0	12.75	14.48	13.98	18.01	16.31	25.41
12.0	13.02	14.58	14.48	18.10	17.51	25.35
13.0	13.46	15.38	15.16	18.99	18.24	26.56
14.0	14.20	15.68	15.89	19.76	19.55	27.61
15.0	14.69	16.26	16.68	20.46	20.67	29.95
16.0	15.11	17.19	17.20	21.22	21.10	29.54
17.0	15.61	17.18	17.66	21.64	21.45	29.36
18.0	16.05	17.15	18.09	21.95	21.63	30.99
19.0	15.67	17.00	17.86	21.36	21.88	30.17
20.0	15.69	17.38	17.69	22.01	21.51	30.80
21.0	16.47	18.26	18.60	22.56	20.92	29.83

3.3c Changes in the LMS values of triceps and subscapular skinfold thicknesses in boys between studies 2 and 3 (Tables 3.3c.i and 3.3c.ii)

Triceps and subscapular skinfold thickness data on boys have been collected in both study 2 and study 3 but not in study 1. Therefore, tables 3.3c.i and 3.3c.ii show that the L values of triceps skinfold have changed from negative to the positive direction over the time span of two study periods. But the L values of subscapular skinfold have not shown any such consistency between ages 7.0 and 16.0 years. The M values of triceps have also increased between the comparing study periods with the highest value of 2.99 mm., noticed at 11.0 year. At the same time, the M values of subscapular site have increased to the highest order of 3.16 mm. noticed at the same age as for triceps. But the S values of the two skinfold sites have not manifested any notable changes over time except for a few age classes (tables 3.3c.i and 3.3c.ii).

Table-3.3c.i: Changes in age specific LMS values (Cole, 1988) of triceps skinfold (mm.) of boys over two study periods

Age (years)	L		M		S	
	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011
7.0	-0.39	0.00	6.79	8.53	0.32	0.30
8.0	-0.50	0.22	7.23	9.83	0.39	0.36
9.0	-0.43	0.12	7.71	9.96	0.34	0.35
10.0	-0.40	0.49	8.80	11.27	0.44	0.34
11.0	-0.18	0.36	8.95	11.94	0.47	0.30
12.0	-0.09	0.27	8.33	11.03	0.42	0.36
13.0	-0.75	0.11	8.58	10.33	0.34	0.35
14.0	-0.40	0.29	7.90	10.18	0.39	0.34
15.0	-0.19	0.25	8.51	10.20	0.43	0.41
16.0	-0.21	0.32	8.22	10.99	0.34	0.38

Table-3.3c.ii: Changes in age specific LMS values (Cole, 1988) of subscapular skinfold (mm.) of boys over two study periods

Age (years)	L		M		S	
	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011
7.0	-0.93	-0.57	5.19	6.67	0.30	0.36
8.0	-0.74	-0.13	5.75	7.70	0.37	0.40
9.0	-0.91	-0.08	5.83	8.21	0.34	0.41
10.0	-0.71	-0.07	6.39	9.33	0.38	0.45
11.0	-0.67	0.03	6.79	9.95	0.37	0.40
12.0	-0.66	-0.11	6.61	9.35	0.42	0.40
13.0	-0.57	-0.19	6.74	9.17	0.25	0.38
14.0	-0.76	0.02	7.06	8.96	0.34	0.33
15.0	-0.35	-0.30	7.95	9.83	0.37	0.42
16.0	-0.25	0.07	8.51	11.26	0.35	0.39

3.3d Changes in the values of three percentiles of triceps and subscapular skinfold thicknesses in boys between studies 2 and 3 (Tables 3.3d.i and 3.3d.ii)

Tables 3.3d.i shows the changes occurred in 10th, 50th and 97th percentile values of triceps skinfold thickness of boys aged 7.0 to 16.0 years between studies 2 and 3. In the 10th percentile rank the maximum increase of 2.83 mm. and in the 50th percentile rank the maximum increase of 2.99 mm. are noticed at 11.0 year. But in the 97th percentile rank the highest increase of 4.64 mm. is found at 16.0 year.

Table 3.3d.ii shows that for subscapular skinfold thickness the maximum increase in the 10th percentile rank is 1.46 mm. (12.0 year). In the 50th percentile rank the respective increase between two study periods is 3.16 mm. (11.0 year) and in the 97th percentile rank the age specific increases are generally larger in magnitude with the highest order of 8.1 mm. noticed at 13.0 year.

Figure 3.3d.i (see page 159) compares the three percentile lines, namely, 10th, 50th and 97th of triceps skinfold thickness of boys for two study periods. Like body mass index all three percentile lines of study 3 are lying consistently above the corresponding percentile lines of study 2. Moreover, the magnitude of increments observed in the percentile lines between the two comparing studies, is found to be greater in the 50th percentile than in the 10th. But in the 97th percentile the trend of comparison between the two studies is not consistent.

Figure 3.3d.ii (see page 159) compares the 50th percentile of triceps skinfold thickness of boys of study 2 and study 3 with the respective percentile line of the WHO (WHO, 1995). It is interesting to note that the WHO percentile line is lying in between the lines of study 1 and study 2.

Figure 3.3d.iii (see page 160) compares the 10th, 50th and 97th percentiles of subscapular skinfold thickness of two study periods (between studies 2 and 3). The trend appears to be same as observed for triceps skinfold, particularly for 10th and 50th percentiles ranks. But in the 97th percentile rank, unlike triceps skinfold, the magnitude of difference between the two comparing studies is not very inconsistent.

Figure 3.3d.iv (see page 160) compares the 50th percentile lines of subscapular skinfold of two study periods with the respective 50th percentile line of WHO (1995). It shows that the lines of the two study periods are lying consistently much above the WHO line. The observed larger difference between the 50th percentile lines of two skinfold sites (triceps and subscapular) with the respective 50th percentile line of the WHO (WHO, 1995), may have resulted due to the fact that the study 3 has been performed much later than the WHO study (WHO, 1995).

Table-3.3d.i: Changes in age specific values of 10th, 50th and 97th percentiles of triceps skinfold (mm.) of boys over two study periods calculated by the LMS method (Cole, 1988)

Age (years)	10th centile		50th centile		97th centile	
	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011
7.0	4.66	5.79	6.79	8.53	13.35	15.04
8.0	4.65	6.05	7.23	9.83	17.79	18.47
9.0	5.20	6.28	7.71	9.96	16.12	18.79
10.0	5.29	6.93	8.80	11.27	24.10	19.59
11.0	5.07	7.90	8.95	11.94	23.31	19.96
12.0	4.94	6.79	8.33	11.03	18.77	20.39
13.0	5.91	6.54	8.58	10.33	20.17	19.44
14.0	5.00	6.43	7.90	10.18	18.83	18.17
15.0	5.04	5.83	8.51	10.20	20.43	20.58
16.0	5.41	6.44	8.22	10.99	16.39	21.03

Table-3.3d.ii: Changes in age specific values of 10th, 50th and 97th percentiles of subscapular skinfold (mm.) of boys over two study periods calculated by the LMS method (Cole, 1988)

Age (years)	10th centile		50th centile		97th centile	
	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011	Study 2 1982-1983	Study 3 1999-2011
7.0	3.75	4.42	5.19	6.67	11.44	15.79
8.0	3.85	4.68	5.75	7.70	15.06	17.06
9.0	4.06	4.93	5.83	8.21	14.90	18.05
10.0	4.19	5.31	6.39	9.33	17.59	22.26
11.0	4.49	5.90	6.79	9.95	17.36	21.09
12.0	4.19	5.65	6.61	9.35	19.94	20.67
13.0	5.03	5.76	6.74	9.17	11.63	19.73
14.0	4.86	5.88	7.06	8.96	16.84	16.52
15.0	5.11	5.98	7.95	9.83	17.79	24.14
16.0	5.55	6.76	8.51	11.26	17.55	23.07

Therefore to sum up the results presented in sections 3.3a to 3.3d, it can be concluded that the magnitude of secular gain in both body mass index and subcutaneous fat as observed between the time difference of the comparing study periods are larger in the higher percentiles than in the lower one (e.g. 97th versus 10th) which are equally manifested in both sexes.

3.3e Changes in means of seven anthropometric traits over time: standing height, sitting height, subischial leg length, biacromial diameter, bi-iliocristal diameter, total arm length and body weight (Tables 3.3e.1a to 3.3e.2g)

3.3e.1 In boys (between studies 1 and 2, 2 and 3, 1and 3)

Standing height

Table 3.3e.1a shows that the maximum and minimum increments of mean standing height between studies 1 and 2 are 11.6 cm. (13.0 year) and 5.8 cm. (16.0 year) respectively while between studies 2 and 3 they are 4.4 cm. (12.0 year) and 1.3 cm. (7.0 year) respectively. But between the time span of studies 1 and 3 the increased value ranges from 3.0 (19.0 year) to 14.4 cm. (at 13.0 years). In all 10 age classes between studies 1 and 2, in 9 of 10 age classes between studies 2 and 3 and in all 15 age classes between studies 1 and 3 the increments in mean are found to be statistically significant.

Table-3.3e.1a: Changes in age specific mean standing height (cm.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	111.5	5.3	0.51	119.3	6.7	0.84	120.6	4.8	0.44	*	0.079	*
8.0	116.7	4.9	0.43	124.1	5.3	0.57	127.1	5.5	0.49	*	*	*
9.0	121.7	5.2	0.44	128.5	6.0	0.62	132.3	6.6	0.58	*	*	*
10.0	126.1	5.2	0.44	133.0	5.5	0.64	136.6	5.6	0.52	*	*	*
11.0	130.4	5.5	0.45	138.4	6.9	0.70	141.7	7.3	0.66	*	*	*
12.0	134.9	5.9	0.49	143.1	8.8	0.9	147.5	8.3	0.68	*	*	*
13.0	139.9	6.7	0.56	151.5	7.9	0.79	154.3	7.6	0.61	*	0.003	*
14.0	146.9	8.1	0.72	157.1	8.6	0.9	161.2	6.8	0.58	*	*	*
15.0	154.0	8.2	0.71	162.4	6.2	0.72	164.4	6.6	0.59	*	0.019	*
16.0	159.9	6.8	0.62	165.7	5.2	0.87	167.7	5.8	0.49	*	0.028	*
17.0	163.1	6.2	0.59				167.9	5.9	0.49			*
18.0	165.2	5.6	0.57				168.8	6.1	0.53			*
19.0	166.1	5.6	0.58				169.1	6.0	0.52			*
20.0	165.9	5.5	0.61				169.8	5.8	0.50			*
21.0	166.1	5.9	1.09				170.1	6.1	0.53			0.001

*** p value <0.001**

Sitting height

Table 3.3e.1b shows that the maximum and minimum increments of mean sitting height between studies 1 and 2 are 5.6 cm. (13.0 year) and 3.3 cm. (9.0 year) respectively. The corresponding increments between studies 2 and 3 are 2.0 cm. (14.0 year) and 0.5 cm. (7.0 year), though at 16.0 year means of both studies are equal. Between studies 1 and 3 the magnitude of increments ranges from 1.5 cm. (20.0 year) to 7.1 cm. (14.0 year). In all 10 age classes between studies 1 and 2, in 8 of 10 age classes between studies 2 and 3 and in all 15 age classes between studies 1 and 3 increments in mean are recorded to be statistically significant.

Table-3.3e.1b: Changes in age specific mean sitting height (cm.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	60.9	2.4	0.24	64.6	3.4	0.44	65.1	2.7	0.24	*	0.158	*
8.0	62.9	2.3	0.20	66.4	2.6	0.29	68.1	2.9	0.27	*	*	*
9.0	64.9	2.5	0.21	68.2	3.3	0.35	69.7	3.4	0.30	*	0.001	*
10.0	66.4	2.5	0.22	70.0	2.8	0.34	71.4	2.7	0.25	*	*	*
11.0	68.2	2.5	0.21	71.7	3.5	0.36	73.0	3.5	0.32	*	0.005	*
12.0	70.0	2.6	0.22	73.6	4.2	0.43	75.4	3.8	0.31	*	*	*
13.0	72.1	3.0	0.26	77.7	4.7	0.49	78.8	3.9	0.31	*	0.035	*
14.0	75.2	3.7	0.33	80.3	5.3	0.56	82.3	3.7	0.32	*	0.001	*
15.0	78.8	4.2	0.37	83.4	4.0	0.48	84.6	3.4	0.31	*	0.018	*
16.0	82.0	3.8	0.36	86.0	2.8	0.49	86.0	3.3	0.29	*	0.488	*
17.0	84.4	3.3	0.32				86.8	3.0	0.27			*
18.0	85.7	2.9	0.30				87.5	3.1	0.30			*
19.0	86.2	3.0	0.33				88.2	2.8	0.25			*
20.0	86.8	2.7	0.33				88.3	3.2	0.28			*
21.0	87.2	2.4	0.51				88.9	3.1	0.28			0.002

*** p value <0.001**

Subischial leg length

Table 3.3e.1c shows that the maximum increment in mean subischial length between the first two comparing studies (study 1 and study 2) is 5.8 cm. (13.0 year) while the minimum is 2.0 cm. (16.0 year). Between studies 2 and 3 the respective increased values are 2.4 cm. (12.0 year) and 0.8 cm. (15.0 year) while between studies 1 and 3 the increased means range from 1.2 cm. (19.0 year) to 7.7 cm. (13.0 year). In all 10 age classes between studies 1 and 2, in 8 age of 10 age classes between studies 2 and 3 and in 14 of 15 age classes between studies 1 and 3 the respective increments in mean are found to be statistically significant.

Table-3.3e.1c: Changes in age specific mean subischial leg length (cm.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	50.5	3.3	0.33	54.7	4.1	0.53	55.6	2.7	0.25	*	0.058	*
8.0	53.9	3.1	0.28	57.7	3.3	0.37	59.1	3.3	0.30	*	0.001	*
9.0	56.8	3.3	0.28	60.3	3.4	0.35	62.6	3.8	0.34	*	*	*
10.0	59.7	3.3	0.28	63.1	3.5	0.43	65.4	3.8	0.36	*	*	*
11.0	62.0	3.5	0.30	66.6	4.2	0.44	68.7	4.4	0.40	*	*	*
12.0	64.9	3.9	0.33	69.5	5.3	0.54	71.9	5.0	0.41	*	*	*
13.0	67.8	4.2	0.35	73.6	4.3	0.45	75.5	4.5	0.36	*	0.001	*
14.0	71.8	5.0	0.47	76.6	5.0	0.54	78.9	4.1	0.35	*	*	*
15.0	75.4	4.6	0.41	78.9	3.5	0.42	79.7	4.5	0.41	*	0.079	*
16.0	77.6	4.1	0.40	79.6	3.3	0.58	81.6	3.9	0.34	0.002	0.003	*
17.0	78.5	3.7	0.37				80.8	4.2	0.38			*
18.0	79.6	3.8	0.40				81.1	4.0	0.39			0.004
19.0	79.8	3.9	0.43				81.0	4.4	0.40			0.018
20.0	79.2	3.8	0.46				81.6	3.7	0.33			*
21.0	79.6	4.6	0.96				81.2	4.3	0.39			0.067

*** p value <0.001**

Biacromial diameter

Table 3.3e.1d shows that the maximum and the minimum increments of mean biacromial diameter between studies 1 and 2 are 2.9 cm. (13.0 year) and 1.4 cm. (10.0 year) respectively. But such differences between studies 2 and 3 are observed to be in the order of 0.7 cm. (14.0 year) and 0.1 cm. (8.0 year) respectively, though a decline of mean is also noticed at 7.0 year. Between studies 1 and 3 the mean has increased at all ages ranging from 0.4 cm. (18.0 year) to 3.4 cm. (14.0 year). In all 10 age classes between studies 1 and 2, in 4 of 10 age classes between studies 2 and 3 and in 14 of 15 age classes between studies 1 and 3 the increments in mean are found to be statistically significant.

Table-3.3e.1d: Changes in age specific mean biacromial diameter (cm.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
**7.0	23.8	1.2	0.12	25.4	1.6	0.20	25.2	1.3	0.12	*	0.210	*
**8.0	24.7	1.1	0.10	26.2	1.4	0.15	26.3	1.5	0.13	*	0.275	*
**9.0	25.6	1.3	0.11	27.3	1.6	0.17	27.6	1.8	0.16	*	0.069	*
**10.0	26.6	1.3	0.11	28.0	1.7	0.20	28.5	1.6	0.15	*	0.012	*
11.0	27.3	1.4	0.12	29.1	2.0	0.20	29.5	1.8	0.16	*	0.048	*
**12.0	28.2	1.5	0.12	30.2	2.1	0.22	30.6	2.1	0.18	*	0.060	*
13.0	29.1	1.7	0.14	32.0	2.2	0.23	32.3	2.1	0.18	*	0.121	*
14.0	30.7	2.0	0.17	33.4	2.5	0.27	34.1	1.9	0.17	*	0.010	*
**15.0	32.1	2.3	0.19	34.5	2.0	0.24	35.1	1.9	0.17	*	0.019	*
16.0	33.6	2.0	0.18	35.9	2.0	0.35	36.4	1.8	0.15	*	0.104	*
17.0	34.7	2.0	0.19				36.3	2.1	0.18			*
18.0	35.7	1.8	0.18				36.1	2.3	0.20			0.063
19.0	36.1	1.6	0.17				37.8	1.9	0.17			*
20.0	36.3	1.7	0.19				38.2	1.8	0.15			*
21.0	36.5	1.5	0.29				37.5	2.2	0.19			0.003

*** p value <0.001**

****** Ages for which heterogeneity in variables has observed in the data collected over two phases (see table 2.6.ii)

Bi-iliocristal diameter

Table 3.3e.1e shows that the maximum and the minimum increments in mean bi-iliocristal diameter between studies 1 and 2 are 1.3 cm. (14.0 year) and 0.2 cm. (16.0 year) respectively. However, the corresponding increments between studies 2 and 3 are observed to be lower in order ranging from 0.9 cm. (16.0 year) to 0.4 cm. (8.0, 10.0 and 13.0 years) than the increments observed between studies 1 and 2. Like biacromial diameter, a decline of mean is also observed at 7.0 year of study 3. However, between studies 1 and 3 a decline of mean in the order of 0.1 cm. is also noticed at 21.0 year. But the magnitude of the increased values ranges from 0.2 cm. (18.0 year) to 2.1 cm. (14.0 year). In 9 of 10 age classes between the first two pairs of the comparing studies and in 12 of the 15 age classes between studies 1 and 3 the increments in mean are found to be statistically significant.

Table-3.3e.1e: Changes in age specific mean bi-iliocristal diameter (cm.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
**7.0	17.2	1.0	0.10	17.9	1.1	0.14	17.7	1.2	0.11	*	0.268	*
**8.0	17.8	0.9	0.08	18.3	1.0	0.12	18.7	1.2	0.11	*	0.006	*
**9.0	18.3	1.0	0.09	18.9	1.0	0.11	19.5	1.5	0.13	*	*	*
**10.0	18.9	1.0	0.08	19.6	1.1	0.14	20.0	1.3	0.12	*	0.030	*
11.0	19.5	1.0	0.08	20.2	1.3	0.13	20.7	1.5	0.13	*	0.004	*
**12.0	20.1	1.2	0.10	20.9	1.6	0.17	21.6	1.6	0.14	*	*	*
13.0	20.9	1.3	0.11	22.1	1.5	0.16	22.5	1.5	0.12	*	0.019	*
14.0	21.9	1.5	0.13	23.2	1.7	0.17	24.0	1.5	0.13	*	*	*
15.0	22.9	1.5	0.13	23.8	1.5	0.18	24.4	1.8	0.16	*	0.011	*
16.0	23.9	1.4	0.12	24.1	1.4	0.25	25.0	1.6	0.14	0.232	0.001	*
17.0	24.5	1.4	0.13				25.2	1.9	0.16			0.001
18.0	24.9	1.2	0.12				25.1	2.0	0.18			0.210
19.0	25.2	1.4	0.15				25.5	1.8	0.16			0.114
20.0	25.2	1.4	0.16				26.0	1.7	0.15			*
21.0	25.6	1.4	0.25				25.5	1.7	0.15			0.370

*** p value <0.001**

****** Ages for which heterogeneity in variables has observed in the data collected over two phases (see table 2.6.ii)

Total arm length

Table 3.3e.1f shows that the maximum and minimum increments of mean total arm length between studies 1 and 2 are 2.7 cm. (13.0 year) and 1.0 cm. (15.0 year) respectively which are found to be greater in magnitude than the increments recorded between studies 2 and 3 (2.4 cm. at 14.0 year and 0.4 cm. at 7.0 year respectively). It is to be noted that at only one age class, i.e. 16.0 year, in both study 1 and study 2 means are equal. Between studies 1 and 3 increments of mean are noticed from 7.0 to 16.0 years. But from 17.0 to 21.0 years the declining trend of means is also notable. The maximum increment of mean between the time span of these two studies is noticed to be in the order of 4.6 cm. (14.0 year) while the minimum of 1.4 cm. is noticed at 16.0 year. In 9 of 10 age classes between studies 1 and 2 and 2 and 3, the differences in increased mean are found to be statistically significant. Further, in 13 of the 15 age classes between studies 1 and 3 both the increased and decreased differences in mean are found to be statistically significant.

Table-3.3e.1f: Changes in age specific mean total arm length (cm.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
**7.0	48.8	2.5	0.24	51.0	3.3	0.43	51.4	2.7	0.24	*	0.179	*
**8.0	51.5	2.5	0.22	53.1	2.8	0.31	53.9	2.6	0.23	*	0.019	*
9.0	53.8	2.7	0.23	55.2	3.0	0.31	56.6	3.1	0.28	*	*	*
**10.0	56.0	2.7	0.24	57.1	2.9	0.37	58.8	3.0	0.28	0.007	*	*
11.0	58.0	2.9	0.25	59.5	3.6	0.38	61.4	3.8	0.34	0.001	*	*
12.0	60.2	3.1	0.26	61.9	4.4	0.46	63.8	4.2	0.35	0.001	*	*
13.0	62.9	3.4	0.29	65.6	4.1	0.43	67.3	4.0	0.32	*	0.001	*
14.0	66.3	4.1	0.38	68.5	4.2	0.45	70.9	3.6	0.31	*	*	*
**15.0	69.7	4.2	0.38	70.7	3.2	0.38	72.0	3.4	0.31	0.028	0.005	*
16.0	72.1	3.6	0.35	72.1	3.0	0.55	73.5	3.2	0.27	0.457	0.015	0.001
17.0	73.3	3.7	0.36				72.9	3.1	0.26			0.190
18.0	74.6	3.3	0.37				72.6	3.4	0.30			*
19.0	74.5	3.3	0.39				73.5	3.1	0.27			0.015
20.0	74.6	3.3	0.41				74.1	3.2	0.28			0.137
21.0	75.5	3.7	0.92				73.6	3.8	0.33			0.034

*** p value <0.001**

****** Ages for which heterogeneity in variables has observed in the data collected over two phases (see table 2.6.ii)

Body weight

Table 3.3e.1g shows that the maximum and minimum increments in mean body weight between studies 1 and 2 are 9.2 kg. (15.0 year) and 3.6 kg. (7.0 and 8.0 years) respectively. Such increments in the order of 8.7 kg. (14.0 year) and 2.5 kg. (7.0 year) respectively are observed between studies 2 and 3. But between studies 1 and 3 the highest and the lowest increments of mean range from 6.1 kg. (7.0 year) to 17.1 kg. (14.0 year). Between the first two pairs of the comparing studies the differences in increased mean in all 10 age classes are found to be statistically significant and between studies 1 and 3 in all 15 age classes the differences in increased mean are found to be statistically significant.

Table-3.3e.1g: Changes in age specific mean body weight (kg.) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	16.7	1.9	0.19	20.3	4.5	0.56	22.8	4.0	0.36	*	*	*
8.0	18.4	2.1	0.18	22.0	4.4	0.47	26.6	6.5	0.58	*	*	*
9.0	20.1	2.4	0.21	25.0	6.2	0.63	29.9	7.7	0.67	*	*	*
10.0	21.7	2.6	0.22	26.9	5.8	0.67	32.8	7.7	0.71	*	*	*
11.0	23.6	2.8	0.24	29.8	7.9	0.80	35.9	8.9	0.8	*	*	*
12.0	25.5	3.2	0.27	32.2	8.0	0.82	40.3	9.6	0.79	*	*	*
13.0	28.1	3.6	0.31	36.5	6.4	0.65	43.9	10.0	0.79	*	*	*
14.0	32.0	4.9	0.42	40.4	8.4	0.86	49.1	10.5	0.9	*	*	*
15.0	36.4	6.1	0.52	45.6	8.2	0.95	52.3	11.3	1.01	*	*	*
16.0	40.6	5.6	0.51	49.0	10.0	1.66	56.4	10.3	0.88	*	*	*
17.0	43.9	5.9	0.54				58.3	11.4	0.95			*
18.0	45.6	5.1	0.51				58.7	12.8	1.13			*
19.0	46.6	5.3	0.56				60.7	12.8	1.11			*
20.0	47.4	6.0	0.66				60.1	10.2	0.88			*
21.0	47.5	5.4	1.01				60.8	10.0	0.87			*

*** p value <0.001**

3.3e.2 In girls (between studies 1 and 2)

Standing height

Table 3.3e.2a shows that the magnitudes of minimum and maximum increments in standing height range from 2.7 cm. (21.0 year) to 11.8 cm. (10.0 and 11.0 year) between the two comparing studies. In all 15 age classes the increments in mean are found to be statistically significant.

Table-3.3e.2a: Changes in age specific mean standing height (cm.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	110.1	4.8	0.45	118.2	5.1	0.41	*
8.0	115.0	4.7	0.46	124.6	5.6	0.45	*
9.0	120.4	5.1	0.47	131.3	6.7	0.55	*
10.0	125.3	6.1	0.56	137.1	6.1	0.49	*
11.0	130.4	5.7	0.56	142.2	6.8	0.57	*
12.0	136.6	6.9	0.65	147.2	6.9	0.57	*
13.0	141.7	7.0	0.66	151.5	5.4	0.45	*
14.0	146.8	6.4	0.63	152.6	5.3	0.44	*
15.0	148.9	5.2	0.54	154.0	5.6	0.46	*
16.0	149.8	5.2	0.54	154.2	5.5	0.47	*
17.0	150.7	4.7	0.50	155.5	5.5	0.46	*
18.0	151.7	5.0	0.64	155.0	5.5	0.47	*
19.0	151.4	5.1	0.71	155.4	6.0	0.50	*
20.0	151.2	5.0	0.79	155.3	6.0	0.48	*
21.0	151.3	6.1	1.83	154.0	5.3	0.45	0.091

*** p value <0.001**

Sitting height

Table 3.3e.2b shows that the range of increments in mean sitting height between the two studies varies from 1.8 cm. (18.0 year) to 5.8 cm. (11.0 year) and in all 15 age classes the increments in mean are found to be statistically significant.

Table-3.3e.2b: Changes in age specific mean sitting height (cm.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	60.0	2.3	0.22	63.3	2.8	0.23	*
8.0	62.0	2.3	0.22	65.5	2.9	0.25	*
9.0	64.3	2.5	0.22	68.2	3.4	0.29	*
10.0	66.1	2.8	0.25	71.1	3.5	0.29	*
11.0	68.3	2.8	0.27	74.1	3.6	0.31	*
12.0	71.0	3.4	0.32	76.4	3.8	0.33	*
13.0	73.6	3.5	0.33	78.9	3.0	0.27	*
14.0	76.4	3.3	0.31	79.3	3.0	0.26	*
15.0	77.8	2.5	0.27	80.7	2.8	0.25	*
16.0	78.4	2.7	0.29	80.9	2.8	0.25	*
17.0	79.2	2.6	0.28	82.2	2.9	0.26	*
18.0	79.7	2.5	0.33	81.5	2.8	0.25	*
19.0	79.7	2.6	0.37	81.7	3.4	0.29	*
20.0	79.5	2.6	0.40	81.7	3.2	0.27	*
21.0	79.6	2.8	0.82	81.5	2.7	0.24	0.019

*** p value <0.001**

Subischial leg length

Table 3.3e.2c shows that the range of increments in mean subischial leg length between the two comparing study periods varies from 0.6 cm. (21.0 year) to 6.8 cm. (10.0 year). In 14 of the 15 age classes the differences of mean subischial leg length between the comparing studies are statistically significant.

Table-3.3e.2c: Changes in age specific mean subischial leg length (cm.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	50.1	3.1	0.29	54.8	2.9	0.24	*
8.0	53.1	3.1	0.30	58.9	3.4	0.28	*
9.0	56.1	3.3	0.30	62.8	4.0	0.33	*
10.0	59.2	3.8	0.35	66.0	3.5	0.28	*
11.0	62.1	3.6	0.35	68.0	3.8	0.33	*
12.0	65.5	4.1	0.39	70.8	3.7	0.32	*
13.0	68.0	4.2	0.40	72.5	3.5	0.30	*
14.0	70.4	4.0	0.39	73.1	3.3	0.29	*
15.0	71.2	3.5	0.38	73.1	3.7	0.32	*
16.0	71.5	3.4	0.37	73.1	3.3	0.29	*
17.0	71.5	3.3	0.36	73.2	3.6	0.32	*
18.0	72.0	3.2	0.42	73.3	3.7	0.33	0.006
19.0	71.7	3.1	0.44	73.4	3.4	0.29	0.001
20.0	71.6	3.2	0.50	73.4	3.9	0.33	0.002
21.0	72.0	4.0	1.20	72.6	3.5	0.31	0.307

*** p value <0.001**

Biacromial diameter

Table 3.3e.2d shows that the maximum and minimum increments in mean biacromial diameter between studies 1 and 2 range from 0.5 cm. (21.0 year) to 3.1 cm. (13.0 year). In 14 of the 15 age classes the increments in means are found to be statistically significant.

Table-3.3e.2d: Changes in age specific mean biacromial diameter (cm.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	23.5	1.2	0.11	25.2	1.6	0.13	*
8.0	24.5	1.2	0.12	26.8	1.7	0.14	*
9.0	25.4	1.3	0.12	28.3	1.7	0.14	*
10.0	26.4	1.4	0.13	29.3	1.8	0.15	*
11.0	27.5	1.4	0.14	30.5	1.9	0.16	*
12.0	28.5	1.8	0.17	31.5	1.9	0.16	*
13.0	29.8	1.9	0.17	32.9	1.9	0.17	*
14.0	30.9	1.8	0.17	33.4	1.6	0.14	*
15.0	31.7	1.6	0.16	33.8	1.6	0.14	*
16.0	32.0	1.6	0.16	33.9	1.5	0.14	*
17.0	32.3	1.7	0.18	34.1	1.6	0.14	*
18.0	32.8	1.6	0.19	34.0	1.6	0.14	*
19.0	32.6	1.6	0.22	34.1	1.6	0.14	*
20.0	32.8	1.7	0.24	34.1	1.7	0.14	*
21.0	33.5	2.1	0.55	34.0	1.5	0.13	0.220

*** p value <0.001**

Bi-iliocristal diameter

Table 3.3e.2e shows that the increased mean of bi-iliocristal diameter between the two comparing studies range from 0.1 cm. (17.0 year) to 1.5 cm. (11.0, 12.0 and 13.0 years). In 11 of 15 age classes these differences in increased mean are statistically significant. However, at the same time in a few age classes (18.0 to 21.0 years) several declining trends of mean are also observed.

Table-3.3e.2e: Changes in age specific mean bi-iliocristal diameter (cm.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	17.0	0.9	0.08	17.2	1.3	0.11	0.056
8.0	17.6	0.9	0.09	18.5	1.5	0.12	*
9.0	18.3	0.9	0.09	19.6	1.5	0.13	*
10.0	19.1	1.1	0.10	20.5	1.6	0.13	*
11.0	19.9	1.2	0.11	21.4	1.7	0.15	*
12.0	20.9	1.5	0.14	22.4	1.7	0.14	*
13.0	22.0	1.5	0.15	23.5	1.6	0.14	*
14.0	23.2	1.4	0.13	24.2	1.7	0.15	*
15.0	23.9	1.4	0.14	24.3	1.6	0.14	0.014
16.0	24.2	1.3	0.14	24.8	1.7	0.15	0.004
17.0	24.8	1.3	0.14	24.9	1.7	0.15	0.209
18.0	25.2	1.4	0.18	24.9	1.7	0.15	0.077
19.0	25.1	1.6	0.22	24.7	1.8	0.16	0.118
20.0	25.4	1.2	0.19	24.7	1.8	0.15	0.001
21.0	25.9	1.5	0.39	24.8	1.8	0.16	0.008

*** p value <0.001**

Total arm length

Table 3.3e.2f shows that the trend of increase in mean total arm length is restricted only from 7.0 to 13.0 years. From 14.0 year onwards the declines of mean in study 2 are observed which continues till 21.0 year. The maximum and minimum increases of mean are 3.6 cm. (10.0 year) and 1.5 cm. (13.0 year) respectively. In 13 of the 15 age classes the increased as well as decreased differences in mean are found to be statistically significant.

Table-3.3e.2f: Changes in age specific mean total arm length (cm.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	48.1	2.4	0.23	49.9	2.5	0.20	*
8.0	50.4	2.4	0.23	52.8	2.8	0.23	*
9.0	52.9	2.6	0.24	56.0	3.1	0.26	*
10.0	55.2	3.2	0.30	58.8	3.0	0.25	*
11.0	57.7	3.1	0.30	60.9	3.5	0.30	*
12.0	60.8	3.6	0.34	63.2	3.5	0.31	*
13.0	63.4	3.9	0.37	64.9	2.8	0.25	0.001
14.0	65.8	3.6	0.36	65.6	2.8	0.24	0.352
15.0	66.9	3.0	0.33	65.8	2.9	0.25	0.003
16.0	67.4	2.8	0.31	66.3	2.7	0.24	0.002
17.0	67.8	2.7	0.30	66.3	3.0	0.26	*
18.0	68.2	3.1	0.42	66.2	3.1	0.28	*
19.0	68.1	2.9	0.44	66.3	2.9	0.26	*
20.0	67.7	3.2	0.57	66.4	3.3	0.29	0.022
21.0	68.2	4.4	1.47	65.7	2.9	0.27	0.068

*** p value <0.001**

Body weight

Table 3.3e.2g shows that in girls the magnitudes of the increment in mean body weight range from 5.6 kg. (7.0 year) to 13.9 kg. (13.0 year). The age specific differences in increased mean between the comparing studies are statistically significant in all 15 age classes.

Table-3.3e.2g: Changes in age specific mean body weight (kg.) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	16.2	1.7	0.16	21.8	5.0	0.41	*
8.0	17.9	2.1	0.20	25.7	6.1	0.49	*
9.0	19.9	2.2	0.20	29.0	6.5	0.53	*
10.0	21.9	3.1	0.28	33.4	7.4	0.58	*
11.0	24.0	3.2	0.30	37.1	8.2	0.69	*
12.0	27.2	4.4	0.40	40.4	9.1	0.76	*
13.0	30.6	4.9	0.46	44.5	9.1	0.77	*
14.0	34.6	5.1	0.47	46.9	9.2	0.78	*
15.0	37.4	5.0	0.50	49.4	10.7	0.88	*
16.0	38.9	5.1	0.52	51.2	9.6	0.83	*
17.0	40.3	4.9	0.51	53.2	10.7	0.91	*
18.0	41.5	5.1	0.61	53.5	11.1	0.95	*
19.0	41.2	5.6	0.76	52.8	11.1	0.92	*
20.0	41.3	5.2	0.76	53.9	10.2	0.81	*
21.0	44.1	6.8	1.75	53.9	8.9	0.75	*

*** p value <0.001**

3.3f Changes in means of eight anthropometric traits in boys between studies 2 and 3: upper arm circumference, calf circumference, bicondylar femur, head length, head breadth, head circumference, morphological facial height and bizygomatic breadth (Tables 3.3f.i to 3.3f.viii)

The following eight anthropometric measurements have been examined for secular trends phenomena in boys only for the age periods of 7.0 to 16.0 years using the growth data of last two studies (study 2 and study 3).

Upper arm circumference

Table 3.3f.i shows that the maximum and minimum increments in mean upper arm circumference between the two comparing study periods have occurred in the order of 3.5 cm. (16.0 year) and 2.0 cm. (7.0 year). In all 10 age classes (from 7.0 to 16.0 years) the differences in increased mean are statistically significant.

Table-3.3f.i: Changes in age specific mean upper arm circumference (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	15.7	2.5	0.33	17.7	2.4	0.22	*
**8.0	16.5	2.8	0.31	18.7	2.9	0.26	*
**9.0	17.2	2.6	0.27	19.9	3.4	0.30	*
10.0	17.9	3.3	0.40	20.4	3.2	0.30	*
**11.0	18.2	3.1	0.32	21.1	3.3	0.30	*
12.0	18.8	3.0	0.31	22.0	3.6	0.30	*
13.0	19.2	2.3	0.24	22.3	3.5	0.28	*
14.0	19.9	2.5	0.27	23.3	3.6	0.31	*
**15.0	21.0	2.7	0.32	24.0	3.7	0.33	*
16.0	21.7	2.8	0.48	25.2	3.1	0.27	*

*** p value <0.001**

****** Ages for which heterogeneity in variables has observed in the data collected over two phases (see table 2.6.ii)

Calf circumference

Table 3.3f.ii shows that the maximum increment in age specific mean calf circumference between the two comparing studies is 3.5 cm. (13.0 year) while the minimum is 2.1 cm. (7.0 year). In all 10 age classes the differences in increased mean between the studies are found to be statistically significant.

Table-3.3f.ii: Changes in age specific mean calf circumference (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	22.2	2.1	0.27	24.3	2.3	0.21	*
8.0	23.0	2.1	0.23	25.6	2.6	0.23	*
9.0	24.2	2.4	0.25	26.9	3.2	0.28	*
10.0	24.9	2.4	0.30	27.6	3.1	0.29	*
11.0	26.0	3.3	0.33	28.7	3.2	0.29	*
12.0	26.7	2.8	0.28	30.0	3.3	0.27	*
13.0	27.6	3.0	0.32	31.1	3.4	0.27	*
14.0	29.0	2.9	0.31	32.3	3.4	0.30	*
15.0	30.0	3.2	0.39	32.6	3.4	0.30	*
16.0	30.5	3.8	0.67	33.8	3.4	0.29	*

*** p value <0.001**

Bicondylar femur

Table 3.3f.iii shows that the increments in age specific mean bicondylar femur between the two comparing studies are statistically significant in all 10 age classes. The highest increment of means between two study periods is noticed to be 0.4 cm. (10.0, 12.0, 13.0 and 14.0 years) while the lowest is 0.2 cm. (7.0 and 16.0 years).

Table-3.3f.iii: Changes in age specific mean bicondylar femur (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	7.2	0.4	0.06	7.4	0.4	0.04	0.004
8.0	7.4	0.4	0.05	7.7	0.5	0.05	*
9.0	7.7	0.4	0.04	8.0	0.5	0.05	*
10.0	7.8	0.5	0.06	8.2	0.5	0.05	*
11.0	8.1	0.5	0.06	8.4	0.6	0.05	*
12.0	8.3	0.6	0.06	8.7	0.5	0.04	*
13.0	8.6	0.4	0.05	9.0	0.5	0.04	*
14.0	8.8	0.5	0.05	9.2	0.5	0.04	*
15.0	8.9	0.4	0.05	9.2	0.5	0.04	*
16.0	9.1	0.5	0.08	9.3	0.5	0.04	0.005

*** p value <0.001**

Head length and Head breadth

Tables 3.3f.iv and 3.3f.v show that increase in means of both head length and head breadth between the comparing study periods are smaller in magnitude and range from only 0.1 cm. to 0.3 cm. For mean head length in 6 of the 10 age classes the increments are found to be statistically significant while for mean head breadth in only 2 out of 10 age classes statistically significant difference in means are observed. It may also be noted that in head length equal means are also observed in two age classes (10.0 and 13.0 years) of the comparing study periods.

Table-3.3f.iv: Changes in age specific mean head length (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	16.8	0.6	0.08	17.1	0.5	0.05	0.004
8.0	17.0	0.6	0.07	17.3	0.7	0.06	0.003
9.0	17.1	0.8	0.08	17.4	0.7	0.06	0.012
10.0	17.4	0.8	0.10	17.4	0.6	0.06	0.281
11.0	17.4	0.6	0.06	17.5	0.6	0.06	0.101
12.0	17.5	0.7	0.07	17.7	0.7	0.06	0.007
13.0	17.8	0.7	0.07	17.8	0.6	0.05	0.301
14.0	17.8	0.6	0.07	18.0	0.7	0.06	0.019
15.0	18.0	0.6	0.08	18.1	0.7	0.06	0.188
16.0	18.1	0.5	0.09	18.3	0.6	0.05	0.021

Similarly, for head breadth the trend of equal means is also noticed at one age class (14.0 year). Further, at 9.0 year of study 3, a little decline of mean head breadth is also recorded.

Table-3.3f.v: Changes in age specific mean head breadth (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	14.4	0.6	0.08	14.5	0.5	0.05	0.290
8.0	14.5	0.6	0.06	14.6	0.5	0.05	0.200
9.0	14.7	0.6	0.06	14.6	0.6	0.05	0.263
10.0	14.6	0.5	0.06	14.7	0.5	0.05	0.118
11.0	14.7	0.5	0.05	14.8	0.5	0.04	0.038
12.0	14.7	0.6	0.06	14.8	0.5	0.04	0.191
13.0	14.8	0.5	0.06	14.9	0.5	0.04	0.166
14.0	14.9	0.6	0.06	14.9	0.5	0.04	0.168
15.0	14.9	0.6	0.08	15.1	0.5	0.04	0.105
16.0	14.8	0.6	0.11	15.1	0.6	0.05	0.022

Head circumference

Table 3.3f.vi shows that the increments of mean head circumference between the two comparing studies are statistically significant in all 10 age classes where the increased values range from 1.0 cm. (8.0 year) to 1.9 cm. (16. 0 year).

Table-3.3f.vi: Changes in age specific mean head circumference (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	49.2	1.5	0.20	50.4	1.3	0.12	*
8.0	50.0	2.3	0.26	51.0	1.6	0.14	*
9.0	50.1	1.3	0.14	51.4	1.5	0.13	*
10.0	50.4	1.4	0.17	51.6	1.5	0.14	*
11.0	50.7	1.6	0.16	52.1	1.5	0.13	*
12.0	50.9	1.5	0.16	52.4	1.6	0.13	*
13.0	51.6	1.4	0.15	52.8	1.5	0.12	*
14.0	51.7	1.5	0.16	53.3	1.5	0.13	*
15.0	52.2	1.6	0.19	53.7	1.5	0.14	*
16.0	52.3	1.3	0.23	54.2	1.5	0.13	*

*** p value <0.001**

Morphological facial height

But surprisingly, the age specific means of morphological facial height are found to have declined between the two comparing studies (table 3.3f.vii). The maximum and minimum declines are recorded to be 0.5 cm. (13.0 year) and 0.2 cm. (11.0 and 14.0 years) respectively which indicate a tendency of smallness of the average facial length in boys due to change of time. Further, in all 10 age classes these declines in mean are found to be statistically significant.

Table-3.3f.vii: Changes in age specific mean morphological facial height (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
**7.0	9.5	0.5	0.07	9.2	0.4	0.04	*
**8.0	9.8	0.5	0.05	9.5	0.4	0.04	*
9.0	9.9	0.6	0.06	9.6	0.5	0.05	*
**10.0	10.0	0.5	0.06	9.7	0.4	0.04	*
11.0	10.1	0.5	0.06	9.9	0.5	0.05	*
**12.0	10.3	0.6	0.06	10.0	0.6	0.05	0.001
13.0	10.7	0.5	0.06	10.2	0.6	0.05	*
14.0	10.8	0.6	0.06	10.6	0.5	0.05	0.003
15.0	11.1	0.6	0.07	10.7	0.6	0.05	*
16.0	11.2	0.5	0.08	10.9	0.5	0.04	0.001

*** p value <0.001**

****** Ages for which heterogeneity in variables has observed in the data collected over two phases (see table 2.6.ii)

Bizygomatic breadth

Finally, table 3.3f.viii shows that the increased differences in age specific mean bizygomatic breadth between the two study points are statistically significant in all 10 age classes. The highest increased value of 0.4 cm. in mean is found at 16.0 year while the lowest of 0.1 cm. is noticed at 13.0 year.

Table-3.3f.viii: Changes in age specific mean bizygomatic breadth (cm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
**7.0	11.6	0.5	0.07	11.9	0.5	0.04	0.001
**8.0	11.8	0.5	0.05	12.1	0.5	0.05	*
**9.0	12.0	0.4	0.05	12.3	0.5	0.05	*
10.0	12.1	0.5	0.06	12.4	0.5	0.05	*
**11.0	12.3	0.5	0.05	12.5	0.5	0.05	*
**12.0	12.4	0.5	0.06	12.7	0.5	0.04	*
13.0	12.7	0.4	0.05	12.8	0.5	0.04	0.005
14.0	12.8	0.5	0.06	13.1	0.5	0.04	*
15.0	13.0	0.5	0.06	13.2	0.6	0.06	0.006
16.0	13.0	0.6	0.10	13.4	0.5	0.04	*

*** p value <0.001**

****** Ages for which heterogeneity in variables has been observed in the data collected over two phases (see table 2.6.ii)

Thus, summing up the results presented in sections 3.3e and 3.3f the following conclusions may be drawn. In both sexes, all seven studied anthropometric traits have responded to secular trend phenomena by manifesting increased age specific means due to change of time. Moreover, the maximum increase of age specific means between the comparing study periods are centred around the adolescent years. In boys, the increments in mean (both maximum and minimum) between study 1 and 3 are observed to be consistently larger than the increments observed between studies 1 and 2 and between studies 2 and 3. Moreover, among boys besides few individual cephalofacial traits the limb width and circumferential measurements have also responded to the secular trend phenomena.

3.3g Changes over time in increased age specific standard deviations of three anthropometric traits in both sexes (for boys between studies 1, 2 and 3 and for girls between studies 1 and 2)

Age specific increased standard deviations (with means) for standing height and related measurements, obtained from cross-sectional growth data, provide some evidences on the initiation of adolescent growth spurt in a given population. In Sarsuna-Barisha growth data (study 1) the increased standard deviations in standing height of boys are noticed between 14.0 to 16.0 years. In the data of Kolkata growth study (study 2), this particular feature has been recorded little ahead i.e. between 12.0 to 14.0 years. But in the data of the current study (i.e. study 3), the increasing trend has further moved ahead and has been recorded between

11.0 to 13.0 years (table 3.3e.1a). In girls data a similar trend is observed i.e. in the data of study 1 (Sarsuna-Barisha growth study) the increased standard deviation of standing height is observed between 12.0 to 14.0 years followed by 9.0 to 12.0 years for the study 2 (table 3.3e.2a). In the same way for sitting height of boys the increasing values of standard deviations are observed between 14.0 to 16.0 years, followed by 12.0 to 14.0 years and 12.0 to 14.0 years respectively for three studies in succession (table 3.3e.1b). In girls, the respective orders are observed between 12.0 to 14.0 years followed by 10.0 to 12.0 years (table 3.3e.2b). Finally, for subischial leg length of boys the increasing orders of standard deviation are noticed between 13.0 to 15.0 years followed by 12.0 to 14.0 years and 11.0 to 13.0 years for the successive studies (table 3.3e.1c) while for girls the orders are 12.0 to 14.0 years and 9.0 to 12.0 years respectively (table 3.3e.2c). For other two dimensions like biacromial diameter and total arm length as well, similar trends are consistently noticed in the data for both sexes (see tables 3.3e.1d, 3.3e.2d, 3.3e.1f and 3.3e.2f).

3.3h Changes in mean indices of four measures of body shape over time: sitting height-standing height index, sitting height-subischial leg length index, body mass index, bi-iliocristal diameter-biacromial diameter index (Tables 3.3h.1a to 3.3h.2d)

3.3h.1 In boys (between studies 1 and 2, 2 and 3, 1 and 3)

Sitting height-standing height index

Table 3.3f.1a shows that between the time difference of studies 1 and 2 the decline of mean sitting height-standing height index continues up to 13.0 year. Thereafter, in 15.0 and 16.0 years, a reversal in the form of increase of the mean index is noticed. In only one age class (14.0 year) the mean index value is observed to be equal in the first pair of the comparing studies (study 1 and study 2). Between the time difference of studies 2 and 3 such declines are noticed in 8 of the 10 age classes between 7.0 to 16.0 years. For two age classes, namely 8.0 and 15.0 years the mean index is observed to be equal in both study 2 and study 3. The magnitude of overall decline of the mean index ranges from 0.1 to 0.6 in two pairs of the comparing studies, (i.e. 1 versus 2 and 2 versus 3). Between studies 1 and 3 the mean index is observed to have declined up to 14.0 year and the maximum declining value of 0.9 is found at 11.0 year. But, thereafter the trend is not very consistent till 20.0 year. In 21.0 year the mean index is equal in both of the comparing studies. In 7 of 10 age classes between studies 1 and 2, in 4 of 10 age classes between studies 2 and 3 the declines of mean index are found to be statistically significant. In 9 of the 15 age classes between studies 1 and 3 both decrease and increase of mean indices are found to be statistically significant.

Table-3.3h.1a: Changes in age specific mean sitting height - standing height index of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	54.7	1.26	0.122	54.2	1.39	0.183	53.9	1.09	0.098	0.013	0.123	*
8.0	53.9	1.14	0.100	53.5	1.15	0.127	53.5	1.06	0.097	0.031	0.408	0.008
9.0	53.4	1.15	0.097	53.1	1.10	0.114	52.7	1.15	0.102	0.040	0.007	*
10.0	52.7	1.04	0.090	52.6	1.16	0.143	52.2	1.36	0.127	0.308	0.022	0.001
11.0	52.4	1.07	0.091	51.9	1.28	0.132	51.5	1.18	0.107	0.001	0.015	*
12.0	51.9	1.11	0.094	51.5	1.24	0.128	51.2	1.19	0.098	0.003	0.075	*
13.0	51.6	1.07	0.091	51.4	1.51	0.156	51.1	1.18	0.094	0.128	0.061	*
14.0	51.2	1.26	0.116	51.2	1.70	0.182	51.1	1.22	0.105	0.490	0.254	0.178
15.0	51.1	1.12	0.101	51.5	1.17	0.141	51.5	1.40	0.127	0.030	0.392	0.010
16.0	51.4	1.18	0.115	51.9	0.98	0.173	51.3	1.28	0.112	0.013	0.003	0.243
17.0	51.8	1.07	0.106				51.8	1.35	0.122			0.494
18.0	51.8	1.14	0.120				51.9	1.17	0.112			0.267
19.0	51.9	1.17	0.130				52.1	1.28	0.116			0.197
20.0	52.3	1.16	0.139				52.0	1.11	0.098			0.043
21.0	52.3	1.35	0.282				52.3	1.22	0.111			0.480

*** p value <0.001**

Sitting height-subischial leg length index

Table 3.3h.1b shows that the second index, i.e. mean sitting height-subischial leg length index has manifested a more or less similar trend as shown by sitting height-standing height index. Between study 1 and study 2 the age specific decline in mean index is notable up to 13.0 year and thereafter increases are observed from 14.0 to 16.0 years. In a similar way, between study 2 and study 3 the decline of mean index is consistent up to 14.0 year. Thereafter a reversal is noticed only in 15.0 year and finally in 16.0 year the decline is again restored. The magnitude of decline ranges from 0.1 to 2.4 combining two pairs of the comparing studies. Between studies 1 and 3 the declines of mean index continues till 14.0 year where the highest declining value of 3.8 is noticed at 11.0 year. Thereafter no consistent trend is noticed till 21.0 year. In 7 of 10 age classes between studies 1 and 2, in 5 of 10 age classes between studies 2 and 3 and in 9 of 15 age classes between study 1 and study 3, both decreasing and increasing trends of mean indices are found to be statistically significant (table 3.3h.1b).

Table-3.3h.1b: Changes in age specific mean sitting height - subischial leg length index of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	120.8	6.16	0.601	118.5	6.62	0.869	117.2	5.22	0.472	0.014	0.110	*
8.0	116.8	5.43	0.478	115.4	5.32	0.584	115.2	4.94	0.453	0.031	0.398	0.008
9.0	114.6	5.32	0.451	113.3	5.02	0.521	111.6	5.16	0.459	0.039	0.007	*
10.0	111.5	4.68	0.405	111.1	5.19	0.639	109.5	6.22	0.583	0.320	0.028	0.002
11.0	110.2	4.72	0.402	108.0	5.76	0.597	106.4	5.02	0.453	0.001	0.016	*
12.0	108.1	4.81	0.407	106.2	5.29	0.545	105.2	5.01	0.415	0.003	0.073	*
13.0	106.6	4.56	0.388	105.8	6.56	0.680	104.5	4.98	0.395	0.162	0.054	*
14.0	105.1	5.32	0.490	105.2	6.76	0.724	104.5	5.09	0.438	0.466	0.208	0.175
15.0	104.7	4.69	0.423	106.1	5.10	0.614	106.4	5.94	0.538	0.032	0.371	0.008
16.0	106.1	5.06	0.492	108.0	4.22	0.747	105.6	5.26	0.459	0.015	0.003	0.248
17.0	107.6	4.67	0.460				107.7	5.86	0.529			0.472
18.0	107.8	4.96	0.520				108.1	5.08	0.487			0.326
19.0	108.2	5.09	0.565				109.0	5.52	0.502			0.140
20.0	109.7	5.15	0.615				108.4	4.78	0.424			0.042
21.0	109.9	5.95	1.242				109.8	5.33	0.486			0.472

*** p value <0.001**

Body mass index

Table 3.3h.1c shows that mean body mass index has exhibited a trend of increase at all 10 ages between the first two pairs of the comparing studies. The increase of means are however noticed to be larger in magnitude between study 2 and study 3 (ranging from 1.51 kg./m.² at 7.0 year to 2.85 kg./m.² at 12.0 year) than between the time difference of first two comparing studies (study 1 and study 2), where the increments range from 0.69 kg./m.² (7.0 year) to 2.02 kg./m.² (15.0 year). Between studies 1 and 3 the highest increment of 4.4 kg./m.² is noticed at 12.0 year while the lowest value of 2.2 kg./m.² occurs at 7.0 year. In all 10 age classes between studies 1 and 2 and 2 and 3 and in all 15 age classes between studies 1 and 3, the increases of means are noticed to be statistically significant.

Table-3.3h.1c: Changes in age specific mean body mass index (kg./m.²) of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	13.40	0.89	0.09	14.09	1.95	0.25	15.60	2.20	0.20	0.005	*	*
8.0	13.40	0.87	0.08	14.19	2.06	0.22	16.30	3.00	0.27	0.001	*	*
9.0	13.55	0.97	0.08	14.95	2.46	0.25	16.90	3.20	0.28	*	*	*
10.0	13.62	0.95	0.08	15.22	2.63	0.31	17.40	3.40	0.32	*	*	*
11.0	13.84	0.96	0.08	15.43	3.04	0.31	17.70	3.30	0.30	*	*	*
12.0	13.96	0.99	0.08	15.55	2.52	0.26	18.40	3.60	0.29	*	*	*
13.0	14.31	1.01	0.09	15.81	1.94	0.20	18.30	3.60	0.28	*	*	*
14.0	14.76	1.14	0.10	16.33	2.24	0.23	18.80	3.50	0.30	*	*	*
15.0	15.26	1.40	0.12	17.28	2.67	0.31	19.30	3.80	0.34	*	*	*
16.0	15.91	1.45	0.14	17.76	3.00	0.50	20.00	3.40	0.29	*	*	*
17.0	16.48	1.51	0.14				20.70	3.80	0.32			*
18.0	16.65	1.35	0.14				20.50	4.00	0.36			*
19.0	16.91	1.46	0.15				21.20	4.10	0.36			*
20.0	17.14	1.65	0.19				20.80	3.30	0.28			*
21.0	17.17	1.42	0.26				21.00	3.10	0.27			*

*** p value <0.001**

Bi-iliocristal-biacromial diameter index

Table 3.3h.1d shows that mean bi-iliocristal diameter-biacromial diameter index has manifested a consistent decline in all 10 age classes between study 1 and study 2 which ranges in the order from 0.9 to 3.9 (recorded at 10.0 and 16.0 years respectively). But between studies 2 and 3 this declining trend is opposed by the increase of the mean index in 8 of the 10 compared age classes though at one age (10.0 year) a decline is also observed. An equal mean index value at 7.0 year is found in both studies 2 and 3. It may be noted here that the magnitude of decline of this index is more pronounced between study 1 and study 2 than between study 2 and study 3 where the minimum and maximum values are 0.4 (13.0 and 15.0 years) and 1.6 (16.0 year) respectively. However, between studies 1 and 3 the mean index show a consistent decline in the highest order of 2.4 noticed at 19.0 year to the lowest of 0.4 noticed at 18.0 year. In all 10 age classes between study 1 and study 2, in only 5 of 10 age classes between study 2 and study 3 and in 14 of 15 age classes between study 1 and study 3, the declines of mean indices are noticed to be statistically significant (table 3.3h.1d).

Table- 3.3h.1d: Changes in age specific mean bi-iliocristal diameter - biacromial diameter index of boys over three study periods

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			p-value		
	Mean	sd	se	Mean	sd	se	Mean	sd	se	1 vs 2	2 vs 3	1 vs 3
7.0	72.2	3.33	0.326	70.5	3.09	0.410	70.5	3.24	0.292	0.001	0.493	*
8.0	71.9	3.23	0.286	70.1	4.01	0.451	71.1	3.13	0.281	0.001	0.040	0.017
9.0	71.6	3.07	0.266	69.6	3.39	0.362	70.7	3.75	0.330	*	0.015	0.019
10.0	71.3	2.93	0.253	70.4	3.28	0.414	70.1	3.36	0.310	0.046	0.246	0.002
11.0	71.4	2.85	0.240	69.6	3.45	0.368	70.1	3.74	0.337	*	0.159	0.001
12.0	71.4	3.01	0.253	69.2	3.81	0.402	70.6	3.80	0.328	*	0.002	0.029
13.0	71.9	3.22	0.275	69.3	3.49	0.368	69.7	3.49	0.286	*	0.153	*
14.0	71.5	3.38	0.290	69.6	4.13	0.435	70.5	3.87	0.333	*	0.045	0.014
15.0	71.6	3.43	0.296	69.2	3.75	0.444	69.6	4.48	0.401	*	0.265	*
16.0	71.2	3.60	0.330	67.3	3.20	0.565	68.9	3.91	0.333	*	0.010	*
17.0	70.6	3.82	0.358				69.5	4.85	0.409			0.015
18.0	69.9	3.53	0.374				69.5	4.69	0.416			0.248
19.0	69.9	3.65	0.389				67.5	4.28	0.377			*
20.0	69.5	3.26	0.374				67.9	3.92	0.339			0.001
21.0	70.0	3.36	0.625				68.0	4.01	0.353			0.004

*** p value <0.001**

3.3h.2 In girls (between studies 1 and 2)

Sitting height-standing height index

Table 3.3h.2a shows that the mean sitting height-standing height index in girls as in boys, has declined up to 12.0 year and thereafter the trend is not very consistent. Further as in boys, no decline of mean values over the study periods are noticed in ages 18.0 and 19.0 years. In 6 of 15 age classes the trend of decline of mean index is found to be statistically significant.

Table-3.3h.2a: Changes in age specific mean sitting height - standing height index of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	54.5	1.29	0.121	53.6	1.12	0.091	*
8.0	53.9	1.23	0.119	52.7	1.17	0.099	*
9.0	53.4	1.22	0.112	52.1	1.26	0.106	*
10.0	52.8	1.20	0.110	51.9	1.08	0.088	*
11.0	52.4	1.18	0.117	52.2	1.11	0.095	0.081
12.0	52.1	1.19	0.112	51.9	1.13	0.098	0.126
13.0	52.0	1.20	0.113	52.1	1.17	0.102	0.327
14.0	52.1	1.18	0.115	52.0	1.12	0.097	0.378
15.0	52.2	1.19	0.129	52.5	1.18	0.102	0.054
16.0	52.3	1.12	0.122	52.5	1.02	0.091	0.066
17.0	52.6	1.14	0.124	52.9	1.16	0.103	0.019
18.0	52.6	0.99	0.128	52.6	1.18	0.105	0.288
19.0	52.7	0.96	0.136	52.7	0.99	0.085	0.392
20.0	52.6	0.96	0.151	52.7	1.21	0.102	0.345
21.0	52.5	1.19	0.358	52.9	1.09	0.097	0.123

*** p value <0.001**

Sitting height-subischial leg length index

Table 3.3h.2b shows that mean sitting height-subischial leg length index in girls, like boys, have also manifested a more or less similar trend. The decline of the mean index continues till 12.0 year with the highest value of 6.1 found at 9.0 year. Thereafter till 21.0 year, no consistent trend is observed. In only 5 of 15 age classes both decreasing and increasing trends of mean indices are found to be statistically significant.

Table-3.3h.2b: Changes in age specific mean sitting height - subischial leg length index of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	120.2	6.19	0.585	115.8	5.27	0.429	*
8.0	117.0	5.85	0.568	111.5	5.25	0.442	*
9.0	114.8	5.62	0.515	108.7	5.50	0.463	*
10.0	112.0	5.44	0.499	107.9	4.64	0.382	*
11.0	110.1	5.23	0.517	109.2	4.88	0.420	0.078
12.0	108.8	5.16	0.486	108.0	4.89	0.422	0.121
13.0	108.6	5.19	0.493	108.9	5.09	0.445	0.329
14.0	108.8	5.08	0.496	108.6	4.87	0.425	0.371
15.0	109.5	5.24	0.565	110.6	5.20	0.450	0.054
16.0	109.8	4.91	0.532	110.8	4.54	0.404	0.069
17.0	110.9	5.14	0.561	112.4	5.29	0.471	0.020
18.0	110.9	4.38	0.570	111.3	5.33	0.473	0.270
19.0	111.3	4.29	0.607	111.5	4.42	0.382	0.389
20.0	111.1	4.25	0.672	111.5	5.39	0.457	0.323
21.0	110.5	5.31	1.602	112.5	4.91	0.437	0.128

*** p value <0.001**

Body mass index

Table 3.3h.2c shows that in girls the mean body mass index has increased between the time difference of two study periods with the highest order of 4.5 kg./m.² to the lowest of 2.2 kg./m.², found at 20.0 year and 7.0 year respectively. In all 15 age classes, the increased mean body mass index between the two comparing study periods are noticed to be statistically significant (table 3.3h.2c).

Table-3.3h.2c: Changes in age specific mean body mass index (kg./m.²) of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	13.34	1.02	0.10	15.52	2.82	0.23	*
8.0	13.53	1.19	0.12	16.37	3.04	0.24	*
9.0	13.71	0.98	0.09	16.74	2.99	0.25	*
10.0	13.84	1.10	0.10	17.67	3.19	0.25	*
11.0	14.06	1.17	0.12	18.24	3.27	0.27	*
12.0	14.60	1.37	0.13	18.50	3.35	0.28	*
13.0	15.27	1.46	0.14	19.29	3.47	0.29	*
14.0	16.10	1.65	0.16	20.07	3.68	0.31	*
15.0	16.78	1.83	0.19	20.80	3.99	0.33	*
16.0	17.32	1.89	0.20	21.51	3.66	0.32	*
17.0	17.74	1.80	0.20	21.90	3.90	0.33	*
18.0	18.16	1.79	0.23	22.25	4.34	0.37	*
19.0	17.86	1.89	0.27	21.85	4.15	0.34	*
20.0	17.82	1.93	0.30	22.33	3.98	0.32	*
21.0	18.50	1.72	0.52	22.70	3.50	0.30	*

*** p value <0.001**

Bi-iliocristal-biacromial diameter index

Table 3.3h.2d shows that mean biiliocristal-biacromial diameter index in girls has declined with the highest order of 5.8 noticed at 20.0 year to the lowest order of 2.2 noticed at 12.0 year. In all 15 age classes the declining trends of mean indices are found to be statistically significant.

Table-3.3h.2d: Changes in age specific mean biiliocristal diameter - biacromial diameter index of girls over two study periods

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	72.5	3.16	0.306	68.2	3.31	0.270	*
8.0	71.9	3.14	0.308	68.9	3.57	0.297	*
9.0	72.3	2.95	0.273	69.3	3.79	0.316	*
10.0	72.5	2.66	0.242	69.9	3.74	0.305	*
11.0	72.5	2.58	0.248	70.1	3.53	0.306	*
12.0	73.2	2.89	0.270	71.0	3.76	0.323	*
13.0	73.9	2.87	0.270	71.5	3.83	0.335	*
14.0	75.0	3.03	0.280	72.7	4.50	0.386	*
15.0	75.5	3.32	0.343	72.2	3.90	0.336	*
16.0	75.9	3.27	0.342	73.1	3.95	0.347	*
17.0	76.6	3.12	0.333	73.1	4.05	0.358	*
18.0	76.7	2.81	0.354	73.2	4.25	0.380	*
19.0	77.0	3.74	0.524	72.5	4.01	0.354	*
20.0	78.0	2.80	0.432	72.2	4.42	0.382	*
21.0	77.7	2.82	0.752	72.9	4.62	0.420	*

*** p value <0.001**

3.3i Changes in mean indices of two measures of cephalofacial shape in boys between studies 2 and 3: bizygomatic breadth-morphological facial height index and head breadth-head length index (Tables 3.3i.i and 3.3i.ii)

Two measures of cephalofacial shape have been examined for secular trends phenomena in boys only for the age period of 7.0-16.0 years from the data of last two growth study periods.

Table 3.3i.i shows that over the time difference of latter two studies the means of bizygomatic breadth-morphological facial height index have increased at all ages from 7.0 to 16.0 years. The highest increase of 7.1 between the studies has occurred both at 8.0 and 13.0 years while the lowest of 5.3 is found at 14.0 year. In all 10 age classes the increased differences between the studies are found to be statistically significant.

Table-3.3i.i: Changes in age specific mean bizygomatic breadth - morphological facial height index of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	122.4	6.18	0.811	129.1	6.67	0.601	*
8.0	121.6	5.58	0.613	128.7	6.75	0.604	*
9.0	121.9	6.78	0.703	127.7	7.56	0.666	*
10.0	121.9	6.02	0.741	128.8	6.69	0.618	*
11.0	121.6	6.77	0.706	127.5	5.99	0.538	*
12.0	121.0	6.68	0.693	127.3	6.92	0.567	*
13.0	118.5	6.69	0.698	125.6	7.43	0.590	*
14.0	118.1	5.94	0.630	123.4	6.66	0.569	*
15.0	117.6	6.61	0.796	124.0	7.22	0.640	*
16.0	116.3	6.42	1.135	123.1	6.21	0.529	*

*** p value <0.001**

But table 3.3i.ii shows that during the same time interval, mean cephalic index (head breadth/head length x 100) has manifested an inconsistent trend of simultaneous increase and decrease over the ages 7.0 to 16.0 years. Only at one age (9.0 year) out of 10 age classes, statistically significant difference of decreased means between the two comparing studies is noted.

Table-3.3i.ii: Changes in age specific mean head breadth - head length index of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	85.7	4.34	0.570	84.6	3.88	0.349	0.061
8.0	85.2	4.20	0.461	84.4	3.73	0.333	0.084
9.0	85.8	4.15	0.426	84.4	4.15	0.364	0.007
10.0	84.5	4.15	0.507	84.6	3.81	0.353	0.412
11.0	84.4	3.82	0.394	84.5	3.53	0.317	0.366
12.0	84.5	4.51	0.468	83.8	3.90	0.319	0.107
13.0	83.7	4.09	0.426	83.8	3.82	0.304	0.392
14.0	83.6	3.92	0.416	83.2	3.54	0.302	0.171
15.0	83.0	4.06	0.485	83.2	3.54	0.314	0.346
16.0	82.2	4.09	0.723	82.6	3.60	0.307	0.306

Thus, summing up the results presented in sections 3.3h and 3.3i, it can be stated that in both sexes during the period of growth, while the transverse shape of the body has undergone notable consistent secular trends, the linear shape of the body has not manifested any such pattern. But the head shape in boys has remained neutral in manifesting secular changes from ages 7.0 to 16.0 years. The face shape however has strongly responded to the phenomena of secular trend in boys between the same age periods.

3.3j Changes in six measures of body composition in boys between studies 2 and 3: triceps, biceps, subscapular and suprailiac skinfold thicknesses (untransformed and log transformed values), percentage of body fat mass (Deurenberg et al., 1990 and Slaughter et al., 1988) and body fat distribution (skinfold thickness ratios) (Tables 3.3j.i to 3.3j.xii)

Four skinfold thickness measurements and their derivatives have been examined for secular trends phenomena in six measures of body composition for boys aged 7.0-16.0 years utilising the data set of two latter growth studies (studies 2 and 3).

Triceps skinfold thickness

Table 3.3j.i shows that between the time difference of latter two comparing studies (study 2 and study 3) the maximum increase in mean triceps skinfold thickness (2.7 mm.) has occurred at 16.0 year while the minimum (1.7 mm.) has occurred at three ages (7.0, 13.0 and 15.0 years). In all 10 age classes the increased differences are found to be statistically significant.

Table-3.3j.i: Changes in age specific mean triceps skinfold (mm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	7.3	3.0	0.38	9.0	2.8	0.25	*
8.0	8.2	4.0	0.44	10.2	3.7	0.33	*
9.0	8.4	3.5	0.37	10.7	3.8	0.34	*
10.0	10.1	5.4	0.61	11.9	4.0	0.37	0.005
11.0	10.2	5.4	0.54	12.2	3.8	0.35	0.001
12.0	9.3	4.2	0.43	11.7	4.2	0.38	*
13.0	9.3	3.8	0.39	11.0	4.0	0.34	*
14.0	8.8	4.1	0.43	10.6	3.6	0.31	*
15.0	9.3	4.4	0.51	11.0	4.3	0.39	0.004
16.0	9.0	3.9	0.65	11.7	4.4	0.38	*

*** p value <0.001**

Again when these age specific increments are calculated from the means of log transformed values (triceps skinfold thickness) and compared between two studies, the same trend as observed for the untransformed values, is maintained (table 3.3j.ii).

Table-3.3j.ii: Changes in age specific mean triceps skinfold (log10) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	0.83	0.16	0.02	0.94	0.14	0.01	*
8.0	0.88	0.19	0.02	0.98	0.17	0.01	*
9.0	0.89	0.15	0.02	1.00	0.16	0.01	*
10.0	0.96	0.20	0.02	1.05	0.17	0.02	*
11.0	0.96	0.21	0.02	1.07	0.14	0.01	*
12.0	0.93	0.19	0.02	1.04	0.17	0.02	*
13.0	0.93	0.15	0.02	1.01	0.16	0.01	*
14.0	0.90	0.19	0.02	1.00	0.16	0.01	*
15.0	0.93	0.19	0.02	1.01	0.18	0.02	0.001
16.0	0.92	0.17	0.03	1.03	0.18	0.02	0.001

*** p value <0.001**

Biceps skinfold thickness

Table 3.3j.iii shows that between the same two comparing study periods the maximum increase of mean biceps skinfold thickness (1.5 mm.) has occurred at 16.0 year, while the minimum (0.3 mm.) at 7.0 year. However, the differences in increased mean are statistically significant in 8 of 10 age classes.

Table-3.3j.iii: Changes in age specific mean biceps skinfold (mm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	4.6	1.5	0.19	4.9	1.7	0.15	0.096
8.0	4.9	1.9	0.21	5.3	2.1	0.19	0.046
9.0	4.7	2.1	0.22	5.5	2.1	0.18	0.003
10.0	5.5	3.1	0.35	6.2	2.4	0.23	0.043
11.0	5.7	3.0	0.31	6.2	2.3	0.21	0.092
12.0	5.4	2.7	0.28	6.0	2.5	0.23	0.042
13.0	4.8	2.1	0.21	5.4	2.3	0.20	0.019
14.0	4.3	1.8	0.19	5.1	2.0	0.18	0.001
15.0	4.5	2.0	0.24	5.3	2.5	0.23	0.004
16.0	3.9	1.5	0.25	5.4	2.3	0.20	*

*** p value <0.001**

Again when these increments are calculated from the means of log transformed values (biceps skinfold thickness) and compared between the studies the results show the same trend as observed for the untransformed values (table 3.3j.iv).

Table-3.3j.iv: Changes in age specific mean biceps skinfold (log10) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	0.64	0.13	0.02	0.67	0.15	0.01	0.116
**8.0	0.66	0.15	0.02	0.69	0.18	0.02	0.064
**9.0	0.64	0.17	0.02	0.71	0.17	0.02	0.001
**10.0	0.70	0.20	0.02	0.76	0.18	0.02	0.008
11.0	0.70	0.20	0.02	0.76	0.16	0.01	0.013
12.0	0.69	0.19	0.02	0.74	0.18	0.02	0.020
13.0	0.66	0.15	0.02	0.69	0.18	0.02	0.024
14.0	0.60	0.15	0.02	0.68	0.17	0.01	0.001
**15.0	0.61	0.17	0.02	0.68	0.19	0.02	0.005
16.0	0.57	0.14	0.02	0.69	0.19	0.02	*

*** p value <0.001**

****** Ages for which heterogeneity in variables was observed in the data collected over two phases (see table 2.6.ii)

Subscapular skinfold thickness

Table 3.3j.v shows that mean subscapular skinfold thickness in boys has exhibited the highest increase of 3.3 mm. at 10.0 year while the lowest increase of 1.6 mm. is noticed at 14.0 year between the time interval of studies 2 and 3. Like triceps skinfold, the increased differences between two studies are also found to be statistically significant in all 10 age classes.

Table-3.3j.v: Changes in age specific mean subscapular skinfold (mm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	5.8	2.1	0.27	7.5	3.2	0.29	*
8.0	6.5	3.7	0.40	8.6	3.8	0.34	*
9.0	6.5	3.2	0.33	9.0	4.0	0.35	*
10.0	7.2	3.7	0.43	10.5	4.8	0.44	*
11.0	7.8	3.9	0.40	10.8	4.4	0.40	*
12.0	7.7	4.3	0.45	10.3	4.4	0.40	*
13.0	7.1	2.4	0.25	10.0	4.2	0.36	*
14.0	7.9	4.1	0.42	9.5	3.3	0.28	0.001
15.0	8.6	3.6	0.42	11.1	5.4	0.49	*
16.0	9.2	3.8	0.64	12.4	4.9	0.42	*

*** p value <0.001**

The age specific means of log transformed values of subscapular skinfold thickness have exhibited the same trend as already found on the untransformed values (table 3.3j.vi).

Table-3.3j.vi: Changes in age specific mean subscapular skinfold (log10) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	0.74	0.14	0.02	0.84	0.16	0.01	*
8.0	0.77	0.17	0.02	0.89	0.18	0.02	*
**9.0	0.78	0.17	0.02	0.91	0.19	0.02	*
**10.0	0.81	0.17	0.02	0.98	0.20	0.02	*
11.0	0.85	0.18	0.02	1.00	0.18	0.02	*
12.0	0.83	0.19	0.02	0.97	0.19	0.02	*
13.0	0.83	0.13	0.01	0.96	0.18	0.02	*
**14.0	0.86	0.17	0.02	0.95	0.15	0.01	*
**15.0	0.90	0.17	0.02	1.00	0.19	0.02	*
**16.0	0.93	0.17	0.03	1.06	0.18	0.02	*

*** p value <0.001**

****** Ages for which heterogeneity in variables was observed in the data collected over two phases (see table 2.6.ii)

Suprailiac skinfold thickness

Table 3.3j.vii shows that the highest increase of mean suprailiac skinfold thickness (1.2 mm.) between the two comparing studies has occurred at 11.0 year while the lowest of 0.20 mm. is at 15.0 year. In 8 of 10 age classes the increased differences due to change of time are found to be statistically significant.

Table-3.3j.vii: Changes in age specific mean suprailiac skinfold (mm.) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	4.1	2.0	0.26	4.5	1.8	0.16	0.069
8.0	4.4	2.2	0.24	4.9	2.1	0.19	0.029
9.0	4.3	2.2	0.23	5.3	2.4	0.21	0.001
10.0	5.0	2.9	0.34	6.0	2.4	0.22	0.009
11.0	5.1	2.3	0.25	6.3	2.2	0.20	*
12.0	5.4	2.9	0.31	6.3	2.5	0.23	0.011
13.0	5.1	2.7	0.28	6.1	2.2	0.19	0.002
14.0	5.2	2.3	0.24	5.7	2.0	0.17	0.039
15.0	6.1	3.1	0.36	6.3	2.7	0.25	0.320
16.0	5.6	2.4	0.44	6.5	2.3	0.20	0.027

*** p value <0.001**

Again when these age specific increments of means are compared on log transformed values, in 9 of 10 age classes they are found to be statistically significant (table 3.3j.viii).

Table-3.3j.viii: Changes in age specific mean suprailiac skinfold (log10) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	0.57	0.17	0.02	0.63	0.16	0.01	0.023
8.0	0.60	0.17	0.02	0.66	0.17	0.02	0.010
9.0	0.59	0.16	0.02	0.69	0.19	0.02	*
10.0	0.65	0.20	0.02	0.74	0.17	0.02	0.001
11.0	0.67	0.18	0.02	0.77	0.16	0.01	*
12.0	0.69	0.20	0.02	0.77	0.17	0.02	0.001
13.0	0.67	0.15	0.02	0.77	0.16	0.01	*
14.0	0.68	0.16	0.02	0.74	0.15	0.01	0.008
15.0	0.74	0.19	0.02	0.77	0.16	0.01	0.173
16.0	0.71	0.17	0.03	0.79	0.15	0.01	0.016

*** p value <0.001**

Percentage of body fat mass

Table 3.3j.ix shows that the means of the percentage of body fat mass in boys when calculated from triceps and biceps skinfolds thicknesses (Deurenberg et al., 1990) have manifested statistically significant increase of about 2.1% for the pre pubertal and 1.9% for the pubertal ages between the time span of the two comparing study periods. Further, when it has been calculated from the summation of triceps, biceps, subscapular and suprailiac skinfolds thicknesses (Deurenberg et al., 1990) both prepubertal and pubertal increases are found to be larger in magnitude by 2.6% and 1.9% respectively and are also statistically significant.

Table-3.3j.ix: Changes in percentage of body fat mass (Deurenberg et al., 1990) of prepubertal and pubertal boys (7.0-16.0 yrs.) over two study periods

Skinfold sites	Maturation stages	Study 2 (1982-1983)				Study 3 (1999-2011)				p-value
		n	Mean	sd	se	n	Mean	sd	se	
(Biceps+Triceps)	Prepubertal	309	14.4	4.3	0.25	489	16.5	4.2	0.19	*
	Pubertal	476	14.6	3.8	0.17	771	16.5	3.7	0.13	*
(Biceps+Triceps+ Subscapular+Suprailiac)	Prepubertal	295	13.5	4.0	0.23	486	16.1	4.4	0.20	*
	Pubertal	452	14.2	2.9	0.14	762	16.1	3.0	0.11	*

*** p value <0.001**

Finally, when it has been calculated from the equation of Slaughter et al. (1988), both prepubertal and pubertal boys have manifested a further increase in the order of 5.4% and 5.9% respectively between the two comparing studies that are also observed to be statistically significant. In this context it may be noted that when the equation of Slaughter et al. (1988) has been used to calculate the percentage of body fat mass the pubertal increase is found to be larger than the prepubertal one. But, on the other hand when the equation of Deurenberg et al. (1990) has been used, a reversal of this trend is observed (table 3.3j.ix and 3.3j.x).

Table-3.3j.x: Changes in percentage of body fat mass (Slaughter et al., 1988) of prepubertal and pubertal boys (7.0-16.0 yrs.) over two study periods

Skinfold sites	Maturation stages	Study 2 (1982-1983)				Study 3 (1999-2011)				p-value
		n	Mean	sd	se	n	Mean	sd	se	
(Triceps+Subscapular)	Prepubertal	308	14.3	7.2	0.41	489	19.7	8.4	0.38	*
	Pubertal	473	14.7	7.8	0.36	771	20.6	8.7	0.31	*

*** p value <0.001**

Body fat distribution ratios

Among the two studied measures of body fat distribution, the first one, i.e. mean of triceps/subscapular skinfold thicknesses ratio (untransformed values) over the time interval of the two comparing studies manifests a consistent decline till 13.0 year (table 3.3j.xi). Only at 14.0 year, however, the trend of decrease is interrupted once with a very little increase. Thereafter, the trend of decrease continues till 16.0 year though in a smaller magnitude. The maximum decline in the average ratio over 10 age classes is 0.14 (10.0 year). In only 4 of 10 age classes the observed declines of this ratio between the two study periods are found to be statistically significant.

Table-3.3j.xi: Changes in age specific mean triceps skinfold / subscapular skinfold ratio (untransformed value) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	1.30	0.296	0.038	1.26	0.201	0.018	0.190
8.0	1.29	0.293	0.032	1.24	0.217	0.020	0.096
9.0	1.34	0.264	0.028	1.24	0.218	0.019	0.002
10.0	1.34	0.237	0.028	1.20	0.224	0.021	*
11.0	1.24	0.272	0.028	1.18	0.198	0.018	0.033
12.0	1.23	0.323	0.034	1.18	0.205	0.019	0.105
13.0	1.27	0.290	0.030	1.14	0.190	0.016	*
14.0	1.12	0.270	0.028	1.13	0.168	0.014	0.387
15.0	1.06	0.236	0.028	1.03	0.196	0.018	0.170
16.0	0.97	0.184	0.031	0.96	0.167	0.014	0.406

*** p value <0.001**

The second ratio of body fat distribution refers to the summation of triceps and biceps skinfolds divided by the summation of subscapular and suprailiac skinfolds (untransformed value). Table 3.3j.xii shows that between the time intervals of two growth studies the mean ratio has declined in the order of 0.10 (at 10.0 year) to 0.04 (at 8.0 year) from 7.0 to 13.0 years. But between 14 .0 to 16.0 years a reversal in the form of increase of mean ratio is also noticed. However, in only 4 out of 10 age classes declines of mean ratio are noticed to be statistically significant (table 3.3j.xii).

Table-3.3j.xii: Changes in age specific mean ratio (untransformed value) of summation of limb and trunk skinfolds (triceps + biceps) / (subscapular + suprailiac) of boys over two study periods

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			p-value
	Mean	sd	se	Mean	sd	se	
7.0	1.25	0.270	0.035	1.19	0.169	0.015	0.075
8.0	1.22	0.237	0.026	1.18	0.172	0.016	0.082
9.0	1.25	0.198	0.021	1.16	0.160	0.014	*
10.0	1.23	0.181	0.022	1.13	0.163	0.015	*
11.0	1.15	0.209	0.022	1.10	0.150	0.014	0.019
12.0	1.14	0.242	0.026	1.09	0.161	0.015	0.072
13.0	1.13	0.199	0.021	1.04	0.168	0.014	*
14.0	1.01	0.233	0.025	1.03	0.153	0.013	0.268
15.0	0.93	0.182	0.022	0.95	0.154	0.014	0.246
16.0	0.87	0.128	0.023	0.90	0.136	0.012	0.159

*** p value <0.001**

Therefore, to sum up the results presented in section 3.3j, it can be stated that in contemporary Bengali boys aged 7.0 to 16.0 years, both trunk and the limb subcutaneous fat thicknesses in association with percentage of body fat have significantly increased due to the change of time (between the two comparing studies). Moreover, between the same time intervals, their body fat distribution tends to be truncal to a smaller extent.

3.3k Changes in four indicators of nutritional status over time: age specific prevalence of stunting, thinness, overweight and obesity (Tables 3.3k.1a to 3.3k.2e)

3.3k.1 In boys (between studies 1 and 2, 2 and 3, 1 and 3)

Stunting

Table 3.3k.1a shows that in boys, declines in the prevalence of stunting (WHO, 2007) at all ages between studies 1 and 2 are larger in magnitude (from 32.23% at 12.0 year to 55.92% at 13.0 year) than the declines observed between studies 2 and 3 (from 0.49% at 16.0 year to 15.84% at 12.0 year). However as exception, only a negligible amount in the percentage of increase in the prevalence (0.02%) is also observed at 13.0 year. But between studies 1 and 3 the prevalence is observed to have declined in all ages from 7.0 to 21.0 years where the highest decline of 55.90% is noticed at 13.0 year and the lowest of 16.79% is found at 19.0 year. In all 10 age classes between study 1 and study 2 and in 4 of 10 age classes (7.0, 9.0, 12.0 and 14.0 years) between study 2 and study 3 and in all 13 age classes between study 1 and study 3 the declines in the prevalence of stunting are observed to be statistically significant.

Table-3.3k.1a: Changes in age-specific prevalence of stunting in boys over three study periods (WHO, 2007)

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			z-statistic			p-value		
	n	f	%	n	f	%	n	F	%	1 vs 2	2 vs 3	1 vs 3	1 vs 2	2 vs 3	1 vs 3
7.0	107	52	48.60	63	9	14.29	123	5	4.07	-5.3	-2.2	-8.7	*	0.016	*
8.0	132	66	50.00	87	5	5.75	125	3	2.40	-8.8	-1.2	-10.4	*	0.120	*
9.0	141	61	43.26	96	8	8.33	130	4	3.08	-6.9	-1.6	-9.1	*	0.050	*
10.0	140	60	42.86	75	5	6.67	117	5	4.27	-7.1	-0.7	-8.4	*	0.243	*
11.0	146	70	47.95	97	11	11.34	124	8	6.45	-7.0	-1.3	-8.9	*	0.105	*
12.0	146	79	54.11	96	21	21.88	149	9	6.04	-5.5	-3.4	-10.5	*	*	*
13.0	142	91	64.08	98	8	8.16	159	13	8.18	-11.5	0.0	-12.2	*	0.499	*
14.0	127	74	58.27	93	17	18.28	137	6	4.38	-6.7	-3.2	-11.4	*	0.001	*
15.0	132	65	49.24	75	6	8.00	127	9	7.09	-7.7	-0.2	-8.6	*	0.407	*
16.0	117	46	39.32	36	2	5.56	138	7	5.07	-5.7	-0.1	-7.0	*	0.455	*
17.0	110	36	32.73				143	17	11.89			-4.0			*
18.0	95	27	28.42				128	13	10.16			-3.4			*
19.0	92	28	30.43				132	18	13.64			-3.0			0.001

f-frequency   * p value <0.001

Thinness

Table 3.3k.1b shows that the second indicator of nutritional status, i.e. the prevalence of thinness (WHO, 2007), like the prevalence of stunting, has also shown a declining trend in all ages between the first two pairs of the comparing studies due to change of time. In the first pair i.e. from study 1 to study 2, the magnitude of decline ranges from 18.06% (8.0 year) to 42.96% (13.0 year) In between the time period of study 2 and study 3 the magnitude of decline varies from 17.03% (15.0 year) to 34.40% (14.0 year). The prevalence has also declined over the time difference of study 1 and study 3. The highest decline in the order of 65.14% is noticed at 12.0 year while the lowest of 46.72% is noticed at 8.0 year. It may be noted that in all 10 age classes between studies 1 and 2 and 2 and 3 and in all 13 age classes between studies 1 and 3 the declines in the prevalence of thinness are found to be statistically significant.

Table-3.3k.1b: Changes in age-specific prevalence of thinness in boys over three study periods (WHO, 2007)

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			z-statistic			p-value		
	n	f	%	n	f	%	n	f	%	1 vs 2	2 vs 3	1 vs 3	1 vs 2	2 vs 3	1 vs 3
7.0	106	64	60.38	62	26	41.94	123	15	12.20	-2.4	-4.3	-8.6	0.010	*	*
8.0	129	84	65.12	85	40	47.06	125	23	18.40	-2.6	-4.5	-8.6	0.004	*	*
9.0	141	95	67.38	96	38	39.58	130	20	15.38	-4.4	-4.1	-10.3	*	*	*
10.0	139	97	69.78	74	29	39.19	117	23	19.66	-4.5	-2.9	-9.4	*	0.002	*
11.0	144	111	77.08	96	45	46.88	124	18	14.52	-4.9	-5.4	-13.3	*	*	*
12.0	144	117	81.25	94	45	47.87	149	24	16.11	-5.5	-5.3	-14.7	*	*	*
13.0	141	121	85.82	98	42	42.86	159	33	20.75	-7.4	-3.7	-14.9	*	*	*
14.0	126	105	83.33	93	51	54.84	137	28	20.44	-4.6	-5.5	-13.2	*	*	*
15.0	130	107	82.31	74	33	44.59	127	35	27.56	-5.7	-2.4	-10.6	*	0.008	*
16.0	116	92	79.31	36	17	47.22	138	29	21.01	-3.5	-2.9	-11.4	*	0.002	*
17.0	110	86	78.18				143	36	25.17			-9.9			*
18.0	95	82	86.32				128	38	29.69			-10.6			*
19.0	90	75	83.33				132	34	25.76			-10.5			*

f-frequency   * p value <0.001

Overweight

Table 3.3k.1c compares the prevalence of the third indicator of nutritional status, i.e., overweight in boys between the three study periods, when assessed by the criteria of International Obesity Task Force (Cole et al., 2000). The comparison shows an evidence of larger increase in the prevalence between the time span of the latter two comparing study periods (study 2 and study 3) than between the first two (study 1 and study 2). For example, between study 1 and study 2 the highest increase in the prevalence is only 9.46% (10.0 year) while the lowest is 1.08% (14.0 year). In the second pair of the comparing studies (i.e. study 2 and study 3) the highest increase is 18.09% (9.0 year) while the lowest is 8.21% (16.0 year.). But when age specific prevalence of overweight between the time differences of study 1 and study 3 is compared the maximum increase of 25.38% is noticed at 9.0 year while the minimum of 10.94% is noticed at 18.0 year. In 5 of 10 age classes between studies 1 and 2, in all 10 age classes between studies 2 and 3 and in all 12 age classes between studies 1 and 3 the increased prevalence of overweight is found to be statistically significant (table 3.3k.1c).

Table 3.3k.1d shows that the prevalence of overweight, when calculated by the criteria of World Health Organisation (WHO, 1995), has manifested an increasing trend in first two pairs of the comparing studies (studies 1 to 2 and studies 2 to 3). It may be noted that the increments in the prevalence observed between study 1 and study 2 are smaller in magnitude than the increments found between study 2 and study 3. Between studies 1 and 2, the maximum increase in the prevalence is 10.81% (10.0 year) while the minimum is 1.08% (14.0 year). At 13.0 year the prevalence remains equal in both studies. But between the time difference of study 2 and study 3, the highest increase in the prevalence is 20.4% (9.0 year) while the lowest is 6.64% (16.0 year). Again between studies 1 and 3 the prevalence of overweight has also increased from 7.81% (18.0 year) to 27.69% (9.0 year). In 4 of 8 age classes between studies 1 and 2, in all 8 age classes between studies 2 and 3 and in all 10 age classes from 9.0 to 18.0 years between studies 1 and 3, increases in the prevalence due to change of time are observed to be statistically significant.

Table-3.3k.1c: Changes in age-specific prevalence of overweight in boys over three study periods by IOTF classification (Cole et al., 2000)

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			z-statistic			p-value		
	n	f	%	n	f	%	n	F	%	1 vs 2	2 vs 3	1 vs 3	1 vs 2	2 vs 3	1 vs 3
7.0	106	0	-	62	2	3.23	123	16	13.01	1.4	2.6	4.3	0.075	0.005	*
8.0	129	0	-	85	4	4.71	125	22	17.60	2.1	3.1	5.2	0.020	0.001	*
9.0	141	0	-	96	7	7.29	130	33	25.38	2.8	3.9	6.7	0.003	*	*
10.0	139	0	-	74	7	9.46	117	29	24.79	2.8	2.9	6.2	0.003	0.002	*
11.0	144	0	-	96	7	7.29	124	22	17.74	2.8	2.4	5.2	0.003	0.008	*
12.0	144	0	-	94	4	4.26	149	32	21.48	2.0	4.4	6.4	0.020	*	*
13.0	141	0	-	98	0	-	159	24	15.09	-	5.3	5.3	-	*	*
14.0	126	0	-	93	1	1.08	137	20	14.60	1.0	4.2	4.8	0.157	*	*
15.0	130	0	-	74	2	2.70	127	18	14.17	1.4	3.2	4.6	0.076	0.001	*
16.0	116	0	-	36	2	5.56	138	19	13.77	1.5	1.7	4.7	0.073	0.044	*
17.0	110	0	-				143	27	18.88			5.8			*
18.0	95	0	-				128	14	10.94			4.0			*

f-frequency * p value <0.001

Table3.3k.1d: Changes in age-specific prevalence of overweight in boys over three study periods (WHO, 1995)

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			z-statistic			p-value		
	n	f	%	n	f	%	n	f	%	1 vs 2	2 vs 3	1 vs 3	1 vs 2	2 vs 3	1 vs 3
9.0	141	0	-	96	7	7.29	130	36	27.69	2.8	4.3	7.1	0.003	*	*
10.0	139	0	-	74	8	10.81	117	32	27.35	3.0	3.0	6.6	0.001	0.001	*
11.0	144	0	-	96	7	7.29	124	24	19.35	2.8	2.7	5.5	0.003	0.003	*
12.0	144	0	-	94	5	5.32	149	32	21.48	2.3	4.0	6.4	0.011	*	*
13.0	141	0	-	98	0	-	159	24	15.09	-	5.3	5.3	-	*	*
14.0	126	0	-	93	1	1.08	137	19	13.87	1.0	4.1	4.7	0.157	*	*
15.0	130	0	-	74	2	2.70	127	17	13.39	1.4	3.0	4.4	0.076	0.001	*
16.0	116	0	-	36	1	2.78	138	13	9.42	1.0	1.8	3.8	0.155	0.036	*
17.0	110	0	-				143	22	15.38			5.1			*
18.0	95	0	-				128	10	7.81			3.3			*

f-frequency   * p value <0.001

Obesity

The fourth studied indicator of nutritional status, i.e. the prevalence of obesity has been calculated for boys from the data of all three studies by the criteria of International Obesity Task Force (Cole et al., 2000). The results presented in table 3.3k.1e show that like overweight, the prevalence of obesity has also increased though in a lesser magnitude between the time span of study 1 and study 2 than between the time span of study 2 and study 3. For example, between study 1 and study 2, there is no increase in prevalence at 4 age classes (12.0 to 15.0 years) due to its non occurrence. For the remaining age classes the increase ranges from only 1.04% (11.0 year) to 2.78% (16.0 year). Thus taken all 10 age classes together, changes in the prevalence of obesity are observed to be statistically insignificant. But between the time periods of study 2 and study 3 the prevalence has increased from ages 7.0 to 15.0 years in the order of 1.64% (7.0 year) to 4.05% (8.0 year). However, at 16.0 year a decline of 1.33% is also notable. Thus, at least in 4 age classes (12.0 to 15.0 years) out of 10, the increase in the prevalence is found to be statistically significant. Between study 1 and study 3 the increases in the prevalence (from 7.0 to 16.0 year) between the comparing studies are found to be lower in order ranging from only 0.70% (17.0 year) to 6.40% (8.0 year). In 10 of 12 age classes these increases in the prevalence of obesity are found to be statistically significant (table 3.3k.1e). It is important to mention here that in study 1 (Sarsuna-Barisha study of 1952-1966) the data required to calculate the prevalence of obesity following the WHO, 1995 criteria have not been collected. Therefore, the results related to changes in the prevalence of obesity between the time differences of study 1 and study 2 cannot be prepared for this report. On the contrary, it has been possible to see changes in the prevalence of obesity in boys aged 9.0 to 16.0 years between the time differences of study 2 and study 3 and accordingly the results show that the highest increase in the prevalence has occurred in the order of 14.45% (9.0 year) to the lowest of 0.74% (13.0 year). At the same time a decrease in the prevalence in the order of 0.37% is also observed at 14.0 year between the time span of studies 2 and 3. In 4 (9.0, 11.0, 12.0, and 16.0 years) of the 8 age classes the increases in the prevalence of obesity are found to be statistically significant (table 3.3k.1f).

Table-3.3k.1e: Changes in age-specific prevalence of obesity in boys over three study periods by IOTF classification (Cole et al., 2000)

Age (years)	Study 1 (1952-1966)			Study 2 (1982-1983)			Study 3 (1999-2011)			z-statistic			p-value		
	n	f	%	n	f	%	n	f	%	1 vs 2	2 vs 3	1 vs 3	1 vs 2	2 vs 3	1 vs 3
7.0	106	0	-	62	1	1.61	123	4	3.25	1.0	0.7	2.0	0.157	0.234	0.021
8.0	129	0	-	85	2	2.35	125	8	6.40	1.4	1.5	2.9	0.076	0.070	0.002
9.0	141	0	-	96	2	2.08	130	6	4.62	1.4	1.1	2.5	0.076	0.140	0.006
10.0	139	0	-	74	1	1.35	117	5	4.27	1.0	1.3	2.3	0.157	0.102	0.011
11.0	144	0	-	96	1	1.04	124	5	4.03	1.0	1.5	2.3	0.157	0.072	0.011
12.0	144	0	-	94	0	-	149	6	4.03	-	2.5	2.5	-	0.006	0.006
13.0	141	0	-	98	0	-	159	3	1.89	-	1.8	1.8	-	0.040	0.040
14.0	126	0	-	93	0	-	137	3	2.19	-	1.8	1.8	-	0.040	0.040
15.0	130	0	-	74	0	-	127	4	3.15	-	2.0	2.0	-	0.021	0.021
16.0	116	0	-	36	1	2.78	138	2	1.45	1.0	-0.5	1.4	0.155	0.325	0.077
17.0	110	0	-				143	1	0.70			1.0			0.158
18.0	95	0	-				128	4	3.13			2.0			0.021

f-frequency

Table-3.3k.1f: Changes in age-specific prevalence of obesity in boys over two study periods (WHO, 1995)

Age (years)	Study 2 (1982-1983)			Study 3 (1999-2011)			z-statistic	p-value
	n	frequency	%	n	frequency	%		
9.0	90	2	2.22	126	21	16.67	3.9	*
10.0	70	4	5.71	117	13	11.11	1.3	0.090
11.0	90	1	1.11	121	6	4.96	1.7	0.044
12.0	88	0	-	120	3	2.50	1.8	0.040
13.0	91	0	-	136	1	0.74	1.0	0.158
14.0	89	1	1.12	134	1	0.75	-0.3	0.389
15.0	71	1	1.41	124	6	4.84	1.4	0.075
16.0	34	0	-	136	4	2.94	2.0	0.021

*** p value <0.001**

3.3k.2 In girls (between studies 1 and 2)

Stunting

Table 3.3k.2a shows that in girls, the declines in the prevalence of stunting (WHO, 1995) are noticed at all ages from the highest order of 61.99% (10.0 year) to the lowest of 22.41% (18.0 year). The declines are found to be statistically significant in all 13 age classes.

Table-3.3k.2a: Changes in age-specific prevalence of stunting in girls over two study periods (WHO, 2007)

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			z-statistic	p-value
	n	frequency	%	n	frequency	%		
7.0	112	56	50.00	154	12	7.79	-8.1	*
8.0	106	55	51.89	155	10	6.45	-8.7	*
9.0	119	62	52.10	150	10	6.67	-9.1	*
10.0	119	76	63.87	160	3	1.88	-13.7	*
11.0	102	67	65.69	143	10	6.99	-11.4	*
12.0	113	66	58.41	143	16	11.19	-8.9	*
13.0	111	57	51.35	140	6	4.29	-9.3	*
14.0	105	48	45.71	140	15	10.71	-6.3	*
15.0	90	40	44.44	147	25	17.01	-4.5	*
16.0	90	45	50.00	135	32	23.70	-4.1	*
17.0	88	41	46.59	138	28	20.29	-4.2	*
18.0	60	25	41.67	135	26	19.26	-3.1	0.001
19.0	50	26	52.00	146	37	25.34	-3.4	*

*** p value <0.001**

Thinness

Table 3.3k.2b shows that the declines in the prevalence of thinness (WHO, 2007) in girls are observed at all ages ranging from 12.09% (18.0 year) to 53.94% (11.0 year) and these declines are found to be statistically significant in all 13 age classes.

Table-3.3k.2b: Changes in age-specific prevalence of thinness in girls over two study periods (WHO, 2007)

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			z-statistic	p-value
	n	frequency	%	n	frequency	%		
7.0	112	45	40.18	153	24	15.69	-4.5	*
8.0	106	50	47.17	155	21	13.55	-6.0	*
9.0	118	59	50.00	149	27	18.12	-5.7	*
10.0	117	58	49.57	160	18	11.25	-7.3	*
11.0	102	65	63.73	143	14	9.79	-10.0	*
12.0	112	71	63.39	143	20	13.99	-9.2	*
13.0	109	65	59.63	140	18	12.86	-8.5	*
14.0	101	53	52.48	140	15	10.71	-7.4	*
15.0	89	43	48.31	147	18	12.24	-6.1	*
16.0	90	37	41.11	135	12	8.89	-5.6	*
17.0	85	25	29.41	138	12	8.70	-3.8	*
18.0	59	15	25.42	135	18	13.33	-1.9	0.029
19.0	50	19	38.00	146	16	10.96	-3.7	*

*** p value <0.001**

Overweight

Tables 3.3k.2c shows that age specific prevalence of overweight in girls between the two comparing study periods, calculated by the criteria of International Obesity Task Force (Cole et al., 2000), has increased ranging from 16.08% (12.0 year) to 26.67% (18.0 year). But when the age specific prevalence is calculated by the criteria of World Health Organisation (WHO, 1995), the magnitude of increase ranges from 12.86% (13.0 year) to 25.19% (18.0 year) (table 3.3k.2d). It is important to note that following both classifications (IOTF and WHO), increases in the prevalence are observed to be statistically significant in all 12 and 10 age classes respectively.

Table-3.3k.2c: Changes in age-specific prevalence of overweight in girls over two study periods by IOTF classification (Cole et al., 2000)

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			z-statistic	p-value
	n	frequency	%	n	frequency	%		
7.0	112	0	-	153	31	20.26	6.2	*
8.0	106	0	-	155	41	26.45	7.5	*
9.0	118	0	-	149	32	21.48	6.4	*
10.0	117	0	-	160	41	25.63	7.4	*
11.0	102	0	-	143	32	22.38	6.4	*
12.0	112	0	-	143	23	16.08	5.2	*
13.0	109	0	-	140	23	16.43	5.3	*
14.0	101	0	-	140	27	19.29	5.8	*
15.0	89	0	-	147	30	20.41	6.1	*
16.0	90	0	-	135	31	22.96	6.3	*
17.0	85	0	-	138	32	23.19	6.5	*
18.0	59	0	-	135	36	26.67	7.0	*

*** p value <0.001**

Table-3.3k.2d: Changes in age-specific prevalence of overweight in girls over two study periods (WHO, 1995)

Age (years)	Study 1 (1952-1966)			Study 2 (2005-2011)			z-statistic	p-value
	n	frequency	%	n	frequency	%		
9.0	118	0	-	149	31	20.81	6.3	*
10.0	117	0	-	160	35	21.88	6.7	*
11.0	102	0	-	143	27	18.88	5.8	*
12.0	112	0	-	143	20	13.99	4.8	*
13.0	109	0	-	140	18	12.86	4.5	*
14.0	101	0	-	140	23	16.43	5.3	*
15.0	89	0	-	147	28	19.05	5.9	*
16.0	90	0	-	135	29	21.48	6.1	*
17.0	85	0	-	138	27	19.57	5.8	*
18.0	59	0	-	135	34	25.19	6.7	*

*** p value <0.001**

Obesity

The fourth studied indicator of nutritional status, i.e. the prevalence of obesity, has been calculated by the criteria of International Obesity Task Force (Cole et al., 2000). The results presented in table 3.3k.2e shows that increases in the prevalence are statistically significant in 9 of 12 age classes where the highest increase of only 6.54% is noticed at 7.0 year and the lowest of 0.70% is noticed at 12.0 year.

Table-3.3k.2e: Changes in age-specific prevalence of obesity in girls over two study periods by IOTF classification (Cole et al., 2000)

Age (years)	Study1 (1952-1966)			Study 2 (2005-2011)			z-statistic	p-value
	n	frequency	%	n	frequency	%		
7.0	112	0	-	153	10	6.54	3.3	0.001
8.0	106	0	-	155	8	5.16	2.9	0.002
9.0	118	0	-	149	4	2.68	2.0	0.021
10.0	117	0	-	160	8	5.00	2.9	0.002
11.0	102	0	-	143	5	3.50	2.3	0.011
12.0	112	0	-	143	1	0.70	1.0	0.158
13.0	109	0	-	140	3	2.14	1.8	0.040
14.0	101	0	-	140	2	1.43	1.4	0.077
15.0	89	0	-	147	7	4.76	2.7	0.003
16.0	90	0	-	135	3	2.22	1.8	0.040
17.0	85	0	-	138	2	1.45	1.4	0.077
18.0	59	0	-	135	6	4.44	2.5	0.006

Thus summarising the results presented in section 3.3k, it can be stated that in both sexes, the prevalence of stunting and thinness have significantly declined in most of the age classes due to change of time with varied magnitude. The magnitude of decline in boys in particular, depends on the time difference between the comparing studies i.e. larger the time difference greater is the decline. Simultaneously, the prevalence of overweight is found to have increased in both sexes due to change of time, where the increase of prevalence in boys, in particular, again depends on the duration of the comparing study periods. But increase in the prevalence of obesity is not very alarming in both sexes between the comparing study periods.

3.3l Changes in the averages (mean/median) of three biological parameters of the adolescent growth spurt for standing height, sitting height, subischial leg length, biacromial diameter, bi-iliocristal diameter, total arm length and body weight over time (Tables 3.3l.1a to 3.3l.2g)

Three biological parameters of the adolescent growth spurt, namely mean/median age at maximum increment, mean/median peak velocity and mean/median final size of seven anthropometric traits have been calculated from the data of five study periods for both sexes (three for boys and two for girls). These three parameters have been estimated by fitting the Preece-Baines growth model 1 (Preece and Baines, 1978) to the cross-sectional mean/median of seven traits, like standing height, sitting height, subischial leg length, biacromial and biiliocristal diameters, total arm length and body weight. The means of five mathematical parameters of Preece-Baines growth model l and three biological parameters of adolescent growth spurt of these seven traits estimated from the model are given in tables 3.3l.1a to

3.3k.2g. It is important to note that in girls for two variables namely, sitting height and bi-iliocristal diameter, the mean age at maximum increment, mean peak velocity and mean final/mature size can not be estimated due to some methodological reasons which may be described as follows: The Preece-Baines growth curve has a convex region in between the ages at take off and peak velocity. For some cross-sectional means of girls of study 2 (present study of 2005-2011) this feature is missing from the observed plot and for this data set a reasonable Preece-Baines fit is not available. The convex region may have been obliterated by the process of averaging of individual growth curves that cannot be avoided for cross-sectional means. Therefore due to this, the trend as clearly observed for boys is not observed for girls for some traits. Hence the means of three biological parameters of these two traits are replaced by the median values (see tables 3.3l.2b and 3.3l.2e). It may further be noted that due to the same reason neither mean nor median ages of maximum increment as well as mean/median peak velocity of standing height and total arm length can be estimated from the data availabe from girls. Nevertheless, the obtained results on other parameters of the studied anthropometric traits show the following trends.

3.3l.1 In boys (between studies 1 and 2, 2 and 3, 1and 3)

Mean age at maximum increment

For standing height the mean age at maximum increment has although declined between the two pairs of the comparing studies but more decline is observed in the first pair (by 1.33 year) than in the second one (0.13 year). Again, between the times span of studies 1 and 3 mean age is observed to have declined by 1.46 year. Similarly, for sitting height the first two declines are by 1.26 year and 0.26 year respectively while between studies 1 and 3 the decline is found to be highest in the order of 1.52 year. For subischial leg length the declining values are in the order of 1.39 year, 0.02 year and 1.41 year respectively. For biacromial diameter the first decline is by l.69 year while the second, by 0.45 year but between studies 1 and 3 the decline is by 2.14 year. But exceptionally, for bi-iliocristal diameter, the decline in the first pair is little lower (by 0.50 year) than in the second one (by 0.99 year) while between studies 1 and 3 the decline is by 1.49 year. But again for total arm length the first decline is more (1.17 year) than the second one (0.09 year) while the last declining value is by 1.26 year. Finally, for body weight while the first decline is by 1.25 year, in the second pair of comparison it has unusually increased by 0.21 year and again between the time difference of studies 1 and 3 it has further declined by 1.04 year (tables 3.3l.1a, 3.3l.1b, 3.3l.1c, 3.3l.1d, 3.3l.1e, 3.3l.1f and 3.3l.1g).

Table-3.3l.1a: Changes in average biological parameters (mean) of the adolescent growth spurt of standing height in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.096(0.004)	0.098(0.015)	0.119(0.011)
S1	0.961(0.055)	0.984(0.187)	1.008(0.120)
Theta	14.970(0.084)	13.629(0.210)	13.653(0.195)
H max	166.468(0.259)	167.632(1.706)	169.332(0.359)
H theta	153.712(0.410)	154.945(1.110)	158.374(0.946)
Biological parameters			
Mean age at maximum increment (yr.)	14.365(0.185)	13.039(0.576)	12.906(0.45)
Mean peak velocity (cm./yr.)	7.095(0.675)	7.229(1.988)	6.656(1.453)
Mean final standing height (cm.)	166.467(0.259)	167.632(1.706)	169.332(0.359)

Table-3.3l.1b: Changes in average biological parameters (mean) of the adolescent growth spurt of sitting height in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.072(0.005)	0.074(0.020)	0.079(0.018)
S1	0.883(0.059)	0.939(0.253)	0.818(0.137)
Theta	15.336(0.102)	14.036(0.308)	13.994(0.352)
H max	87.130(0.182)	87.632(1.631)	88.349(0.316)
H theta	79.980(0.257)	80.759(0.820)	81.767(0.868)
Biological parameters			
Mean age at maximum increment (yr.)	14.840(0.207)	13.581(0.739)	13.321(0.698)
Mean peak velocity (cm./yr.)	3.528(0.413)	3.557(1.541)	3.092(1.195)
Mean final sitting height (cm.)	87.130(0.182)	87.632(1.631)	88.349(0.316)

Table-3.3l.1c: Changes in average biological parameters (mean) of the adolescent growth spurt of subischial leg length in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.120(0.005)	0.119(0.013)	0.154(0.011)
S1	1.113(0.078)	1.054(0.150)	1.243(0.153)
Theta	14.527(0.091)	13.211(0.159)	13.189(0.157)
H max	79.437(0.133)	80.350(0.504)	81.226(0.158)
H theta	73.599(0.223)	74.166(0.448)	76.265(0.391)
Biological parameters			
Mean age at maximum increment (yr.)	13.939(0.201)	12.548(0.452)	12.530(0.371)
Mean peak velocity (cm./yr.)	3.827(0.399)	3.882(0.769)	3.772(0.681)
Mean final leg length (cm.)	79.437(0.133)	80.350(0.504)	81.226(0.158)

Mean peak velocity

The second parameter of the adolescent growth spurt i.e. mean peak velocity has not manifested any consistent trend between first two pairs of the comparing studies. Between the time difference of study 1 and study 2, six of the seven investigated traits have manifested increased values. For standing height the increase is 0.13 cm./yr., for sitting height it is 0.03 cm./yr., for subischial leg length it is 0.06 cm./yr., for bi-iliocristal diameter it is 0.01 cm./yr., for total arm length it is 0.13 cm./yr. and for body weight it is 0.47 kg./yr. Only for biacromial diameter, the value of mean peak velocity of the first two study periods are observed to be similar (1.57 cm./yr.). On the contrary, between studies 2 and 3, mean peak velocity in six of the seven studied traits has declined. For standing height it has declined by 0.57 cm./yr, for sitting height by 0.47 cm./yr., for subischial leg length by 0.11 cm./yr., for biacromial diameter by 0.16 cm./yr., for bi-iliocristal diameter by 0.08 cm./yr. and for body weight by 0.56 kg./yr. Exceptionally, for total arm length it has increased by 0.18 cm./yr. Finally, between the time difference of studies 1 and 3 mean peak velocity in six of the seven investigated anthropometric traits have also declined in the following order: for standing height by 0.44 cm./yr., for sitting height by 0.44 cm./yr., for subischial leg length by 0.06

cm./yr. , for biacromial diameter by 0.16 cm./yr., for bi-iliocristal diameter by 0.07 cm./yr. and finally, for body weight by 0.09 kg./yr. Exceptionally for total arm length it has increased between the two study periods by 0.31cm./yr. (tables 3.3l.1a, 3.3l.1b, 3.3l.1c, 3.3l.1d, 3.3l.1e, 3.3l.1f and 3.3l.1g).

Table-3.3l.1d: Changes in average biological parameters (mean) of the adolescent growth spurt of biacromial diameter in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.072(0.003)	0.072(0.019)	0.065(0.048)
S1	0.822(0.039)	0.789(0.181)	0.584(0.218)
Theta	15.545(0.077)	13.917(0.268)	13.994(1.350)
H max	36.400(0.066)	36.748(0.0690)	37.861(0.447)
H theta	33.006(0.088)	33.243(0.335)	33.777(1.652)
Biological parameters			
Mean age at maximum increment (yr.)	14.957(0.168)	13.268(0.851)	12.822(2.924)
Mean peak velocity (cm./yr.)	1.576(0.137)	1.575(0.575)	1.414(2.014)
Mean final biacromial diameter (cm.)	36.400(0.066)	36.748(0.690)	37.861(0.447)

Table-3.3l.1e: Changes in average biological parameters (mean) of the adolescent growth spurt of bi-iliocristal diameter in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.072(0.003)	0.063(0.039)	0.089(0.028)
S1	0.829(0.029)	0.705(0.397)	0.783(0.197)
Theta	15.023(0.061)	14.651(0.885)	13.852(0.591)
H max	25.268(0.029)	26.408(1.855)	25.617(0.149)
H theta	22.998(0.049)	23.734(0.799)	23.493(0.471)
Biological parameters			
Mean age at maximum increment (yr.)	14.446(0.127)	13.945(1.299)	12.956(1.299)
Mean peak velocity (cm./yr.)	1.062(0.073)	1.070(0.639)	0.991(0.639)
Mean final bi-iliocristal diameter (cm)	25.268(0.029)	26.408(0.149)	25.617(0.149)

Mean final/mature size

The mean final/mature size of seven traits, as expected, has manifested in general, a trend of increase between three pairs of comparing study periods with few exceptions. The magnitude of the increase varies according to the time interval of the comparing studies. For example, between studies 1 and 2 the increase in mean standing height is 1.16 cm. which is lesser than the increase noticed between studies 2 and 3 (1.70 cm.). But between the study periods 1 and 3 the increase is the highest in the order of 2.86 cm. The same trend is restored for other four traits, like mean body weight, mean sitting height, mean subischial leg length and mean biacromial diameter. The respective increasing orders for mean body weight are 1.33 kg., 11.87 kg. and 13.20 kg. For mean sitting height the respective orders are 0.50 cm., 0.72 cm. and 1.22 cm. For mean subischial leg length, they are 0.91cm, 0.88cm and 1.79 cm and for mean biacromial diameter the in creasing orders are 0.35 cm., 1.11cm. and 1.46 cm. But for bi-iliocristal diameter and total arm length, inconsistent trends are noticed. For example, between studies 1 and 2, the mean final size of bi-iliocristal diameter has increased by 1.14 cm. while in the second pair of comparison (between studies 2 and 3), the mean has unexpectedly declined by 0.79 cm. Again between studies 1 and 3 it has increased by 0.35 cm. Further, for total arm length, the means have declined by 2.53 cm. and 1.68 cm. respectively between two pairs of the comparing studies (studies 1 to 2 and 1 to 3). But between studies 2 and 3 the mean has increased by 0.85 cm. (tables 3.3l.1a, 3.3l.1b, 3.3l.1c, 3.3l.1d, 3.3l.1e, 3.3l.1f and 3.3l.1g).

Table-3.3l.1f: Changes in average biological parameters (mean) of the adolescent growth spurt of total arm length in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.099(0.005)	0.105(0.010)	0.134(0.013)
S1	0.963(0.063)	1.117(0.139)	1.358(0.230)
Theta	14.83(0.099)	13.508(0.129)	13.358(0.185)
H max	75.058(0.138)	72.531(0.434)	73.382(0.206)
H theta	69.025(0.231)	67.041(0.315)	68.675(0.431)
Biological parameters			
Mean age at maximum increment (yr.)	14.203(0.219)	13.035(0.302)	12.941(0.343)
Mean peak velocity (cm./yr.)	3.382(0.377)	3.507(0.602)	3.687(0.823)
Mean final total arm length (cm.)	75.058(0.138)	72.531(0.434)	73.382(0.206)

Table-3.3l.1g: Changes in average biological parameters (mean) of the adolescent growth spurt of body weight in boys estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over three study periods

Model parameters	Study 1 (1952-66)	Study 2 (1982-83)	Study 3 (1999-2011)
	Mean (se)	Mean (se)	Mean (se)
S0	0.053(0.004)	0.082(0.011)	0.085(0.014)
S1	0.849(0.042)	1.100(0.174)	0.772(0.119)
Theta	15.174(0.080)	13.915(0.163)	14.654(0.317)
H max	47.461(0.181)	48.790(1.011)	60.658(0.515)
H theta	37.454(0.275)	40.449(0.577)	50.816(1.115)
Biological parameters			
Mean age at maximum increment (yr.)	14.814(0.144)	13.564(0.331)	13.778(0.752)
Mean peak velocity (kg./yr.)	4.589(0.427)	5.060(1.180)	4.502(1.551)
Mean final body weight (kg.)	47.461(0.181)	48.790(1.011)	60.658(0.515)

3.3l.2 In girls (between studies 1 and 2)

Mean /Median age at maximum increment

As stated before, secular change in this parameter for two traits, namely, mean standing height and mean total arm length cannot be examined since mean/medain ages at maximum increment cannot be determined from the data of study 2 (2005-2011 data). Nevertheless, for two major segments of standing height, namely, sitting height and subischial leg length the median and mean ages respectively have been calculated. Accordingly, the trend shows that the median age at maximum increment for sitting height between the time differences of two studies has declined by 2.53 year, mean age for subischial leg length by 0.25 year, mean age for biacromial diameter by 0.97 year, median age for bi-iliocristal diameter by 0.12 year and mean age for body weight by 2.21 year (tables 3.3l.2a, 3.3l.2b, 3.3l.2c, 3.3l.2d, 3.3l.2e, 3.3l.2f and 3.3l.2g).

Table-3.3l.2a: Changes in average biological parameters (mean) of the adolescent growth spurt of standing height in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	**Study 1 (1952-66)**	**Study 2 (2005-2011)**
	Mean (se)	**Mean (se)**
S0	0.129(0.010)	0.157(0.036)
S1	0.965(0.079)	0.852(0.133)
Theta	12.943(0.165)	11.579(0.581)
H max	151.075(0.185)	154.795(0.222)
H theta	141.465(0.732)	145.427(2.566)
Biological parameters		
Mean age at maximum increment (yr.)	11.966(0.415)	**NA**
Mean peak velocity (cm./yr.)	5.824(1.067)	**NA**
Mean final standing height (cm.)	151.075(0.185)	154.795(0.222)

NA- Not Available

Table-3.3l.2b: Changes in average biological parameters (median) of the adolescent growth spurt of sitting height in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	**Study 1 (1952-66)**	**Study 2 (2005-2011)**
	Median (se)	**Median (se)**
S0	0.101(0.018)	-0.057(0.107)
S1	0.929(0.138)	0.557(0.104)
Theta	13.129(0.301)	9.328(1.244)
H max	79.380(0.185)	81.721(0.220)
H theta	74.178(0.675)	68.694(4.043)
Biological parameters		
Median age at maximum increment (yr.)	12.422(0.602)	9.893(1.498)
Median peak velocity (cm./yr.)	2.847(0.952)	3.375(4.442)
Median final sitting height (cm.)	79.380(0.185)	81.721(0.220)

Table-3.3l.2c: Changes in average biological parameters (mean) of the adolescent growth spurt of subischial leg length in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	**Study 1 (1952-66)**	**Study 2 (2005-2011)**
	Mean (se)	**Mean (se)**
S0	0.151(0.012)	0.287(0.017)
S1	1.044(0.096)	1.796(0.379)
Theta	12.597(0.172)	12.093(0.185)
H max	71.729(0.096)	73.152(0.106)
H theta	67.022(0.407)	70.998(0.257)
Biological parameters		
Mean age at maximum increment (yr.)	11.542(0.492)	11.296(0.798)
Mean peak velocity (cm./yr.)	3.185(0.619)	2.648(0.604)
Mean final leg length (cm.)	71.729(0.096)	73.152(0.106)

Mean/ Median peak velocity

Due to the similar methodological problem as stated before, the mean/ median peak velocity in of two traits, namely standing height and total arm length in girls cannot be determined from the data of study 2. However, from the remaining five studied traits, in two, like sitting height and subischial leg length, the median and mean peak velocity have decreased by 0.53 cm./yr. and 0.54 cm./yr. respectively. On the contrary, for two other traits like bi-iliocristal diameter and body weight the median and mean peak velocity have increased by.0.06 cm./yr. and 0.12 kg./yr. respectively. In one trait like biacromial diameter, mean peak velocity remains unchanged due to the occurrence of equal values in both studies (tables 3.3l.2a, 3.3l.2b, 3.3l.2c, 3.3l.2d, 3.3l.2e, 3.3l.2f and 3.3l.2g).

Table-3.3l.2d: Changes in average biological parameters (mean) of the adolescent growth spurt of biacromial diameter in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	**Study 1 (1952-66)**	**Study 2 (2005-2011)**
	Mean (se)	**Mean (se)**
S0	0.109(0.017)	0.191(0.131)
S1	0.849(0.120)	1.138(0.012)
Theta	13.439(0.322)	12.949(0.177)
H max	32.547(0.083)	34.036(0.041)
H theta	30.282(0.301)	32.614(0.134)
Biological parameters		
Mean age at maximum increment (yr.)	12.410(0.786)	11.441(5.233)
Mean peak velocity (cm./yr.)	1.145(0.420)	1.145(0.426)
Mean final biacromial diameter (cm.)	32.547(0.083)	34.036(0.041)

Table-3.3l.2e: Changes in average biological parameters (median) of the adolescent growth spurt of bi-iliocristal diameter in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	**Study 1 (1952-66)**	**Study 2 (2005-2011)**
	Median (se)	**Median (se)**
S0	0.051(0.034)	0.180(0.017)
S1	0.629(0.136)	1.395(0.286)
Theta	13.192(0.794)	13.021(0.227)
H max	25.234(0.157)	24.644(0.066)
H theta	22.162(0.758)	23.377(0.153)
Biological parameters		
Median age at maximum increment (yr.)	12.506(1.333)	12.391(0.558)
Median peak velocity (cm./yr.)	1.079(0.912)	1.096(0.297)
Median final bi-iliocristal diameter (cm.)	25.234(0.157)	24.644(0.066)

Mean/Median mature/final size

Between the two comparing study periods mean mature size of standing height in girls has increased by 3.72 cm., median mature size of sitting height by 2.34 cm., mean mature size of subischial leg length by 1.42 cm., mean mature size of biacromial diameter by 1.49 cm. and mean mature size of body weight by 11.10 kg. Unusually, the median mature/final size of bi-iliocristal diameter and mean mature/final size of total arm length between the two study periods have declined by 0.59 cm. and 1.87 cm. respectively (tables 3.3l.2a, 3.3l.2b, 3.3l.2c, 3.3l.2d, 3.3l.2e, 3.3l.2f and 3.3l.2g).

Table-3.3l.2f: Changes in average biological parameters (mean) of the adolescent growth spurt of total arm length in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	Study 1 (1952-66)	Study 2 (2005-2011)
	Mean (se)	Mean (se)
S0	0.118(0.012)	0.192(0.174)
S1	0.906(0.080)	1.031(0.030)
Theta	12.767(0.204)	11.792(0.408)
H max	68.057(0.099)	66.191(0.100)
H theta	62.932(0.465)	62.862(0.751)
Biological parameters		
Mean age at maximum increment (yr.)	11.781(0.475)	**NA**
Mean peak velocity (cm./yr.)	2.887(0.650)	**NA**
Mean final total arm length (cm).	68.057(0.099)	66.191(0.100)

NA- Not Available

Table-3.3l.2g: Changes in average biological parameters (mean) of the adolescent growth spurt of body weight in girls estimated by Preece-Baines growth model-1 (Preece and Baines, 1978) over two study periods

Model parameters	Study 1 (1952-66)	Study 2 (2005-2011)
	Mean (se)	Mean (se)
S0	0.063(0.014)	0.097(0.039)
S1	0.801(0.093)	0.628(0.143)
Theta	13.566(0.270)	12.886(1.021)
H max	41.27(0.252)	52.373(0.442)
H theta	32.892(0.830)	43.213(3.187)
Biological parameters		
Mean age at maximum increment (yr.)	13.053(0.460)	10.845(3.341)
Mean peak velocity (kg./yr.)	3.727(1.106)	3.848(4.180)
Mean final body weight (kg.)	41.270(0.252)	52.373(0.442)

Thus summing up the results presented in section 3.3l, it can be concluded that out of the three investigated parameters of adolescent growth spurt, two, namely, mean age at maximum increment and mean final/mature size have presented a more or less consistent pattern of change over time in both sexes. While the former has declined, the latter on the other hand, has increased. The third parameter, i.e. mean peak velocity however has not manifested any notable pattern of change over time. Apart from these three studied parameters of adolescent growth spurt, several other biological parameters of adolescent growth spurt have also been recently estimated for Chinese children by fitting Preece-Baines model 1 to age specific cross-sectional means (Mao et al., 2011). Secular investigation in these additional parameters may be explored in future on contemporary Bengali children from a substantially larger data base.

3.4 Average age at menarche of the contemporary Bengali girls of Kolkata city, estimated from both status quo and recall data: age distribution, presentation of mean and median ages in the light of secular trends phenomena

In the current study of 2005-2011 a sample of 2,195 households of girl students has been surveyed for collection of data on onset of menarche and age at onset by the recollection method. In addition anthropometric, socioeconomic and dietary data have also been collected from these subjects and the results have already been presented in the earlier sections of this report. Out of 2,195 girls, only 444 have recollected their exact dates of occurrence of menarche and therefore for them a separate analysis has been performed. From the total sample of 2,195 the age distribution of the menstruating and non menstruating girls (both in frequencies and in percentages) has been plotted and shown in the table 3.4.i. The table shows that in this sample 100% girls have menstruated between 8.0 to 16.0 years of age. This is based on the analysis of status quo data where the girls have been asked whether they have started menstruation or not in the form of “yes” or “no” along with the information on their exact date of birth. From this distribution (table 3.4.i) the median age of menarche of girls has been calculated by Probit analysis (Finney, 1952). A Probit of the data has yielded the following equation.

$$\text{Probit (Prevalence of Menarche)} = -9.615 + 0.831 * \text{Age}$$
$$(0.481) \quad (0.041)$$

Both the coefficients are turned out to be highly significant (p-value smaller than 0.001). The chi square (χ^2) goodness of fit test for the probit model has not indicated any misfit (p value of 0. 929). The figures in the parenthesis refer to the standard error of the coefficients.

Table- 3.4.i: Age distribution of menarcheal status of Bengali girls from 2005-2011 study (Status-quo data)

Age during examination (Years)	n	Not menstruating		Menstruating	
		frequency	%	frequency	%
7.0	155	155	100	0	-
8.0	156	155	99.36	1	0.64
9.0	151	149	98.68	2	1.32
10.0	161	146	90.68	15	9.32
11.0	143	103	72.03	40	27.97
12.0	145	49	33.79	96	66.21
13.0	140	13	9.29	127	90.71
14.0	141	4	2.84	137	97.16
15.0	148	1	0.68	147	99.32
16.0	135	0	-	135	100
17.0	139	0	-	139	100
18.0	136	0	-	136	100
19.0	146	0	-	146	100
20.0	158	0	-	158	100
21.0	141	0	-	141	100
Total	2195	775	-	1420	-

The figure 3.4.i (see page 161) shows the observed and the fitted values on the occurrence of menarche for different ages.

By fiiting Probit, the estimated median age at onset of menarche is found to be 11.57 year. The 95% confidence limits for this age are 11.44 year (lower limit) and 11.71 year (upper limit) respectively. An inverse Probit on the occurrence of menarche has also been fitted and shown in figure 3.4.ii (see page 161).

The age range of girls of the present study is 7.0 to 21.0 years which is much wider than the established range of menarcheal age as recommended, viz. 9.0 to 17.0 years (Weiner and Lourie, 1981). There are no observed cases of menarche in the age groups 7.0 and 8.0 years, while all the respondents older than 17.0 year reported having had menarche. However, while fitting the Probit model, the entire data set aged 7.0 to 21.0 years has been used (including the age groups outside the range 9.0 to 17.0 years), in order to make maximal use of the information gathered from the present study. As a cross-check, a separate Probit model has been fitted for the subset of respondents in the age range 9.0 to 17.0 years. The resulting estimates are not statistically significantly different from those obtained from the main analysis. In particular, the median age at menarche turned out to be 11.59 year (compared to 11.57 year from the complete data set).

The retrospective data on age at menarche are available from 444 girls. Accordingly, age distribution with frequencies and percentages of the menstruating girls derived from this data set are shown in table 3.4.ii. Figure 3.4.iii (see page 162) shows the histogram plot of this distribution.

Table-3.4.ii: Age distribution of menarcheal Bengali girls from 2005-2011 study (Retrospective data), n=444

Age range (Years)	**frequency**	**% of menstruating girls**
8.1-8.5	3	0.68
8.6-9.0	3	0.68
9.1-9.5	9	2.03
9.6-10.0	20	4.50
10.1-10.5	27	6.08
10.6-11.0	52	11.71
11.1-11.5	66	14.86
11.6-12.0	90	20.27
12.1-12.5	56	12.61
12.6-13.0	61	13.74
13.1-13.5	27	6.08
13.6-14.0	17	3.83
14.1-14.5	8	1.80
14.6-15.0	5	1.13
Total	444	100

Mean age at menarche, calculated from the retrospective data is found to be in the order of 11.80 year ± 0.06 with the sd of 1.19 year. However, the median age at menarche calculated from this particular data set, is found to be little higher (11.75 year) than the median age calculated by the Probit method from the status quo data (11.57 year).

Mean ages at menarche of urban Bengali girls are also known from earlier studies based on retrospective data and have been presented for different time periods (table 3.4.iii). The comparison shows lowering of the mean age at menarche of girls of the current study (study 2) and thereby it indicates an evidence of positive secular trends phenomenon to imply faster rate of sexual maturation of contemporary Bengali girls of Kolkata city.

Table-3.4.iii: Secular trends in mean age at menarche of Bengali girls of Kolkata (based on retrospective data)

Sl.no.	Author	Year	n	Mean age in years
1	Gupta	1848	37	12.38
2	Sen	1953	647	12.78
3	Bardhan	1962	-	12.48
4	Mukherji and Sengupta	1962	-	13.10
5	***Sen**	1966-67	1837	12.48
6	Sarkar and Roy	1968	169	12.90
7	Datta et al.	2012	68	12.10
8	Dasgupta et. al. (present study)	2005-11	444	11.80

***Published in Sen, 1988, - sample size not known**

Finally, a comparison between three different methods for calculating median age at onset of menarche has been made on the data collected in the current study (study 2). The recall data on menarche (in case the event has already occurred) consists of the exact days of occurrence, or range of dates. Turnbull Non Parametric Estimate (Turnbull, 1976) has been used for these data. On the other hand the Kaplan Meier Non Parametric Estimation (Kaplan and Meier, 1958) has been used after excluding the cases when only a range of dates has been recalled (i.e. retaining only those cases where menarche has not occurred or the exact date of menarche has not been recalled). With these two estimates, i.e. Turnbull and Kaplan Meier, together with the Probit estimate, the occurrence of menarche is shown in figure 3.4.iv (see page 162). It may be noted that the median age at onset of menarche of the three curves happened to be at 11.57 year (Probit), 12.10 year (Turnbull) and 12.03 year (Kaplan and Meier) respectively. The graphs also show that the two estimates, namely, Turnbull and Kaplan-Meier estimates, calculated from the recalled data point towards later onset of menarche in comparison to the Probit estimate calculated from the status quo data alone.

3.5 Effects of socioeconomic factors

Out of all the socioeconomic factors on which data have been collected, effects of six, namely fathers' education, mothers' education, fathers' occupation, per capita monthly expenditure (INR), birth order of the subject (parity) and size of sibship have been investigated on four individual measurements (standing height, body weight, sitting height and leg length), two measures of body shape (sitting height/leg length ratio and body mass index), four measures of body composition (triceps skinfold, subscapular skinfold, percentage of body fat mass and body fat distribution) through analysis of variance (ANOVA) and multiple analysis of variance (MANOVA). In addition, effects of these socioeconomic factors on two measures of nutritional status (prevalence of stunting and thinness) and age at menarche have been investigated by multiple logistic regression and Cox's proportional hazards regression model (Cox, 1972) respectively.

3.5a Individual measurements

For both boys and girls, the effects of fathers' education, mothers' education and per capita expenditure of the family on each of the four measures, namely, standing height, body weight, sitting height and leg length and on their pooled values are found to be significant (tables 3.5a.i to 3.5a.iv). Age specific level of significance of all four traits has been further tested by ANOVA and their F-values are given in tables 3.5a.va to 3.5a.viiib. Although, age wise variation in the level of significance exists, overall effects of these socioeconomic factors on four measures are found to be statistically significant. A small degree of variation between the sexes in the level of significance is also noticed. On the other hand, fathers' occupation is found to have no effect on these individual measurements in both sexes. While birth order of the subject (parity) and size of sibship have shown no effect on four measures for boys, effects of these two familial variables are found to be significant on the pooled measures and in age specific body weight for girls. That is why the effects of these two variables on other measures are not shown in the results (tables 3.5a.va to 3.5a.viiib).

For boys, fathers' occupation, size of sibship and parity (first born/later born) are ignored for age-specific MANOVA of the four growth variables, as they do not have significant impact even when all ages are combined. Age-specific ANOVA of each of these growth variables are carried out only for the factors that happen to be significant at the 5% level in the tables below (tables 3.5a.ii, 3.5a.va, 3.5a.via, 3.5a.viia and 3.5a.viiia).

For girls, fathers' occupation is ignored for age-specific MANOVA of the four growth variables, as they do not have significant impact even when all ages are combined. Age-specific ANOVA of each of these growth variables are carried out only for the factors that happen to be significant at the 5% level in the tables below (tables 3.5a.iv, 3.5a.vb, 3.5a.vib, 3.5a.viib and 3.5a.viiib).

Table-3.5a.i: ANOVA/MANOVA for effects of various socioeconomic factors on four indicators of body size (standing height, body weight, sitting height, subischial leg length) of boys (corrected for age)

Body size variables	p-value of Hotelling's test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
Standing height	0.006	0.005	0.003	0.003	0.002	0.002	0.126	0.001	0.430	0.102
Body weight	0.012	0.005	0.012	0.002	0.007	0.000	0.662	0.000	0.001	0.058
Sitting height	0.007	0.019	0.002	0.001	*	0.009	0.122	0.002	0.754	0.228
Subischial leg length	0.124	0.045	0.111	0.044	0.068	0.014	0.105	0.051	0.651	0.127
	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All four	0.005	0.001	0.008	0.001	0.003	0.001	0.163	*	0.056	0.248

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5a.ii: MANOVA for effects of various socioeconomic factors on four indicators of body size (standing height, body weight, sitting height and subischial leg length) of boys

Age in years	p-value of Hotelling's test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All	0.005	0.001	0.008	0.001	0.003	0.001	*
7.0	0.850	0.489	0.789	0.025	0.086	0.018	0.748
8.0	0.575	0.394	0.227	0.646	0.318	0.464	0.421
9.0	0.691	0.525	0.289	0.454	0.535	0.132	0.444
10.0	0.480	0.262	0.293	0.342	0.124	0.207	0.388
11.0	0.042	0.434	0.178	0.184	0.135	0.668	0.219
12.0	0.383	0.106	0.228	0.585	0.577	0.232	0.002
13.0	0.088	0.034	0.045	0.344	0.081	0.478	0.701
14.0	0.941	0.920	0.775	0.743	0.904	0.444	0.070
15.0	0.536	0.871	0.206	0.432	0.237	0.569	0.302
16.0	0.652	0.693	0.773	0.606	0.976	0.437	0.287
17.0	0.278	0.092	0.464	0.860	0.568	0.630	0.415
18.0	0.450	0.278	0.506	0.275	0.878	0.090	0.179
19.0	0.884	0.660	0.603	0.617	0.590	0.420	0.453
20.0	0.082	0.029	0.019	0.278	0.082	0.672	0.742
21.0	0.884	0.868	0.505	0.275	0.351	0.744	0.004

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5a.iii: ANOVA/MANOVA for effects of various socioeconomic factors on four indicators of body size (standing height, body weight, sitting height and subischial leg length) of girls (corrected for age)

Body size variables	p-value of Hotelling's test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
Standing height	*	*	*	*	*	*	0.365	*	0.531	0.395
Body weight	*	*	*	*	*	*	0.343	*	*	*
Sitting height	*	*	*	*	*	0.001	0.314	*	0.832	0.729
Subischial leg length	*	*	*	*	*	*	0.545	*	0.222	0.272
	(df = 6)	(df = 3)	(df = 3)	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All four	*	*	*	*	*	*	0.731	*	*	*

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5a.iv: MANOVA for effects of various socioeconomic factors on four indicators of body size (standing height, body weight, sitting height and subischial leg length) of girls

Age in years	p-value of Hotelling's test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 6)	(df = 3)	(df = 3)	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All	*	*	*	*	*	*	*	*	*
7.0	0.491	0.548	0.267	0.957	0.690	0.781	0.217	0.637	0.927
8.0	0.142	0.057	0.079	0.113	0.190	0.019	0.001	0.402	0.789
9.0	0.066	0.018	0.081	0.101	0.045	0.052	0.109	0.763	0.869
10.0	0.059	0.013	0.246	0.339	0.433	0.336	0.279	0.017	*
11.0	0.352	0.869	0.331	0.551	0.494	0.518	0.474	0.980	0.874
12.0	0.181	0.063	0.256	0.080	0.013	0.194	0.001	0.016	0.020
13.0	0.103	0.174	0.019	0.144	0.028	0.121	0.078	0.517	0.212
14.0	0.313	0.204	0.693	0.882	0.710	0.534	0.285	0.709	0.522
15.0	0.437	0.139	0.570	0.812	0.512	0.851	0.345	0.244	0.920
16.0	0.648	0.481	0.671	0.246	0.108	0.090	0.279	0.265	0.278
17.0	0.555	0.690	0.244	0.452	0.625	0.275	0.135	0.708	0.407
18.0	0.138	0.033	0.117	0.102	0.071	0.239	0.056	0.374	0.472
19.0	0.190	0.055	0.609	0.331	0.219	0.097	*	0.029	0.255
20.0	0.173	0.090	0.612	0.820	0.477	0.597	0.012	0.261	0.019
21.0	0.473	0.547	0.551	0.493	0.534	0.356	0.436	0.381	0.292

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5a.va: ANOVA for effects of various socioeconomic factors on standing height of boys

Age in years	p-value of F test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)
All	0.006	0.005	0.003	0.003	0.002	0.002	0.001
7.0	0.377	0.189	0.552	0.005	0.015	0.001	0.557
8.0	0.249	0.293	0.095	0.355	0.149	0.356	0.149
9.0	0.280	0.186	0.125	0.074	0.156	0.022	0.309
10.0	0.805	0.598	0.956	0.335	0.270	0.141	0.231
11.0	0.823	0.789	0.566	0.624	0.354	0.796	0.053
12.0	0.758	0.480	0.503	0.650	1.000	0.462	0.034
13.0	0.015	0.007	0.013	0.193	0.069	0.297	0.236
14.0	0.592	0.873	0.381	0.351	0.581	0.174	0.209
15.0	0.922	0.748	0.701	0.458	0.757	0.256	0.125
16.0	0.335	0.247	0.908	0.173	0.952	0.138	0.212
17.0	0.663	0.835	0.426	0.871	0.737	0.603	0.283
18.0	0.461	0.563	0.607	0.407	0.754	0.347	0.162
19.0	0.543	0.330	0.303	0.896	0.748	0.977	0.120
20.0	0.936	0.726	0.847	0.576	0.406	0.334	0.299
21.0	0.330	0.326	0.136	0.201	0.145	0.814	0.383

df- Degrees of freedom, HS- Higher secondary

Table-3.5a.vb: ANOVA for effects of various socioeconomic factors on standing height of girls

Age in years	p-value of F test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*
7.0	0.164	0.308	0.060	0.518	0.288	0.314	0.221
8.0	0.053	0.021	0.047	0.323	0.366	0.132	*
9.0	0.046	0.050	0.016	0.017	0.005	0.024	0.040
10.0	0.029	0.011	0.216	0.522	0.254	0.381	0.146
11.0	0.925	0.795	0.949	0.459	0.540	0.221	0.362
12.0	0.008	0.002	0.018	0.015	0.004	0.054	0.000
13.0	0.033	0.074	0.009	0.174	0.084	0.399	0.125
14.0	0.162	0.066	0.396	0.486	0.333	0.237	0.281
15.0	0.182	0.072	0.132	0.509	0.244	0.471	0.107
16.0	0.481	0.244	0.660	0.179	0.260	0.066	0.108
17.0	0.202	0.242	0.073	0.669	0.990	0.537	0.085
18.0	0.567	0.313	0.643	0.694	0.699	0.415	0.085
19.0	0.478	0.224	0.429	0.226	0.214	0.084	0.004
20.0	0.259	0.335	0.872	0.665	0.366	0.531	0.033
21.0	0.157	0.221	0.851	0.413	0.198	0.531	0.345

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5a.via: ANOVA for effects of various socioeconomic factors on sitting height of boys

Age in years	p-value of F test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)
All	0.007	0.019	0.002	0.001	*	0.009	0.002
7.0	0.456	0.233	0.570	0.018	0.011	0.012	0.558
8.0	0.312	0.257	0.129	0.525	0.256	0.441	0.226
9.0	0.274	0.216	0.115	0.187	0.347	0.068	0.143
10.0	0.767	0.555	0.476	0.987	0.927	0.973	0.085
11.0	0.329	0.709	0.507	0.261	0.223	0.817	0.052
12.0	0.992	0.906	0.905	0.679	0.932	0.453	0.021
13.0	0.006	0.004	0.004	0.068	0.020	0.165	0.273
14.0	0.527	0.793	0.314	0.359	0.623	0.185	0.261
15.0	0.335	0.658	0.158	0.357	0.207	0.797	0.656
16.0	0.314	0.271	0.777	0.837	0.748	0.815	0.464
17.0	0.810	0.899	0.712	0.437	0.200	0.367	0.249
18.0	0.407	0.571	0.516	0.558	0.998	0.365	0.098
19.0	0.466	0.243	0.276	0.698	0.395	0.566	0.222
20.0	0.922	0.740	0.689	0.686	0.406	0.533	0.946
21.0	0.657	0.696	0.368	0.065	0.128	0.789	0.061

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5a.vib: ANOVA for effects of various socioeconomic factors on sitting height of girls

Age in years	p-value of F test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*
7.0	0.511	0.406	0.246	0.825	0.584	0.569	0.095
8.0	0. 125	0.041	0.195	0.870	0.964	0.662	*
9.0	0.025	0.015	0.016	0.035	0.017	0.018	0.023
10.0	0.192	0.069	0.218	0.590	0.395	0.832	0.358
11.0	0.787	0.512	0.808	0.557	0.295	0.371	0.534
12.0	0.065	0.019	0.126	0.313	0.128	0.341	0.001
13.0	0.092	0.281	0.033	0.218	0.093	0.326	0.026
14.0	0.064	0.046	0.666	0.560	0.455	0.280	0.136
15.0	0.139	0.047	0.213	0.470	0.220	0.502	0.356
16.0	0.342	0.428	0.598	0.471	0.450	0.223	0.497
17.0	0.403	0.343	0.179	0.214	0.841	0.159	0.097
18.0	0.659	0.779	0.407	0.795	0.734	0.856	0.120
19.0	0.042	0.015	0.221	0.065	0.053	0.021	*
20.0	0.571	0.299	0.533	0.343	0.155	0.243	0.004
21.0	0.288	0.577	0.532	0.284	0.150	0.141	0.309

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5a.viia: ANOVA for effects of various socioeconomic factors on subischial leg length of boys

Age in years	p-value of F test for		
	Father HS	Mother graduate, HS or less educated	Mother graduate
	(df = 1)	(df = 2)	(df = 1)
All	0.045	0.044	0.014
7.0	0.593	0.013	0.003
8.0	0.459	0.368	0.474
9.0	0.451	0.103	0.033
10.0	0.162	0.092	0.054
11.0	0.431	0.799	0.578
12.0	0.411	0.806	0.863
13.0	0.038	0.559	0.569
14.0	0.872	0.350	0.159
15.0	0.839	0.471	0.220
16.0	0.962	0.154	0.156
17.0	0.524	0.939	0.768
18.0	0.488	0.846	0.655
19.0	0.509	0.714	0.447
20.0	0.370	0.699	0.433
21.0	0.438	0.472	0.621

df- Degrees of freedom, HS- Higher secondary

Table-3.5a.viib: ANOVA for effects of various socioeconomic factors on subischial leg length of girls

Age in years	p-value of F test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*
7.0	0.138	0.398	0.058	0.503	0.253	0.360	0.478
8.0	0.014	0.007	0.010	0.033	0.082	0.009	*
9.0	0.307	0.236	0.138	0.063	0.019	0.105	0.097
10.0	0.015	0.006	0.181	0.276	0.139	0.132	0.170
11.0	0.539	0.899	0.441	0.566	0.951	0.443	0.391
12.0	0.059	0.020	0.051	0.006	0.001	0.045	*
13.0	0.036	0.075	0.010	0.537	0.268	0.454	0.589
14.0	0.349	0.157	0.232	0.614	0.359	0.369	0.396
15.0	0.600	0.373	0.349	0.452	0.209	0.492	0.073
16.0	0.389	0.171	0.495	0.162	0.144	0.057	0.172
17.0	0.161	0.302	0.057	0.689	0.387	0.542	0.046
18.0	0.235	0.089	0.268	0.384	0.784	0.245	0.257
19.0	0.916	0.694	0.708	0.501	0.534	0.257	0.126
20.0	0.230	0.268	0.957	0.788	0.536	0.881	0.157
21.0	0.484	0.279	0.688	0.480	0.316	0.857	0.913

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5a.viiia: ANOVA for effects of various socioeconomic factors on body weight of boys

Age in years	p-value of F test for							
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	0.012	0.005	0.012	0.002	0.007	*	*	0.003
7.0	0.893	0.773	0.950	0.099	0.032	0.143	0.244	0.711
8.0	0.102	0.102	0.035	0.180	0.081	0.115	0.128	0.055
9.0	0.952	0.983	0.820	0.693	0.977	0.491	0.387	0.032
10.0	0.438	0.726	0.248	0.502	0.945	0.403	0.386	0.257
11.0	0.571	0.591	0.299	0.824	0.542	0.661	0.048	0.407
12.0	0.223	0.091	0.140	0.181	0.377	0.067	0.001	0.517
13.0	0.311	0.283	0.129	0.128	0.042	0.229	0.556	0.273
14.0	0.265	0.648	0.891	0.354	0.937	0.267	0.010	0.642
15.0	0.724	0.445	0.817	0.934	0.712	0.791	0.605	0.462
16.0	0.317	0.474	0.482	0.256	0.726	0.130	0.077	0.057
17.0	0.141	0.048	0.196	0.570	0.610	0.315	0.181	0.751
18.0	0.852	0.599	0.624	0.493	0.675	0.242	0.026	0.078
19.0	0.619	0.395	0.355	0.419	0.800	0.264	0.173	0.695
20.0	0.008	0.005	0.003	0.024	0.006	0.269	0.233	0.599
21.0	0.455	0.379	0.212	0.205	0.130	0.729	0.036	0.787

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5a.viiib: ANOVA for effects of various socioeconomic factors on body weight of girls

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*	*	*
7.0	0.297	0.136	0.181	0.673	0.503	0.380	0.073	0.389	0.788
8.0	0.243	0.101	0.197	0.727	0.906	0.490	0.011	0.390	0.932
9.0	0.005	0.002	0.007	0.012	0.011	0.004	0.030	0.477	0.459
10.0	0.111	0.041	0.254	0.511	0.656	0.697	0.851	0.002	*
11.0	0.399	0.670	0.470	0.390	0.498	0.178	0.120	0.713	0.604
12.0	0.096	0.033	0.241	0.174	0.067	0.119	0.006	0.486	0.002
13.0	0.014	0.031	0.004	0.007	0.002	0.006	0.016	0.776	0.137
14.0	0.977	0.945	0.843	0.749	0.497	0.475	0.151	0.155	0.074
15.0	0.166	0.063	0.128	0.596	0.354	0.794	0.964	0.303	0.497
16.0	0.450	0.244	0.756	0.127	0.080	0.048	0.095	0.070	0.216
17.0	0.577	0.294	0.482	0.305	0.123	0.291	0.286	0.986	0.428
18.0	0.303	0.126	0.212	0.122	0.045	0.278	0.006	0.400	0.545
19.0	0.892	0.656	0.665	0.321	0.572	0.176	0.002	0.016	0.131
20.0	0.014	0.012	0.415	0.194	0.144	0.076	0.009	0.750	0.056
21.0	0.272	0.137	0.557	0.229	0.479	0.104	0.115	0.716	0.066

df- Degrees of freedom, HS- Higher secondary,*p<0.001

3.5b Body shape

None of the investigated socioeconomic factors is found to have any significant effect on sitting height/subischial leg length ratio of boys or girls. Since all factors are insignificant, age wise ANOVA has not been performed for this measure for either sex (tables 3.5b.i to 3.5b.iv). On the other hand, fathers' education, mothers' education, per capita monthly expenditure, parity and size of sibship are found to have significant effects on body mass index for girls. However for boys, only three factors namely fathers' education, mothers' education and per capita monthly expenditure are found to have significant effects (tables 3.5b.va and 3.5b.vb). Pooling of all ages and the two measures of body shape have produced almost similar results for the two sexes.

Table-3.5b.i: ANOVA/MANOVA for effects of various socioeconomic factors on two indicators of body shape (sitting height / subischial leg length ratio and body mass index) of boys (corrected for age)

Body shape variables	p-value of Hotelling's test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
SH by LL	0.46	0.698	0.519	0.209	0.548	0.351	0.313	0.588	0.788	0.331
BMI	0.006	0.005	0.003	0.003	0.002	0.002	0.216	0.001	0.606	0.071
	(df = 4)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)
Both	0.03	0.006	0.072	0.004	0.063	0.001	0.368	*	0.008	0.117

df- Degrees of freedom, HS- Higher secondary, SH- Sitting height, LL- Subischial leg length, BMI- Body mass index,*p<0.001

Table-3.5b.ii: MANOVA for effects of various socioeconomic factors on two indicators of body shape (sitting height / subischial leg length ratio and body mass index) of boys

Age in years	p-value of Hotelling's test for					
	Father graduate, HS or less educated	Father HS	Mother graduate, HS or less educated	Mother graduate	Monthly family expenditure	Size of sibship
	(df = 4)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)
All	0.030	0.006	0.004	0.001	*	0.008
7.0	0.941	0.734	0.251	0.643	0.514	0.784
8.0	0.383	0.223	0.358	0.247	0.381	0.153
9.0	0.995	0.918	0.854	0.529	0.393	0.015
10.0	0.278	0.141	0.150	0.103	0.623	0.420
11.0	0.168	0.269	0.450	0.398	0.353	0.513
12.0	0.153	0.044	0.354	0.119	0.001	0.760
13.0	0.943	0.943	0.473	0.484	0.980	0.250
14.0	0.938	0.813	0.866	0.769	0.086	0.760
15.0	0.366	0.750	0.449	0.426	0.285	0.166
16.0	0.745	0.717	0.574	0.324	0.180	0.003
17.0	0.105	0.026	0.933	0.676	0.500	0.315
18.0	0.544	0.256	0.330	0.107	0.122	0.413
19.0	0.854	0.930	0.417	0.240	0.697	0.531
20.0	0.033	0.017	0.129	0.550	0.563	0.555
21.0	0.856	0.782	0.658	0.628	0.008	0.931

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5b.iii: ANOVA/MANOVA for effects of various socioeconomic factors on two indicators of body shape (sitting height / subischial leg length ratio and body mass index) of girls (corrected for age)

Body shape variables	p-value of Hotelling's test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
SH by LL	0.167	0.337	0.063	0.16	0.132	0.058	0.843	0.632	0.181	0.431
BMI	*	*	0.001	*	*	0.001	0.492	*	*	*
	(df = 4)	(df = 2)	(df = 2)	(df = 4)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)
Both	*	*	*	*	*	*	0.785	*	*	*

df- Degrees of freedom, HS- Higher secondary, SH- Sitting height, LL- Subischial leg length, BMI- Body mass index,*p<0.001

Table-3.5b.iv: MANOVA for effects of various socioeconomic factors on two indicators of body shape (sitting height / subischial leg length ratio and body mass index) of girls

Age in years	p-value of Hotelling's test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 4)	(df = 2)	(df = 2)	(df = 4)	(df = 2)	(df = 2)	(df = 2)	(df = 2)	(df = 2)
All	*	*	*	*	*	*	*	*	*
7.0	0.389	0.393	0.230	0.834	0.550	0.599	0.160	0.509	0.854
8.0	0.172	0.104	0.070	0.113	0.127	0.029	0.020	0.735	0.952
9.0	0.112	0.024	0.255	0.195	0.188	0.100	0.389	0.613	0.671
10.0	0.056	0.016	0.170	0.154	0.286	0.296	0.528	0.007	*
11.0	0.268	0.782	0.200	0.289	0.291	0.376	0.286	0.984	0.793
12.0	0.378	0.271	0.747	0.147	0.038	0.165	0.138	0.008	0.006
13.0	0.262	0.172	0.088	0.088	0.019	0.063	0.124	0.601	0.168
14.0	0.712	0.890	0.721	0.808	0.730	0.469	0.318	0.696	0.408
15.0	0.516	0.238	0.749	0.818	0.693	0.953	0.461	0.341	0.795
16.0	0.774	0.597	0.513	0.257	0.084	0.160	0.272	0.194	0.307
17.0	0.791	0.876	0.635	0.462	0.403	0.210	0.412	0.739	0.428
18.0	0.050	0.012	0.042	0.030	0.028	0.124	0.068	0.595	0.365
19.0	0.279	0.127	0.639	0.631	0.409	0.366	0.027	0.016	0.138
20.0	0.135	0.088	0.486	0.896	0.748	0.605	0.310	0.113	0.008
21.0	0.733	0.448	0.397	0.564	0.993	0.433	0.353	0.573	0.296

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5b.va: ANOVA for effects of various socioeconomic factors on body mass index on of boys

Age in years	p-value of Hotelling's test for						
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)
All	0.006	0.005	0.003	0.003	0.002	0.002	0.001
7.0	0.895	0.719	0.638	0.224	0.152	0.940	0.225
8.0	0.149	0.108	0.058	0.212	0.116	0.109	0.257
9.0	0.748	0.446	0.602	0.891	0.706	0.998	0.450
10.0	0.372	0.464	0.166	0.500	0.598	0.657	0.542
11.0	0.262	0.376	0.116	0.447	0.204	0.483	0.157
12.0	0.180	0.075	0.103	0.178	0.291	0.063	0.005
13.0	0.770	0.956	0.545	0.271	0.106	0.288	0.948
14.0	0.843	0.567	0.779	0.534	0.879	0.478	0.032
15.0	0.594	0.308	0.611	0.884	0.857	0.807	0.199
16.0	0.573	0.819	0.468	0.548	0.706	0.290	0.137
17.0	0.085	0.028	0.086	0.687	0.770	0.442	0.247
18.0	0.705	0.419	0.749	0.198	0.714	0.090	0.053
19.0	0.877	0.662	0.625	0.302	0.709	0.177	0.359
20.0	0.007	0.005	0.002	0.029	0.008	0.370	0.414
21.0	0.732	0.606	0.430	0.561	0.364	0.838	0.005

df- Degrees of freedom, HS- Higher secondary

Table-3.5b.vb: ANOVA for effects of various socioeconomic factors on body mass index of girls

Age in years	p-value of Hotelling's test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	0.001	*	*	0.001	*	*	*
7.0	0.384	0.167	0.400	0.836	0.824	0.567	0.093	0.321	0.980
8.0	0.495	0.273	0.303	0.281	0.850	0.175	0.097	0.218	0.785
9.0	0.023	0.007	0.048	0.055	0.104	0.016	0.162	0.590	0.324
10.0	0.354	0.152	0.366	0.273	0.739	0.427	0.639	0.002	*
11.0	0.188	0.484	0.391	0.579	0.545	0.297	0.131	0.652	0.591
12.0	0.275	0.167	0.718	0.535	0.313	0.292	0.106	0.255	*
13.0	0.067	0.091	0.020	0.011	0.005	0.006	0.039	0.509	0.053
14.0	0.785	0.486	0.660	0.814	0.598	0.530	0.210	0.301	0.133
15.0	0.425	0.196	0.311	0.709	0.527	0.987	0.538	0.076	0.416
16.0	0.674	0.450	0.934	0.330	0.147	0.199	0.307	0.184	0.084
17.0	0.606	0.398	0.896	0.237	0.098	0.357	0.594	0.855	0.176
18.0	0.327	0.167	0.166	0.078	0.033	0.337	0.018	0.563	0.575
19.0	0.976	0.934	0.837	0.535	0.864	0.388	0.030	0.018	0.075
20.0	0.033	0.017	0.285	0.228	0.214	0.086	0.055	0.636	0.074
21.0	0.557	0.279	0.435	0.246	0.845	0.177	0.191	0.976	0.209

df- Degrees of freedom, HS- Higher secondary,*p<0.001

3.5c Body composition

Five of the six socioeconomic factors, namely, fathers' education, mothers' education, per capita monthly expenditure, size of sibship and parity are found to have significant effects on three measures of body composition namely, triceps skinfold thickness, subscapular skinfold thickness and percentage of body fat mass in both boys and girls (tables 3.5c.i to 3.5c.viib). For body fat distribution, effect of sibship size is significant for both sexes, while the effect of parity is also noticed in the case of girls (tables 3.5c.viiia to 3.5c.ixb).

Table-3.5c.i: ANOVA/MANOVA for effects of various socioeconomic factors on three indicators of body composition: percentage of body fat mass (Slaughter et al., 1988), triceps skinfold (log10) and subscapular skinfold (log10) of boys (corrected for age)

Body composition variables	p-value of F test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
Percentage of body fat mass	*	*	*	*	0.001	*	0.776	*	*	0.007
log10 of triceps skinfold thickness	*	*	*	*	0.001	*	0.725	*	*	0.006
log10 of subscapular skinfold thickness	0.001	*	0.004	*	*	*	0.579	*	*	0.041
	(df = 6)	(df = 3)	(df = 3)	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All three	*	*	0.001	0.006	0.004	0.002	0.266	*	*	0.045

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.ii: MANOVA for effects of various socioeconomic factors on three indicators of body composition: percentage of body fat mass (Slaughter et al., 1988), triceps skinfold (log10) and subscapular skinfold (log10) of boys

Age in years	p-value of Hotelling's test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 6)	(df = 3)	(df = 3)	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All	*	*	0.001	0.006	0.004	0.002	*	*	0.045
7.0	0.602	0.866	0.283	0.392	0.526	0.163	0.522	0.563	0.917
8.0	0.856	0.602	0.807	0.736	0.636	0.450	0.373	0.469	0.353
9.0	0.995	0.895	0.934	0.886	0.629	0.742	0.643	0.069	0.811
10.0	0.620	0.303	0.400	0.763	0.871	0.827	0.061	0.520	0.156
11.0	0.167	0.975	0.353	0.908	0.725	0.960	0.468	0.842	0.818
12.0	0.698	0.973	0.577	0.755	0.587	0.742	0.015	0.621	0.476
13.0	0.374	0.114	0.408	0.020	0.005	0.039	0.278	0.089	0.771
14.0	0.520	0.207	0.731	0.702	0.494	0.793	0.192	0.932	0.339
15.0	0.758	0.536	0.455	0.590	0.378	0.999	0.008	0.388	0.677
16.0	0.666	0.318	0.910	0.188	0.121	0.117	0.043	0.136	0.588
17.0	0.642	0.312	0.336	0.974	0.960	0.858	0.852	0.747	0.552
18.0	0.092	0.035	0.036	0.382	0.189	0.315	0.183	0.495	0.328
19.0	0.017	0.006	0.692	0.364	0.382	0.131	0.287	0.002	0.127
20.0	0.009	0.006	0.001	0.009	0.003	0.390	0.509	0.270	0.380
21.0	0.009	0.279	0.035	0.379	0.180	0.311	0.015	0.259	0.426

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.iii: ANOVA/MANOVA for effects of various socioeconomic factors on three indicators of body composition: percentage of body fat mass (Slaughter et al., 1988), triceps skinfold (log10) and subscapular skinfold (log10) of girls (corrected for age)

Body composition variables	p-value of F test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
Percentage of body fat mass	*	*	*	*	*	*	0.291	*	*	*
log10 of triceps skinfold thickness	*	*	*	*	*	*	0.213	*	*	*
log10 of subscapular skinfold thickness	*	*	*	*	*	*	0.191	*	*	*
	(df = 6)	(df = 3)	(df = 3)	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All three	*	*	*	*	*	*	0.572	*	*	*

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.iv: MANOVA for effects of various socioeconomic factors on three indicators of body composition: percentage of body fat mass (Slaughter et al., 1988), triceps skinfold (log10) and subscapular skinfold (log10) of girls

Age in years	p-value of Hotelling's test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 6)	(df = 3)	(df = 3)	(df = 6)	(df = 3)	(df = 3)	(df = 3)	(df = 3)	(df = 3)
All	*	*	*	*	*	*	*	*	*
7.0	0.527	0.257	0.376	0.818	0.607	0.430	0.040	0.141	0.500
8.0	0.309	0.194	0.401	0.846	0.671	0.456	0.036	0.260	0.847
9.0	0.022	0.019	0.011	0.269	0.309	0.058	0.265	0.207	0.046
10.0	0.259	0.077	0.133	0.338	0.221	0.308	0.533	0.004	*
11.0	0.076	0.020	0.373	0.265	0.454	0.094	0.548	0.887	0.496
12.0	0.342	0.140	0.296	0.355	0.105	0.265	0.036	0.695	0.018
13.0	0.089	0.128	0.040	0.069	0.016	0.119	0.059	0.103	0.309
14.0	0.543	0.331	0.966	0.061	0.049	0.041	0.565	0.390	0.697
15.0	0.121	0.532	0.185	0.057	0.477	0.095	0.488	0.396	0.139
16.0	0.376	0.204	0.837	0.311	0.162	0.243	0.355	0.724	0.309
17.0	0.970	0.808	0.975	0.813	0.507	0.763	0.804	0.785	0.200
18.0	0.027	0.168	0.017	0.543	0.302	0.668	0.020	0.031	0.124
19.0	0.798	0.543	0.443	0.025	0.078	0.006	*	0.467	0.447
20.0	0.441	0.188	0.153	0.398	0.299	0.198	0.038	0.227	0.073
21.0	0.672	0.673	0.345	0.024	0.801	0.514	0.286	0.647	0.258

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.va: ANOVA for effects of various socioeconomic factors on percentage of body fat mass (Slaughter et al., 1988) of boys

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	0.001	*	*	*	0.007
7.0	0.968	0.996	0.853	0.173	0.134	0.072	0.166	0.355	0.510
8.0	0.458	0.212	0.374	0.712	0.449	0.835	0.813	0.135	0.081
9.0	0.949	0.745	0.837	0.948	0.756	0.910	0.259	0.008	0.469
10.0	0.496	0.415	0.235	0.248	0.623	0.380	0.118	0.459	0.098
11.0	0.223	0.838	0.325	0.880	0.888	0.626	0.694	0.450	0.365
12.0	0.863	0.779	0.909	0.390	0.375	0.760	0.025	0.655	0.386
13.0	0.236	0.103	0.178	0.064	0.065	0.023	0.080	0.119	0.566
14.0	0.282	0.111	0.273	0.644	0.490	0.349	0.036	0.603	0.233
15.0	0.681	0.387	0.725	0.935	0.759	0.969	0.403	0.797	0.449
16.0	0.480	0.225	0.513	0.219	0.083	0.392	0.081	0.111	0.260
17.0	0.241	0.109	0.143	0.641	0.872	0.456	0.534	0.917	0.728
18.0	0.362	0.208	0.194	0.464	0.813	0.241	0.227	0.082	0.089
19.0	0.061	0.019	0.212	0.034	0.101	0.009	0.341	0.008	0.089
20.0	*	*	*	0.003	0.001	0.494	0.839	0.486	0.263
21.0	0.017	0.483	0.009	0.083	0.027	0.079	0.112	0.072	0.600

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.vb: ANOVA for effects of various socioeconomic factors on percentage of body fat mass (Slaughter et al., 1988) of girls

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*	*	*
7.0	0.148	0.051	0.161	0.287	0.222	0.121	0.005	0.027	0.228
8.0	0.265	0.284	0.103	0.890	0.810	0.634	0.007	0.219	0.530
9.0	0.010	0.006	0.008	0.028	0.064	0.007	0.166	0.995	0.543
10.0	0.056	0.017	0.055	0.227	0.196	0.888	0.873	0.001	*
11.0	0.107	0.080	0.851	0.197	0.867	0.143	0.203	0.707	0.366
12.0	0.386	0.223	0.730	0.561	0.355	0.298	0.367	0.330	0.017
13.0	0.023	0.017	0.009	0.022	0.006	0.019	0.042	0.832	0.340
14.0	0.766	0.465	0.641	0.140	0.078	0.061	0.505	0.561	0.272
15.0	0.247	0.332	0.094	0.262	0.114	0.523	0.656	0.982	0.736
16.0	0.804	0.508	0.706	0.160	0.059	0.115	0.072	0.544	0.102
17.0	0.755	0.505	0.877	0.771	0.496	0.773	0.327	0.395	0.165
18.0	0.056	0.045	0.018	0.251	0.221	0.960	0.082	0.025	0.037
19.0	0.368	0.232	0.173	0.011	0.010	0.003	*	0.477	0.519
20.0	0.207	0.111	0.087	0.804	0.529	0.577	0.943	0.038	0.030
21.0	0.571	0.301	0.365	0.015	0.349	0.163	0.065	0.288	0.679

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.via: ANOVA for effects of various socioeconomic factors on triceps skinfold thickness (log10) of boys

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	0.001	*	*	*	0.006
7.0	0.977	0.945	0.923	0.227	0.133	0.115	0.148	0.342	0.620
8.0	0.557	0.300	0.360	0.736	0.668	0.801	0.854	0.195	0.098
9.0	0.968	0.800	0.869	0.909	0.706	0.680	0.343	0.007	0.525
10.0	0.340	0.216	0.156	0.245	0.590	0.403	0.272	0.339	0.036
11.0	0.636	0.725	0.748	0.899	0.817	0.832	0.293	0.451	0.414
12.0	0.846	0.955	0.720	0.558	0.375	0.983	0.100	0.995	0.356
13.0	0.635	0.402	0.388	0.122	0.135	0.042	0.142	0.047	0.412
14.0	0.200	0.073	0.301	0.572	0.308	0.368	0.045	0.761	0.161
15.0	0.779	0.490	0.795	0.756	0.555	0.993	0.378	0.818	0.669
16.0	0.263	0.102	0.387	0.079	0.025	0.082	0.106	0.045	0.274
17.0	0.070	0.035	0.036	0.541	0.374	0.270	0.348	0.940	0.908
18.0	0.819	0.926	0.583	0.302	0.935	0.201	0.060	0.062	0.122
19.0	0.011	0.003	0.165	0.090	0.336	0.036	0.200	0.050	0.105
20.0	0.001	0.001	*	0.006	0.003	0.629	0.912	0.997	0.573
21.0	0.069	0.495	0.030	0.131	0.044	0.153	0.023	0.055	0.837

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.vib: ANOVA for effects of various socioeconomic factors on triceps skinfold thickness (log10) of girls

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*	*	*
7.0	0.110	0.041	0.081	0.190	0.155	0.074	0.008	0.087	0.261
8.0	0.437	0.749	0.234	0.976	0.833	0.850	0.005	0.465	0.518
9.0	0.069	0.025	0.073	0.078	0.098	0.024	0.153	0.458	0.129
10.0	0.039	0.014	0.026	0.186	0.099	0.506	0.680	*	*
11.0	0.366	0.311	0.901	0.170	0.758	0.110	0.258	0.721	0.337
12.0	0.702	0.539	0.994	0.683	0.526	0.381	0.431	0.517	0.011
13.0	0.015	0.014	0.006	0.005	0.001	0.008	0.006	0.888	0.464
14.0	0.926	0.862	0.705	0.033	0.036	0.010	0.613	0.701	0.404
15.0	0.086	0.086	0.029	0.240	0.141	0.118	0.440	0.968	0.671
16.0	0.362	0.156	0.479	0.067	0.020	0.071	0.076	0.756	0.212
17.0	0.851	0.583	0.816	0.531	0.304	0.706	0.290	0.389	0.057
18.0	0.036	0.107	0.010	0.292	0.203	0.817	0.391	0.187	0.064
19.0	0.243	0.150	0.109	0.007	0.011	0.002	*	0.334	0.298
20.0	0.128	0.061	0.056	0.394	0.178	0.291	0.624	0.057	0.026
21.0	0.499	0.325	0.794	0.254	0.821	0.290	0.111	0.462	0.239

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5c.viia: ANOVA for effects of various socioeconomic factors on subscapular skinfold thickness (log10) of boys

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	0.001	*	0.004	*	*	*	*	*	0.041
7.0	0.859	0.795	0.598	0.312	0.152	0.201	0.119	0.264	0.586
8.0	0.585	0.300	0.489	0.639	0.505	0.905	0.682	0.153	0.075
9.0	0.741	0.442	0.576	0.939	0.838	0.925	0.527	0.013	0.467
10.0	0.373	0.255	0.169	0.205	0.523	0.410	0.160	0.536	0.048
11.0	0.267	0.623	0.512	0.979	0.860	0.850	0.623	0.379	0.456
12.0	1.000	0.989	0.993	0.650	0.543	0.833	0.039	0.667	0.166
13.0	0.359	0.162	0.278	0.008	0.006	0.005	0.155	0.064	0.323
14.0	0.294	0.118	0.361	0.646	0.439	0.362	0.037	0.846	0.428
15.0	0.400	0.206	0.265	0.973	0.836	0.964	0.023	0.241	0.949
16.0	0.537	0.276	0.418	0.072	0.022	0.124	0.014	0.146	0.474
17.0	0.037	0.018	0.020	0.541	0.504	0.275	0.246	0.557	0.723
18.0	0.589	0.529	0.302	0.247	0.330	0.095	0.006	0.230	0.623
19.0	0.091	0.030	0.267	0.123	0.451	0.055	0.100	0.341	0.636
20.0	0.001	0.002	*	0.002	*	0.207	0.976	0.879	0.718
21.0	0.140	0.100	0.060	0.214	0.106	0.106	0.010	0.251	0.336

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5c.viib: ANOVA for effects of various socioeconomic factors on subscapular skinfold thickness (log10) of girls

Age in years	p-value of F test for								
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
All	*	*	*	*	*	*	*	*	*
7.0	0.241	0.094	0.198	0.415	0.339	0.187	0.017	0.123	0.682
8.0	0.357	0.660	0.175	0.739	0.895	0.497	0.045	0.186	0.552
9.0	0.099	0.081	0.040	0.078	0.124	0.024	0.084	0.887	0.465
10.0	0.285	0.112	0.244	0.451	0.596	0.695	0.228	*	*
11.0	0.359	0.622	0.474	0.079	0.308	0.029	0.096	0.918	0.457
12.0	0.237	0.089	0.259	0.177	0.085	0.086	0.046	0.918	0.001
13.0	0.113	0.038	0.131	0.053	0.020	0.027	0.129	0.639	0.136
14.0	0.644	0.518	0.940	0.207	0.455	0.092	0.228	0.141	0.485
15.0	0.106	0.037	0.303	0.243	0.191	0.984	0.848	0.295	0.236
16.0	0.698	0.896	0.453	0.311	0.146	0.476	0.139	0.236	0.378
17.0	0.750	0.567	0.989	0.890	0.748	0.628	0.489	0.755	0.456
18.0	0.012	0.039	0.003	0.145	0.064	0.413	0.011	0.110	0.020
19.0	0.486	0.253	0.297	0.267	0.104	0.239	0.037	0.132	0.335
20.0	0.024	0.011	0.010	0.140	0.198	0.047	0.026	0.218	0.018
21.0	0.579	0.336	0.326	0.251	0.780	0.307	0.695	0.199	0.336

df- Degrees of freedom, HS- Higher secondary,*$p<0.001$

Table-3.5c.viiia: ANOVA for effects of various socioeconomic factors on the indicator of body fat distribution (ratio of log10 triceps + biceps skinfolds / subscapular + suprailiac skinfolds) of boys (corrected for age)

Body fat distribution variable	p-value of F test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
(TS+BS) by (SS+SIS)	0.451	0.281	0.836	0.176	0.062	0.232	0.645	0.223	0.043	0.165

df- Degrees of freedom, HS- Higher secondary, TS- Triceps skinfold, BS- Biceps skinfold, SS- Subscapular skinfold, SIS- Suprailiac skinfold

Table-3.5c.viiib: ANOVA for effects of various socioeconomic factors on the indicator of body fat distribution (ratio of log10 triceps + biceps skinfolds / subscapular + suprailiac skinfolds) of girls (corrected for age)

Body fat distribution variable	p-value of F test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	First born
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
(TS+BS) by (SS+SIS)	0.838	0.568	0.799	0.661	0.634	0.373	0.836	0.722	0.001	0.023

df- Degrees of freedom, HS- Higher secondary, TS- Triceps skinfold, BS- Biceps skinfold, SS- Subscapular skinfold,SIS- Suprailiac skinfold

Table-3.5c.ixa: ANOVA for effect of size of sibship on the indicator of body fat distribution (ratio of log10 triceps + biceps skinfolds / subscapular + suprailiac skinfolds) of boys

Age in years	p-value of F test
	(df = 1)
All	0.045
7.0	0.350
8.0	0.275
9.0	0.180
10.0	0.669
11.0	0.974
12.0	0.090
13.0	0.430
14.0	0.584
15.0	0.244
16.0	0.180
17.0	0.794
18.0	0.055
19.0	0.020
20.0	0.780
21.0	0.156

df- Degrees of freedom

Table-3.5c.ixb: ANOVA for effect of size of sibship on the indicator of body fat distribution (ratio of log10 triceps + biceps skinfolds / subscapular + suprailiac skinfolds) of girls

Age in years	p-value of F test	
	(df = 1)	(df = 1)
All	0.001	0.023
7.0	0.226	0.980
8.0	0.418	0.405
9.0	0.489	0.520
10.0	0.379	0.037
11.0	0.220	0.753
12.0	0.396	0.047
13.0	0.094	0.350
14.0	0.190	0.614
15.0	0.067	0.049
16.0	0.272	0.480
17.0	0.248	0.613
18.0	0.422	0.297
19.0	0.195	0.194
20.0	0.668	0.547
21.0	0.463	0.361

df- Degrees of freedom

3.5d Nutritional status

Out of the six socioeconomic factors only mothers' education is found to have significant effect in the prevalence of stunting in boys. However for girls, in addition to mothers' education, fathers' education and per capita monthly expenditure are also found to be significant. As for the prevalence of thinness, per capita monthly expenditure, parental education and parity are found to have significant effects for both sexes, while size of sibship has significant effect in the case of girls (tables 3.5d.ia and 3.5d.ib).

Table-3.5d.ia: Logistic regression for effects of various socioeconomic factors on the prevalence of nutritional status (stunting and thinness) in boys

Indicators of nutritional status	p-value of F test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	Parity
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
Stunting	0.085	0.087	0.069	0.07	0.022	0.232	0.542	0.751	0.074	0.077
Stunting (corrected for age)	0.197	0.109	0.095	0.116	0.04	0.279	0.419	0.127	0.315	0.158
Thinness	0.062	0.024	0.343	0.128	0.328	0.046	0.042	0.014	0.011	0.148
Thinness (corrected for age)	0.047	0.023	0.48	0.136	0.415	0.053	0.074	*	0.196	0.014

df- Degrees of freedom, HS- Higher secondary,*p<0.001

Table-3.5d.ib: Logistic regression for effects of various socioeconomic factors on the prevalence of nutritional status (stunting and thinness) in girls

Indicators of nutritional status	p-value of Wald chi-square test for									
	Father graduate, HS or less educated	Father HS	Father graduate	Mother graduate, HS or less educated	Mother HS	Mother graduate	Father in service	Monthly family expenditure	Size of sibship	Parity
	(df = 2)	(df = 1)	(df = 1)	(df = 2)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)	(df = 1)
Stunting	0.27	0.199	0.112	0.014	0.004	0.083	0.755	0.036	0.334	0.512
Stunting (corrected for age)	0.027	0.031	0.009	0.01	0.002	0.037	0.745	*	0.791	0.434
Thinness	0.071	0.022	0.125	0.001	*	0.007	0.801	*	0.021	*
Thinness (corrected for age)	0.091	0.029	0.178	*	*	0.006	0.86	*	0.007	*

df- Degrees of freedom, HS- Higher secondary,*p<0.001

3.5e Age at menarche

In respect of the recall data, the effects of socioeconomic factors have been investigated through Cox's proportional hazards regression model (Cox, 1972) after excluding the cases when the date has not been recalled or only a range of dates has been recalled (i.e., retaining only those cases where menarche has not occurred or the exact date of menarche has been recalled). The statistical significance of the binary variable described in table no. 3.5e, taken one at a time along with age as predictors in the Cox regression model for age at menarche, is examined (FHS-1 if father has passed higher secondary and above and 0 for others, MHS-1 if mother has passed higher secondary and above and 0 for others, FSER-1 if father is in service and 0 for others, Affluent-1 if per capita monthly family expenditure is > 9000 and above (INR) and 0 for ≤ 9000 (INR), Small family-1 if family size is ≤ 3 and 0 for others, Sibling-1 if the number of sib is ≥ 1 and 0 for others, Parity-1 if first born and 0 for others). The results are summarised in table no 3.5e. None of these variables is significant when more than one of them is included in the model. It shows that fathers' and mothers' education is significant at 1% level while sibship size is significant at 5% level. Further, girls having father or mother with at least higher secondary level of education are more likely to have earlier onset of menarche than others. On the other hand, having a sibling reduces the chance of earlier onset of menarche (table 3.5e).

Table-3.5e: Effects of different socioeconomic factors on age at menarche of Bengali girls of Kolkata (2005-2011 study)

Socioeconomic variables	Estimated multiplier for baseline hazard of menarche (with standard error of regression coefficient)	p-value for socioeconomic variables
FHS	exp[0.383 * FHS]-0.123	0.002
MHS	exp[0.271 * MHS]-0.099	0.006
FSER	exp[0.165 * FSER]-0.1	0.100
Affluent	exp[0.159 * Affluent]-0.096	0.098
Sibling	exp[– 0.193 * Sibling]-0.096	0.043
Parity	exp[0.049 * Parity]-0.106	0.644

CHAPTER 4

DISCUSSION

4.1 Uniqueness of three growth surveys performed in Bengali population

Results of three growth surveys performed on predominantly middle class Bengali children of Kolkata city, India aged 7.0 to 21.0 years have generated an enormous amount of information on secular trends for a battery of parameters. The secular phenomena have been examined in these parameters for boys and girls between the time difference of three and two study periods respectively. The studied parameters constitute the measures of body size and segments, body mass and shape, body composition, nutritional status and physical maturation. The three performed growth surveys have been purposefully linked with each other by three important ways which are worthwhile to mention. Firstly, the Sarsuna-Barisha growth survey of 1952-1966 (study 1) has been carried out by S. R. Das (the late) as a principal researcher who has subsequently trained the principal investigator of the present study Parasmani Dasgupta, to carry out the Kolkata growth survey of 1982-83 on Bengali boys (study 2). Parasmani Dasgupta, in turn, has trained his male students named Rana Saha and Samrat Paul to take the body measurements from all boys who have participated in the survey of 1999-2011 (study 3) and female student Rituparna Das to take body measurements from all girls who have participated in the survey of 2005-2011 (study 2). In this way an uniform technique of measurements has been followed up in all three growth studies to minimise the variation from three collected data sets, which otherwise would have been escalated due to differences in the technique of measurements with more number of measurers. Secondly, in all three growth surveys the measurements have been taken on and around birth dates of the subjects. Therefore, by this way, it has been possible to maintain a uniformity in age grouping of growth data of all three series of the comparing studies so as to enable an uniform technique of data analysis and thereby to generate more interpretative results as far as practicable.Thirdly, the residential areas of the subjects who have participated in all three growth studies are located within a radius of about twenty kilometres from the centre of the Kolkata city which has also enabled to maintain a homogeneity in the physical environment of the participants. These are some of the important criteria that are usually required to fulfil before drawing any meaningful conclusion from the analysis of secular growth data (Lindgren and Cernerud, 1992, Rao et al., 2012).

In spite of the uniqueness in three growth studies it may also be noted that the number and the type of the investigated anthropometric traits vary between the comparing studies as well as between the genders to a great extent (see sections 2.6 and 2.10 of chapter 2). As a result, for boys fifteen individual measurements encompassing body size, mass and segments, six measures of body shape and body composition, four measures of nutritional status and three measures of physical maturation have been considered for investigating the secular trend phenomena. But for girls, only seven individual measurements encompassing body size, mass and segments, four measures of body shape and nutritional status and three measures of physical maturation have been examined for secular trends phenomena. Unfortunately, no measures of body composition have been possible to include for girls to study secular trends.

The presented results, in addition, have documented the effects of several socioeconomic indicators like parental education, per capita monthly expenditure, size of sib ship, birth order of the subject (parity) on few selected individual measurements, few measures of body shape, body composition and nutritional status of the contemporary Bengali children (on boys from study 3 and girls from study 2). Moreover, the collected data on age at menarche of contemporary urban Bengali girls have firstly provided an opportunity to examine the secular trends phenomena in this indicator of sexual maturation and secondly, to document the role of several probable socioeconomic factors responsible for its onset. To the best of our knowledge such kind of auxological investigation seems to have been hardly performed on any Indian population before.

4.2 Secular trends in three percentiles of body mass index and skinfold thickness

The first and the foremost evidence in support of the occurrence of positive secular trends, comes from shifting of the values of all three percentiles of body mass index and skinfold thicknesses. A greater magnitude of secular increase in the higher percentile (97^{th}) in comparison to the intermediate (50^{th}) and the lower one (10^{th}) has been observed for body mass index (of both sexes), triceps and subscapular skinfolds thicknesses of boys. This particular trend is also observed in the studies performed on populations of several western countries, like Germany (Meigen et al., 2008), Norway (Bjorrnelv et al., 2007, Kolle et al., 2009, Juliusson et al., 2007), the Netherlands (Fredriks et al., 2000), USA (Rosner et al., 1998, Flegal and Troiano, 2000) and England (Wardle and Boniface, 2008). However, similar analysis on shifting of different percentile values due to change of time may be undertaken for other somatic traits included in this study.

4.3 Secular trends in average body size and mass, body segments and their interrelationship during growth period and at adulthood

Besides increase of the percentile values, the other primary indicators of secular phenomena are observed to be related with changes in mean body size, body segments and body mass in children and adults in association with changes in the timings of onset of physical and pubertal maturation. All these features are clearly manifested from the results of this study on both sexes. Nevertheless, the findings appear to be more conveniently interpretable for boys due to availability of three series of growth data with greater number of variables.

The first indicator i.e. increased age specific means are observed in boys for standing height, body weight, sitting height, subischial leg length and biacromial diameter from ages 7.0 to 21.0 years between the time difference of study 1 and study 3. In girls, a similar trend is noticed for these traits between the time difference of study 1 and study 2. But in boys, magnitudes of the increased mean differ according to age classes, type of the measurements (body weight with standing height) and time difference between the three comparing studies. For example, when mean standing height from study 1 and study 3 are compared the larger values of increment are found in the order of 14.4 cm., 14.3 cm. and 12.6 cm., between ages 12.0 to 14.0 years. When the results of study 1 and study 2 are compared the larger increments of mean height in the order of 11.6 cm. 10.2 cm. and 8.4 cm. are noticed between

13.0 to 15.0 years. Thirdly, between the time difference of study 2 and study 3 larger increments of mean height, in the order of 4.4 cm. 4.1 cm. and 3.8 cm. are noticed at 12.0, 14.0 and 9.0 years respectively. On the other hand for girls, due to the existence of only two growth studies such type of comparison becomes simpler than boys. For them the trend of increment of means between study 1 and study 2 are in the order of 11.8 cm., 10.9 cm. and 10.6 cm. noticed between 9.0 to 12.0 years which are also found to be larger in magnitude in comparison to the incremental values recorded at other ages. Among Hong Kong Chinese children changes in mean standing height in time difference of about thirty years (1963 to 1993) are reported. While for boys the highest increase of 7.4 cm. has occurred at 13.0 year, for girls such increase in the order of 6.5 cm. is noticed at 11.0 year presumably due to sex differences in the timings of the adolescent growth spurt (Leung et al., 1996). Several other traits like bicondylar femur, upper arm and medial calf circumferences, head circumference and bizygomatic breadth have also manifested a consistent trend of higher means which are evident from boys data for the age period 7.0 to 16.0 years (between studies 2 and 3). Therefore, taken together, these informations provide additional supportive evidence for the occurrence of positive secular trends phenomena for these traits as well. The second studied indicator of body size i.e., the mature/final height, which has been estimated for males by fitting Preece-Baines model 1, shows the increases of 3.0 cm. 1.2 cm. and 1.7 cm. between studies 1 and 3, 1 and 2 and 2 and 3 respectively. These increments are observed to be smaller in magnitude than the increments recorded during the adolescent years. By the same way, in females, the difference in mature height between the two comparing study periods is 3.7 cm. which is also noticeably smaller in magnitude than the increments recorded during the adolescent years (11.8 cm. at 10.0 and 11.0 years). These two features therefore confirm two basic phenomena of auxology. Firstly, the secular trend is more perceptible during the adolescent and younger ages in comparison to the other periods of the postnatal life, e.g. adulthood (Eveleth and Tanner, 1990, Sousa et al., 2012). Secondly, larger the time difference between the comparing studies, the greater is the amount of secular gain in means of these traits (for boys in particular). This is also confirmed from the results of a recent study carried out on the children from Hong Kong (So et al., 2008). It is important to note that, in the present study for boys, the time difference between study 1 and study 3 is larger than the time difference between study 1 and study 2 as well as study 2 and study 3. Like standing height, the other related traits, namely, body weight, sitting height, subischial leg length, and biacromial diameter except bi-iliocristal diameter and total arm length, have also followed the same pattern of change in both sexes (see section 3.3 of chapter 3).

Secular changes in relative contribution of sitting height and subischial leg length to the increase of adult height can be explained in males in particular by comparing the results of all three performed studies. Based on the Preece-Baines model 1 estimated values, the mean final standing height of males is found to have increased by 3.0 cm between studies 1 and study 3. The two major constituents of standing height, namely sitting height and subischial leg length have also increased during the same time interval by 1.2 cm. and 1.8 cm. respectively which implies a greater contribution of the lower segment than the upper one for increase of adult height. Such a trend is uniquely restored when the differences between study 1 and study 2 and between study 2 and study 3 are again compared for these three particular linear traits (Standing height, Leg length and Sitting height), which thereby confirms the occurrence of secular trends with certainty. In Japanese population, increase in mean adult height of males from 1957 to 1977 has been recorded to be 4.3 cm. for which increase of sitting height and leg length are found to be 0.5 cm and 3.8 cm. respectively. This finding also signifies a greater contribution of the lower segment of the body than the upper one for the secular increase of adult height (Tanner et al., 1982). On the contrary, from female data, an increase of 3.7 cm. in adult mean height is noticed between the time difference of study 1 and study 2, where, unexpectedly sitting height contributes more (2.3 cm.) than subischial leg length (1.4 cm.) opposing the positive trends as already recorded for the adult males. This anomaly perhaps has resulted due to the methodological problems encountered in calculating the mean final size of sitting height (see table 3.3l.2b). Increased leg length in adults due to change of time is generally stated to be a sensitive indicator of childhood socioeconomic conditions (Gunnell et al., 1998) and it has been observed to be more eco-sensitive in boys than in girls as evident from one transitional country of Western Europe, namely, Poland (Zadzinska et al., 2012, Grabowska, 2001).

4.4 Secular trends in adolescent growth spurt (mean/median age at maximum increment) and age specific standard deviations of anthropometric traits

It has been stated in the section 1.2 of chapter 1 that decline in mean age at peak height velocity during adolescence due to change of time is generally considered to be one of the important indicators of faster rate of physical maturation of the contemporary children in comparison to the children of the earlier periods. The parameter age at peak velocity is usually calculated from the longitudinal growth data. But in this study the mean age at maximum increment has been treated as an equivalent of mean age at peak velocity for considering as one of the biological parameters of adolecsent growth spurt and accordingly for investigating secular trends. According to Tanner (1988, personal communication) fitting of Preece-Baines model 1 (Preece and Baines, 1978) to the cross-sectional means of wider age ranges provides a more or less efficient estimation of mean ages at maximum increment as well as mean mature size at adulthood. Therefore, in this study Preece-Baines model 1 has been fitted to the cross-sectional means of standing height, body weight, sitting height, subischial leg length, biacromial and bi-iliocristal diameters and total arm length obtained from five series of growth data of both sexes (three for boys and two for girls). Accordingly, changes in mean ages at maximum increment in these traits have been calculated to examine the secular trends. The results obtained on boys in particular, show that the magnitudes of decline of mean ages (at maximum increment) in five of the seven studied traits differ according to the interval between the comparing study periods. For example, the highest decline of mean age is noticed across the time difference between study 1 and study 3 followed by studies 1 and 2 and 2 to 3 in order. In standing height, for example, the decline of mean age from study periods 1 to 3 is by 1.46 year followed by 1.33 and 0.13 years for the remaining two study intervals (studies 1 to 2 and 2 to 3). In body weight the corresponding declining value is 1.04 year observed between study 1 and study 3. Unfortunately, for girls, due to methodological reason (see section 3.3l of chapter 3) mean ages of maximum increment for standing height and total arm length cannot be estimated. Nevertheless, the other remaining five traits, as in boys, have consistently manifested their declines in mean/median age between the time difference of study 1 and study 2. Of these, sitting height and subischial leg length, being the two constituents of standing height as well as body weight have manifested a decline of average ages by 2.53 year, 0.25 year and 2.21 year respectively. In Japanese boys, studied between the years 1950 to 2000, mean ages at peak velocity in standing height, sitting height and subischial leg length are reported to have declined by 2.1 year, 2.0 year and 2.0 year respectively (Kagawa and Hills, 2011). Hence, lowering of mean ages at maximum increment as observed in this study for both sexes support the trend of faster rate of physical maturation of the contemporary Bengali children in comparison to the children of the earlier study periods.

Finally, the trend of increased age specific standard deviation values noticed for standing height and the associated traits due to change of time should also be considered as an important phenomenon for the advancement of the adolescent growth spurt in Bengali population. This particular feature (noticed by comparing five series of growth data set of both sexes) in association with the declining trend of mean ages at maximum increment of seven anthropometric traits provide firm evidences to conclude that the urban Bengali children of the contemporary period have experienced positive secular trends in the form of their early onset of physical maturation.

4.5 Secular trends in age at menarche

In this study only a single measure of sexual maturation, namely, age at menarche, has been considered for investigating the secular trends phenomena in urban Bengali girls. In this sample the median and mean ages at menarche are found to be 11.57 year and 11.80 year, estimated from status quo and retrospective data respectively. These two estimates are found to be lower than the means recorded from the study of Sen, 1988 (though performed in 1966-67) and from the study of Sarkar and Roy (1968), where the mean ages have been recorded as 12.48 year and 12.90 year respectively performed on Bengali girls of Kolkata city more than four decades ago.The comparison reveals that mean age has declined by 0.68 year and 1.1 year respectively in about more than four decades of time interval. The rate of decline is certainly slower in comparison to the longer time interval between the comparing study periods (about four decades). Unfortunately, the median age, obtained in this study cannot be compared with any earlier studies due to unavailability of status quo data. In Maharastrian girls (Western India) the mean age is found to have declined by 1 year 10 months (from 14 year 4 months to 12 year 6 months) from 1962 to 1991 (Bagga and Kulkarni, 2000). In a transitional country of Eastern Europe, namely, Poland, during the period of 1980 to 2000 the mean menarcheal age has declined by 0.59 year for which the process of transition is held as one of the principal mediating factors (Poplawska et al., 2013). A recent study from China shows that median age at menarche of urban girls has decreased by 4.2 months per decade from 1980 to 2004 (Chen et al., 2014). From the results of the present investigation it can be concluded that transition in Kolkata city must have acted as one of mediating factors for lowering of the mean age at menarche of contemporary urban Bengali girls. It may be noted that the girl children sampled in this study are selected from predominantly middle class families.Therefore in future, menarche data should be generated on girls from the families of both higher and lower social strata to examine the magnitude of variation between the social classes during transition. Moreover**,** other measures of sexual maturity should also be considered to study secular trends in both sexes and role of different socioeconomic factors affecting these maturity traits should be examined in Bengali population in future.

4.6 Secular trends in the measures of body shape during growth and at adulthood

Several earlier studies have documented that changes of socioeconomic condition can also alter the body proportion or shape (e.g. sitting height-leg length index) of children and adults of a given population over time (Bogin, 2012, Santos and Coimbra, 1991). Some results obtained in this study agree with this feature to a small extent and they need closer attention for review.

Six measures of body shape or proportion have been considered for investigating the secular trends phenomena of which changes in average body mass index reveals a greater increase in body weight than standing height in both sexes across the comparing five study periods. This particular trend is also noticed in several populations of transitioning countries. For example, in Spanish boys aged 8.5 to 11.5 years increase in mean body mass index between the study periods of 1980 to 1995, ranges in the order of 0.80 to 1.45 kg./m.^{2} (Moreno et al., 2001a). Our corresponding value for boys aged 8.0 to 12.0 years come in the order of 2.9 to 4.44 kg./m.^{2} between the time difference of study 1 and study 3 which is certainly longer in duration than the Spanish study. In Portuguese girls aged 10.0-17.0 years increase in mean body mass index varies from 0.9 kg./m.^{2} to 1.9 kg./m.^{2} during the period of 1996 to 2009 (Sousa et al., 2012). In Vietnamese boys aged 6.0-15.0 years the mean body mass index has increased by 0.3 kg./ m.^{2} and in girls for the same age period by 0.25 kg./m.^{2} in about one decade (1992-2000) of time difference (Dang et al., 2010). Our corresponding value for girls (aged 7.0 to 15.0 year) are considerably higher and ranges from 3.83 kg./m.^{2} to 4.19 kg./m.^{2} perhaps due to longer time interval between study 1 and study 2. Moreover, in our study mean body mass index of adult Bengali males (estimated from the Preece-Baines fitted values) has increased in the order of 17.13 to 17.36 to 21.16 kg./m.^{2} between studies 1, 2 and 3 respectively. For females, the corresponding order of increase of adult values range from 18.08 to 21.86 kg./m.^{2} between the time difference of two study periods (study 1 and study 2). In the neighbouring transitional country of China, adult mean body mass index of males is found to have increased by 1.8 kg./m.^{2} (from 21.6 kg./m.^{2} to 23.2 kg./m.^{2}) while in females by 0.8 kg./m.^{2} (from 22.0 to 22.8 kg./m.^{2}) from the year 1993 to 2009 (Xi et al., 2012). These two increases in particular, are found to be lower in magnitude than the increase found in this study, perhaps due to longer time difference. It is generally stated that increased mean body mass index of the contemporary children is an indicative of general improvement in the standard of living of any given population.

Two inter-related indices of body shape or proportion namely mean sitting height-standing height and sitting height-subischial leg length indices have equally manifested larger gain in lower segments of body before and during the adolescent years. Thereafter a reversal in the form of larger gain in upper segment (sitting height) is observed between the time differences of the studies under comparison. This is considered to be one of the basic auxological phenomena generally observed in both sexes. But when these two indices are calculated on the adult values obtained by fitting Preece-Baines model 1, additional information on changes in adult body shape over time are available for both sexes. For example, in males, the mean adult sitting height-standing height index drops by a smaller magnitude in the order of 52.34 (study 1) to 52.28 (study 2) to 52.18 (study 3). In the same way, the mean sitting height-subischial leg length index for adult males has dropped consistently in the order of 109.68 to 109.06 to 108.77 between the three comparing study periods. But on the contrary, the adult subischial leg length-standing height index in males has increased in the order of 47.72 (study 1) to 47.93 (study 2) to 47.97 (study 3). The changes in three different indices for adults tend to manifest a greater secular increase in leg length than sitting height over the time difference of the comparing study periods. This has been confirmed before on the Preece-Baines fitted values obtained for these two different body segments (see section 3.3l of chapter 3). Unfortunately, for females, the trend is found to be completely reverse i.e. both the first (sitting height-standing height) and the second (sitting height-subischial leg length) index have increased in the order of 52.54 to 52.79 and 110.67 to 111.71 respectively while the third index, i.e. subischial leg length-standing height index, unlike boys, has decreased from 47.48 to 47.26 (between study periods 1 and 2). This type of reversal as noticed in female data, thus opposes the trends observed for males. Hence to establish with certainty the pattern of secular change in adult body shape in both sexes, future studies should be attempted in this population.

The declining trend in age specific mean indices of transverse body shape (bi-iliocristal-biacromial diameter index) due to change of time indicates larger gain in shoulder width than hip width noticed for contemporary children. This particular trend is well documented specially from the results of two extreme comparing study periods in particular (study 1 to study 3 for boys and study 1 to study 2 for girls). Further, when the trend of transverse body shape at adulthood is compared between the study periods on the Preece-Baines fitted values, a similar pattern of decline, as noticed during the growing periods, is also confirmed for both sexes. For example in males, the mean adult index declines from 69.42 to 67.66 while in females the declining order is recorded from 77.53 to 72.41. A more or less similar feature in changing pattern of this index is also reported for German children studied between 1975 and 1995 (Kromeyer-Hauschild and Jaeger, 2000) for which the "reunification", as an important socio political transitional event of the country, has been considered to be one of the responsible factors.

Among the studied measures of head and face shape, increased mean facial index in boys suggests a greater decline of face length than breadth in all ages between the time difference of study 2 and study 3.This new finding, related to changes in face shape of boys due to change of time needs validation from future studies. But the trend of increased mean bizygomatic breadth is also found earlier in Australian aborigines (Brown and Townsend, 2001) between three decades of time difference from 1930 to 1960 (0.20 cm.). In this population, contrary to our results, secular increase of face length is also reported**.** A number of researchers have attributed socioeconomic status or social class (Palsson and Schwidetzky, 1973), allometry (Susanne et al., 1988) and nutrition and diet (Kouchi, 2000) to be the probable factors responsible for the manifestation of secular trends in size and shape of cephalofacial traits. To arrive at any firm conclusion on the role of these factors, large scale cephalofacial studies on adult sample (including the female sample) should be undertaken in future.

4.7 Secular trends in the measures of body composition in boys

In this study it is also found that all six investigated measures of body composition have also undergone notable secular changes in boys for the age period of 7.0 to 16.0 years. Two skinfold sites of upper limb (triceps and biceps) and two of upper and lower trunk (subscapular and suprailiac) have exhibited increased age specific means to signify a greater deposition of subcutaneous fat in Kolkata boys of the transition period.The trend of significant increase of subcutaneous fat thickness is also supplemented by the simultaneous increase in the percentage of body fat of both prepubertal and pubertal boys which is also manifested during the same time interval. Although six different equations have been used for estimating percentage of body fat however, they need further validation from other equations, if available for the Asian or Indian population. In conformity with our results, the means of limb skinfold of the Slovenian children have also increased significantly across the study periods of 1960-1980-2000 (Kotnik and Golja, 2012). Similar changes are also reported for the Norwegian children aged 4-15 years studied between the years 1971 to 2006 which counts a time span of about three decades (Juliusson et al., 2007). The sixth studied measure of body composition considered in the present study is body fat distribution, which tends to show more truncal pattern due to change of time. This is more intensely observed in children from one of the transitional populations of Europe, namely, Spain, studied between 1980 to 1995 (Moreno et al., 2001b). The Jena boys from Germany aged 7-12 years have also manifested a greater deposition of subcutaneous fat in trunk between the study periods of 1985 and 1995 (Kromeyer-Hauschild and Jaeger, 1998). But in Bengali boys the change is not so distinctly observed because of the fact that in this study the summed values of biceps and triceps skinfold thickness are considered to be the value for the limb site. Perhaps, inclusion of the calf skinfold thickness jointly with the triceps (instead of biceps), would have been a suitable combination to examine the secular trends in fat distribution in a better way. Unfortunately, this has not been possible because in 1982-83 Kolkata growth study on boys, data on calf skinfold thickness have not been collected (table 2.10b.ii). Further, even in Sarsuna-Barisha growth study (study 1), skinfold thickness data have not at all been collected from the subjects (table 2.10a.ii). Due to these two reasons the time trends comparison in the measures of body composition has to be limited only for boys aged 7.0- 16.0 years between study 2 and study 3. In spite of these limitations the results of this study related to changes in fat distribution in boys agree well with the results obtained from several other populations of both transitional and non transitional countries like Poland (Kowal et al., 2013) and Belgium (Matton et al., 2007). Pawloski et al. (2008) have commented that during adolescence the centralised fat distribution in association with obesity increases the individual risk of developing several non-communicable diseases which also characterise a transitional population.

4.8 Secular trends in the measures of nutritional status

The changing patterns in four measures of nutritional status for the age periods 7.0 to 19.0 years have been analysed between the time interval of five comparing study periods (three for boys and two for girls). The changes are primarily characterised by substantial declines in the prevalence of stunting and thinness coupled with increases in the prevalence of overweight and obesity (with varied magnitudes by age classes and sex). However, an alarming rise in the prevalence of overweight in association with a small rise in the prevalence of obesity characterise that the Bengali urban population is living in an era of transition. The trend also warns about the likelihood of escalated risk for developing various metabolic disorders among urban adolescents and young adults of future generation. A smaller increase in the prevalence of obesity may be interpreted in the light of the socioeconomic characteristics of the samples where the subjects who have participated in three growth studies belong to predominantly middle class families. On the contrary, it has been observed that an alarming rise in the prevalence of obesity is mostly restricted to the Indian children of higher socioeconomic strata (Griffiths and Bentley, 2001). A number of workers have commented that decline in the prevalence of stunting and thinness in association with simultaneous rise in the prevalence of overweight (without obesity), is one of the important features for the populations living in an early stage of transition (Pena Reyes et al., 2009, Romaguera et al., 2008). The causative factors responsible for this dual manifestation (decline and increase in prevalence) are attributed to the overall improvement in socioeconomic condition and thereby the standard of living of the population. Published data on secular trends in all four studied indicators of nutritional status are still not readily available from any one particular transitional population. However, changes in three such indicators are recently known from Portugal studied between the years 1971 to 2000. In this transitional country of Europe, while prevalence of overweight and obesity has increased in children aged 4.0-11.0 years, the third indicator, namely, stunting has become virtually nonexistent (Varela Silva et al., 2010). Among the Sicilian school children aged 11.0-13.0 years surveyed between the year 1999-2010 the prevalence of both thinness and obesity has significantly decreased by 7.8%, and 5.8% respectively while the prevalence of overweight has insignificantly increased by only 3.8% (Parrino et al., 2012). Studies carried out in other transitional countries including India (Subramanyam et al., 2003), South Africa (Armstrong et al., 2011), Spain (Miqueleiz et al., 2014) and Mexico (Pena Reyes et al., 2009), have also manifested this general pattern of changes. However, the magnitude of such changes in prevalence (increase or decrease) has differed according to age classes, sex, country of origin and interval between the comparing study periods. It is important to mention here that for estimating the prevalence of overweight and obesity, both classifications proposed by both the World Health Organisation and International Obesity Task Force have been adopted in this study due to unavailability of the appropriate cut-off values for children of Asian origin. A number of researchers have argued to adopt ethnic specific cut offs instead of the international ones for calculating the prevalence of the indicators of nutritional status (Wikramasinghe et al., 2013, Deurenberg and Deurenberg, 2003). If in future, the ethnic specific cut off values for children is available, then accordingly a reanalysis of the existing data set may be undertaken. However, for adult populations of Asian origin the World Health Organisation (WHO, 2004) has meanwhile introduced new cut off values for estimating prevalence of the indicators of nutritional status.

To conclude therefore, it can be stated with sufficient evidences that the ongoing process of transition in the city of Kolkata may have acted as one of the primary impulses to change the pattern of physical growth, maturation (pubertal and physical), body shape, body composition and nutritional status of contemporary urban Bengali children over last six decades of time interval. In this respect, the findings support the occurrence of positive secular trends phenomena and thereby agree well with the findings of many equivalent studies carried out on children of different transitioning countries like China (Leung et al., 1996), Korea (Kim et al., 2008), Poland (Woronkowicz et al., 2012, Kryst et al., 2012), Papua New Guinea (Adhikari et al., 2011), Bangladesh (Rah et al., 2009), Brazil (Kac and Santos, 1997) etc. By exception, few measures of body shape seem to have exhibited weak evidences for their changes in the transitional environment. A little manifestation of concurrent negative trend is also observed for few cephalofacial traits and for its confirmation large scale studies should be organised in future. Nevertheless, from the results of this study it is quite evident that the middle class contemporary Bengali population of Kolkata city is now passing through an early stage of nutritional transition.

4.9 Role of possible socioeconomic factors responsible for the manifestation of positive secular trends: Their influences in physical growth, body shape, body composition, nutritional status of the contemporary urban Bengali boys (study 3) and in physical growth, body shape, nutritional status and age at menarche of contemporary urban Bengali girls (study 2) of Kolkata city

Not any single specific factor should be assigned to be responsible for the manifestation of positive secular trends as observed to have taken place in Bengali children between the times interval of four study periods of three growth surveys. An aggregation of multiple factors related to changes in overall socioeconomic and socio-hygienic conditions of the Kolkata city population taken place in about last five decades may be considered as the responsible factors for the observed trends. Unfortunately, till now it has not been possible to gather all relevant information on changes in the primary indicators of socioeconomic and socio-hygienic conditions of Kolkata population that have taken place over last five decades. However, meanwhile, many non-governmental and governmental agencies have been approached for providing this information for better interpretation of the findings of this study. In spite of these limitations, relevant information on some of these indicators is meanwhile available from several published sources. These data may be conveniently used to explain the causes of the positive secular trends. Of these, influences of two, namely, education and per capita monthly income/expenditure level appear to be of primary concern.

4.9a Parental Education

The adult literacy rate of Kolkata population has changed in an increasing order from the year 2001 to 2011. For males, it has changed from 83.79% to 89.08% while for females the respective increasing order is from 77.30% to 84.98% (Census of India, 2011). In our previous Kolkata growth study, the changes noticed in average height, weight and body mass index of Bengali boys aged 7.0-16.0 years over almost two decades of time interval are found to be associated with the improvements in the level of maternal education (Dasgupta et al., 2008). Further, role of improved educational level of both parents for occurrence of positive secular trends in average height, weight and body mass index of children is evident from the studies of several transitional countries like Portugal (Padez and Johnston, 1999), Taiwan (Huang and Malina, 1995), Brazil (Monteiro et al., 1994) etc. Above all its influence in declining the prevalence of stunting and thinness in children are reported from Lesotho (Ruel et al., 1992), Bolivia, Nepal, Pakistan and Peru (Frongillo et al., 1997).This particular finding also concurs with the results of our previous Kolkata study (Dasgupta et al., 2008). Frongillo et al. (1997) have commented that a decrease in national stunting is usually indicative of improvements in overall socioeconomic condition of a country which has also reflected from the results of this study. From other Indian studies the risk of both underweight and stunting are found to be significantly higher among the tribal children (0.0-5.0 years) of illiterate mothers of different states (Meshram et al., 2012). Reed et al. (1996) have commented that in the middle class population improved maternal education is related to improved nutritional status of children and this association is not so pronouncedly noticed in the poor segment of the society. It may be noted that the sample used in this study represents the children from predominantly middle class Bengali families. Besides its important role in manifesting the secular trends phenomena, the growth enhancing effect of improved parental education is also evident for increased standing height, sitting height, subischial leg length, body weight, body mass index, percentage of body fat mass, triceps and subscapular skinfolds, the lower prevalence of thinness in children and early onset of menarche in girls as revealed from the results of this study. Moreover, the association between lower prevalence of stunting of contemporary children with improved parental education as found is this study, also agree well with the results of the studies carried out in two transitional countries like Papua New Guinea (King and Mascie-Taylor, 2002) and Morocco (Lopez et al., 2012). In the neighbouring country Bangladesh, improved fathers' education is found to be associated with early onset of menarche of their daughters (Akhtar and Islam, 2012) which also concurs with the results of this study. Thus the association between improved parental education and better growth status with faster rate of pubertal maturation in children appear to be an established fact which has revealed from many auxological investigations.

4.9b Income/Expenditure

The second possible primary factor for socioeconomic development can be related with changes in the level of per capita income/expenditure. In India, the average per capita income per year has increased from INR 12,19,155 (1991-92) to INR 47,94,227 (2012-13) calculated according to the price index of 2004-05 (Ministry of Statictics and Programme Implementation, 20I4). This increasing trend may be held as the responsible factor for the improvement in general standard of living of people living in middle social strata, which is more likely to result in improved growth and nutritional status of contemporary children. Unfortunately, per capita income/expenditure data for the earlier decades like 60s, 70s and 80s are not yet readily available for the entire country as well as for Kolkata city, though continued effort is being made to collect this relevant information. However, from the results of our previous Kolkata study, it is evident that improved per capita monthly expenditure of the family over about two decades of time interval has been responsible for the manifestation of positive secular trends in average height, weight and body mass index of Bengali boys aged 7.0-16.0 years (Dasgupta et al., 2008). Improved growth status of contemporary children due to increased income level of the country is also reported from Papua New Guinea (Norgan, 1995) and Brazil (Castilho and Lahr, 2001). A similar interpretation has been proposed in a different way in explaining the results of the studies carried out in few transitional countries. In these countries like China (Shen et al.1996), Syechelles (Marques-Vidal et al., 2008), North East India (Mungreiphy and Kapoor, 2010), Brazil (Welch et al, 2009) and Ghana (Nube′ et al., 1998) changes in economic policies, rapid epidemiological transition, greater economic development, greater involvement in market economy, improved standard of living etc. are attributed for the manifestation of positive secular trends in physical growth of children and body composition of the adults. Like parental education, the growth enhancing effect of income/expenditure level of family is also a well recognised fact that has been revealed from many studies. In the present study as well, the effect of per capita monthly expenditure level is found to be significant for increased means in standing height, sitting height, body weight, body mass index, percentage of fat mass, triceps and subscapular skinfolds with decreased prevalence of thinness in children. Moreover, its effect is found to be significant for increased subischial leg length and decreased prevalence of stunting in girls. Thus the effect of the socioeconomic factors on the studied measures appears to vary according to gender. In Brazilian population, dual effects of income and wealth are found to be associated with improved fatness and higher prevalence of overweight (Matijasevich et al., 2009), while in Kenyan population such an effect is more intense for the people of higher income group (Steyn et al., 2010). A positive correlation between socioeconomic status and body mass index is reported from the data of the National Family Health Survey, India

(Subramanian et al., 2009) studied over two time points. Our two time point small scale study, performed on Kolkata boys in the year 1982 and in 1999-2002, has also documented a similar pattern of change (Dasgupta et al., 2008). In studies carried out from the developed countries, the economic condition of the families is usually judged from the income level. But for the population of third world countries expenditure level of the family has appeared to be a more dependable index for determining the socioeconomic condition. Although in this study both improved parental education and per capita monthly family expenditure level have influenced several common studied measures, in a number of studies carried out in different third world countries e.g. in Lesotho (Ruel et al., 1992), it has been shown that the magnitude and significance of the effects of maternal education can exceed the effect of income level (Reed et al., 1996). However, for investigating the relative contribution of these two primary socioeconomic indicators a reanalysis of the existing data may be carried out in future.

4.9c Size of Household/Sibship

A little evidence still exists to confirm that decrease in the size of household and sibship also greatly influence the occurrence of positive secular trends in physical growth and maturation of children. Studies carried out in several European countries like Scotland, England and the Netherlands have shown that smaller sibship size may be one of the determining factors of positive secular trends in height and body mass index of children (Chinn et al., 1989, Fredricks et al., 2000). In the context of the present study an example may be cited by comparing the results of two earlier growth surveys performed on boys. In the 1982-83 Kolkata growth study, the percentage of families of school boys with more than one sib is found to be 29.89%, which in 1999-2011 study period, has sharply declined to 5.05%. During the same time interval the percentage of the families of school boys with no sibs has increased from 23.29% to 46.67%. Both these trends, therefore, clearly manifest a tendency of having smaller household and sib size for the families of the contemporary school boys. These dual changes may also be held as one of the possible factors for exhibiting positive secular trends in a few measures of growth and maturation of contemporary children of the transition period. The growth enhancing effect of smaller sibship size is also evident from the results of this study where its effect is found to be significant for increased body weight, percentage of body fat mass, triceps and subscapular skinfold thickness and truncal body fat distribution in boys. Moreover, this household variable is equally responsible for increased body mass index, decreased prevalence of thinness as well as early onset of menarche in girls which, in addition, supports a notable association of higher adiposity level and early sexual maturation in girls with smaller size of sibship. At the same time low birth order is observed to have affected four traits common for both sexes. They are increased percentage of body fat mass, triceps and subscapular skinfolds as well as decreased prevalence of thinness. Moreover, the effect of low birth order in girls is found to be associated with increased body weight and body mass index. It is therefore quite evident that several common traits related to adiposity level may have responded to changes in the frequencies of these two family variables (sib ship size and birth order) over time. In a recent study carried out among Polish boys aged 7.0-16.0 years greater height and body mass index are found for children with sibship size 1-2 than 3 or more (Suliga, 2009). More important to note that in this country where the socioeconomic transition has been initiated in 1980, sibship size has been found to have played a more important role than socioeconomic status in explaining the variability in body mass index of children after the year 1990 (Koziel et al., 2004).

A significant influence of sib size in lowering the mean age at menarche is also reported from Spain (Apraiz, 1999) where single daughters have manifested the earliest median age of menarche (12.48 year) followed by four or more children (12.60 year) and then by two children (12.75 year) and finally three children (13.01 year). In Turkey, a decline of mean age at menarche at the rate of 1.44 months per decade is reported to be associated with the number of siblings which implies a faster rate of pubertal maturation of girls living in smaller sib families (Adali and Koc, 2011). From the results obtained on the contemporary urban Bengali girls of Kolkata city, it is observed that having a sibling reduces the possibilities of having earlier onset of menarche. Therefore, for measuring the relative influences of increased per capita expenditure and decreased size of sibship for the manifestation of a higher adiposity level and earlier sexual maturation in Bengali girls, a reanalysis of the existing data set for different sib categories should be performed in future.

4.9d Father's Occupation

The National classification of occupation (National Classification of Occupation, 2004) has classified the occupation of the people of India under nine categories like (i) Legislators (ii) Professionals (iii) Associate professionals (iv) Clerks (v) Service workers, Shop and Market sales workers (vi) Skilled agricultural and Fishery workers (vii) Crafts and related trade workers (viii) Plants and Machine operators and assemblers and (ix) Elementary occupations. However, the type of fathers' occupation recorded in the present study does not exactly correspond with this classification. Therefore, following our two-way classification it is found that fathers in service and in business have affected a small number of traits and hence fathers' occupation appears to be less important socioeconomic indictor for consideration in this growth study. Parental education and occupation are not found to be always correlated and the degree of their association differs from population to population and sample to sample. Otherwise they would have affected more or less similar type of traits. Perhaps due to this reason the effect of parental occupation is generally considered as less important for growth studies when performed on the children of the third world countries. But for the populations of the industrialised countries, parental occupation is generally considered to be more important indicator of socioeconomic status due to their social structure and hierarchy where the occupational categories are better defined. Therefore, it would be wise to consider parental education and family expenditure as the sensitive indicators of socioeconomic status in performing growth studies on children of third world countries. As far as mothers' occupation is concerned, most of them are reported to be housewives (table 3.1.i). Therefore, in this study the effect of mothers' occupation on the measures of growth and nutrition of the contemporary Bengali children has not been attempted.

4.9e Health and Hygiene

Reviewing global literature it becomes apparent that few indicators of health and hygiene, namely infant mortality and morbidity rates are also associated with the manifestation of positive secular trends in physical growth and maturation of children (Malina, 1979, Sobral, 1990, Blanksby, 1995). Studies carried out in Italy, Austria and Portugal, show that a decrease in post neonatal mortality rate with increased level of survival to adulthood are related with increased mean height of populations (Ulizzi and Terrenato, 1982, Schmidt et al., 1995, Padez and Johnston, 1999). In Kolkata city the infant mortality rate is found to have decreased from 44% to 25% per thousand individuals between 1988 to 1991 (Dutta Roy,

2002) while for the entire state of West Bengal it has declined from 38% to 35% between the year 2005 and 2011 (State Bureau of Health Intelligence, Directorate of Health Services, Government of West Bengal, 2011). Two sensitive indicators of health i.e., life expectancy at birth (for both sexes) for the entire state of West Bengal has increased from 57 year to 64 year between 1970-1975 to 2001-2005 (http://www.wbhealth.gov.in/) and the child immunisation rate has also increased from 52.3% to 70.8% between 1993 to 1996 (Chatterjee and Ghose, 2001). Three components of Human Development Index, namely health index, education index and per capita income index for the city of Kolkata in 1981 has been recorded in the order of 0.73, 0.71 and 0.73 respectively. But in the year 2004, the index values of the first two components have increased in the order of 0.82 and 0.80 respectively while the respective value of the third component namely per capita income index remains the same (0.73). The overall value of Human Development Index of Kolkata city for the same time span has increased from 0.74 to 0.78 (West Bengal Human Development Report, 2004). Therefore, the increased value of this index should also be taken into consideration for one of the supportive evidences to result into positive secular trends as revealed from the results of this study.

This study has made an attempt to explain firstly, the causes of the observed positive secular phenomena in the light of socioeconomic change and secondly, to find out the role of several socioeconomic factors for causing variability in few measures of physical growth, body shape, body composition, nutritional status of contemporary Bengali children and in age at menarche of contemporary Bengali girls. In Poland, a multivariate statistical analysis has been performed to explain the variability in anthropometric traits in relation to different socioeconomic factors. The study has revealed that the socio environmental differentiation of the bodily traits manifest itself in different manner depending on the nature of trait, gender and age. In comparison with the girls, the boys showed a greater eco-sensitivity of body height and mass, lesser eco-sensitivity in body mass index (Gabrowska, 2001). Our results based on primary analysis of data, tend to show similar evidence. Therefore, to measure the magnitude and extent of gender variation of socioeconomic factors in influencing the variables of growth, nutrition, body composition etc, of Bengali children further analysis of the existing data should be undertaken. At the same time it should be remembered that the psychological, behavioural and physiological connections to link the socioeconomic condition is still a poorly understood issue of current debate (Cohen et al., 2010) on which further research is warranted from the third world countries.

4.10 Unexpected results and their possible explanations

Some results generated from this study appear to be both unexpected and exceptional from the viewpoint of secular trend investigation and therefore they need some clarifications.

Firstly, the means of morphological facial height in boys are observed to have decreased consistently over the time difference of last two studies (study 2 to study 3) which reveal a negative secular trend (table no 3.3f.vii). In the world literature there exist little evidences for decline of face length due to change of time. However for its confirmation further studies should be performed in this population on a larger data base (extending upto the period of adulthood). Secondly, between the same time span the age specific mean indices of head form in boys have not manifested any consistent pattern of change (table 3.3i.ii) and thereby do not support the theory of brachycephalisation (more increase in head breadth than length over changes of time) as reported from several Asian countries. Hence to come into any firm conclusion about the trends of these two measures (face length and head shape), further analysis of growth data of children and adults of Sarsuna-Barisha growth study (study 1) beyond 16.0 year of age should be undertaken as a base line for future investigation.

The third unexpected finding may be referred to the inconsistent trend of changes manifested by mean biiliocristal diameter for girls. The mean mature/final size of bi-iliocristal diameter in girls has declined between the time differences of study 1 and study 2 by two ways. Firstly, when the differences (between the studies) are calculated from Preece-Baines estimated values, the mature size declines by 0.59 cm. (table 3.3l.2e). Secondly, when such difference is estimated from the measured values at 21.0 year the mean also declines by 1.1 cm. (table 3.3e.2d). Hence, these two consistent declines opposing the positive secular trend may possibly be explained by the following way. From the results given in tables 3.3h.1d and 2d, it is observed that the age specific means of bi-iliocristal-biacromial diameter index in girls have declined at all ages from 7.0 to 21.0 years between the time difference of study 1 and study 2. It therefore signifies a greater decline of bi-iliocristal than biacromial diameter during the growing period. Thus a consistent decline of this ratio during the growing period has been continued till adulthood when it again declines from 0.775 to 0.724. The declining trend implies a greater magnitude of increment in biacromial diameter than bi-iliac due to changes of time which may possibly have continued till adoulthood to result a negative secular trend in bi-iliocristal diameter.

The fourth deviation from the expected results may be related to the trend shown by total arm length. In males, the mean final/mature size of total arm length estimated from Preece-Baines model 1 is found to have declined between studies 1 and 2 and 1 and 3. Also in females, a similar decline is observed between study 1 and study 2. Both these features signify a negative secular trend which has occurred between the time difference of three comparing study periods (tables 3.3l.1f and 2f). Now, when for boys the difference between study 2 and study 3 is compared, a notable increase of mean total arm length (by 0.85 cm.), together with a decline of mean age at maximum increment (by 0.09 year) are clearly observed. These two features characterize the phenomena of positive secular trends. Therefore, the inconsistencies in the form of both negative and positive trends as observed over four study periods altogether may be interpreted by the following way. In study 1 (Sarsuna-Barisha growth study), total arm length has not been measured straightway from the anthropometric landmark of Acromion-Dactylion points. For the purpose of data analysis, it has been derived by summing up the values of three individual measurements, namely, hand length, forearm length and upper arm length measured from the subjects by S. R. Das (the late), the principal researcher of this study. But for other two studies on boys (studies 2 and 3) and for one study on girls (study 2), total arm length has been measured from the subjects straightway from the Acromion-Dactylion land marks by Parasmani Dasgupta and his students Rana Saha, Samrat Paul and Rituparna Das respectively (see figures 2.7.via and 2.7.vib). Therefore, the discrepancy found between the direct and the derived measurement of total arm length may be held as responsible for manifesting a negative trend between the time interval of the aforementioned three pairs of the comparing studies (studies 1 to 2 and 1 to 3 for boys and 1 to 2 for girls). However, between studies 2 and 3 for boys, as usual, the positive secular trends are restored**.**

The fifth important deviation from the expected results may be related to one of the three studied biological parameters of the adolescent growth spurt, namely, peak velocity (estimated from Preece-Baines model 1). This particular parameter has generated many inconsistent trends over the three comparing study periods on boys and two on girls for all seven studied anthropometric traits (for example, see table 3.3l.1a). However, a similar inconsistency of this parameter has also been revealed from the results of a recent study where secular trends in four anthropometric traits (standing height, sitting height, subischial leg length and body weight) of Japanese children have been studied between the year 1950 to 2000 (Kagawa and Hills, 2011). But the actual explanation of this inconsistent behaviour of this parameter is yet to be revealed.

The sixth and the final deviation from the expected results may be related to sitting height-subischial leg length contrast during growth. It is well established that during adolescence, out of the two major segments of standing height, leg length reaches its peak before sitting height (Tanner, 1990, Dasgupta and Das, 1997). This particular phenomenon is very transparent from the results generated from all three growth data sets of boys and one data set of girls (study 1). But exceptionally, in girls data of study 2, this basic contrast is not reflected, where instead, a reversal is noticed, i.e. sitting height has reached its peak before subischial leg length. This observed feature should be considered as a very unusual contrast in auxology which may possibly have occurred due to methodological reason, like unavailability of mean ages at maximum increment for both standing height and sitting height from Preece-Baines model 1 (see tables 3.3l.2a and 2b).

4.11 Limitations of this study

Majority of the findings presented in this study support the occurrence of the positive secular trends phenomena. But such a straightforward interpretation has several limitations as well. The first and the foremost limitation arises in quantifying the amount of secular changes taken place in the studied measures according to decade/year/month. Around the world, growth data on secular trends are mostly presented decade/year/month wise etc. in accordance with the nature and the duration of the performed surveys. In this study it has not been possible to present the results following this format since three growth studies differ in nature and in respect to time span. For example, study 1 (Sarsuna-Barisha mixed-longitudinal growth study) has continued for fourteen years from 1952-1966 for which it becomes difficult to present the findings specifying any particular decade. But study 2 (Kolkata cross-sectional growth study) has continued only for two years from 1982 to 1983 and therefore the kind of difficulty that has been faced in presenting the results of Sarsuna-Barisha study, does not arise for this study. Again the duration of study 3 for boys (in two phases of 1999-2002 and 2005-2011) and study 2 for girls (2005-2011), though cross-sectional in nature, nevertheless have continued for 12 years and 6 years respectively which are unusually long in duration. Hence in this report the secular data have not been presented decade wise. Instead, they have been compared and interpreted in relation to the time interval between the performed surveys without specifying any decade. Therefore, the presented results should be interpreted with little reservation.

Secondly, Sarsuna-Barisha growth study (study 1) is family based in nature and has been carried out by the mixed-longitudinal method. As a result the participants of this study are related and have been measured over a number of occasions which eventually has reduced the magnitude of variability in the studied somatic traits. Such reduction in variability in the studied anthropometric traits would not have occurred to that extent if the study would have been a population based. On the other hand, the remaining two studies, namely, Kolkata growth study of 1982-83 (study 2) and Kolkata growth study of 1999-2011(study 3 for boys and study 2 for girls) are purely cross-sectional in nature and population based where the participants are unrelated and have been measured in one occasion only. Therefore, the magnitude of secular changes taken place in the studied measures should be interpreted with reservation.

Thirdly, the size of the sample used in three comparing growth studies is not representative of the entire middle class Bengali population of Kolkata city. For example, according to 2011 census, the number of total Bengali population in Kolkata city constitutes 44,86,679 people (Census of India, 2011) of which 3,00,052 belong to child population (0-6 years). On the other hand, the total sample used in the present study constitutes only 4,194 children combining two sexes. Moreover, an unequal age distribution of samples of both sexes of three comparing growth surveys may be considered as one of the probable factors for obtaining few unexpected results.

Finally, the fourth limitation of this study may be related to socioeconomic data. The items of socioeconomic data that have been collected in both Kolkata growth study of 1982-83 and in current Kolkata growth study of 1999-2011 have not at all been collected in Sarsuna-Barisha growth study. This incompleteness has developed another limitation for investigating time trends of socioeconomic factors in relation to changes in growth variables. Fortunately this kind of association has only been possible to know for boys by comparing the socio demographic traits of Kolkata growth study of 1982-83 and of 1999-2011 (see chapter 2). But for girls, unfortunately, equivalent socioeconomic data collected in study 2 (Kolkata growth study of 2005-2011) have not been collected in study 1 (Sarsuna-Barisha growth study of 1952-66). As a result, for girls, like boys, such kind of association between the socioeconomic and growth variables over change of time cannot be studied. Therefore to conclude this section, it may be stressed that in planning future studies on secular trends in auxology of Bengali population, careful attention should be given to overcome all the aforementioned limitations.

CHAPTER 5

CONCLUDING REMARKS

The three series of growth data which have been utilised to prepare this report have not yet been fully analysed. They still have a great potential in unfolding many unknown aspects of Auxology of Bengali population through re analysis. Several important Auxological issues may be handled from these data sets. For example, the first one may be related with investigating the secular phenomena on interrelationship between different studied measures, for example, body composition and nutritional status. Secondly, an investigation may be udertaken for the first occassion on upper arm anthropometric body composition in relation to age and gender and its secular trend in boys. Thirdly, a cross-sectional growth study of Somatotyping in children in relation to age, gender, age at menarche, body composition and associated measures, may be attempted from the data set of the current study period for the first time as well.

So far, the following three papers have been published from the data of this project.

1. Dasgupta, P., Saha, R. and Nube′, M., 2008. Changes in body size, shape and nutritional status of middle class Bengali boys of Kolkata, India, 1982-2002. **Economics and Human Biology, 6: 75-94.**

2. Saha, R. and Dasgupta, P., 2006. Secular trends in measures of cephalofacial traits among Bengali boys aged 7.0 to 16.0 years from Kolkata between 1982-83 and 1999-2001. **International Journal of Anthropology, 21: 33-43.**

3. Sedigheh, M. S., Sengupta, D. and Das, R., 2014. Parametric estimation of menarcheal age distribution based on recall data. **Scandinavian Journal of Statistics. doi 10.1111/sjos.12107.**

Besides these papers, the results of new analysis to be undertaken on the entire data set will have strong possibilities to get published in different scientific journals of national and international repute.

A major portion of the findings presented in this report has been used to develop three Ph.D. theses on the following titles.

1. Sex differences and secular trends in physical growth and nutritional status of the Bengali Children of Calcutta, India (Anthropology, Calcutta University, India.).

2. Age at menarche of urban Hindu Bengali Girls (Kolkata): Socio-cultural determinants and effects on Growth, Nutritional Status and Body Composition (Nutrition and Home Science, Calcutta University, India).

3. Inference on aspects of Human Growth (Statistics, Indian Statistical Institute).

In order to disseminate the results generated from this study with the results obtained from other related studies carried out in different transitional populations a project- linked

International Symposium titled " Countries in Economic Transition: evidences from auxology and related areas" has been planned to be organised in Indian Statistical Institute, Kolkata, India. Many researchers of auxology and allied disciplines working in different transitional countries have sent their initial consent of participation in the Symposium. The final date of the Symposium will be announced later.

This small scale project has made a primary attempt to investigate the occurrence of secular phenomena in different aspects of somatic growth, nutrition etc. of children of an Indian population during transition by analysing three data sets. However, similar attempt may be made for children of both lower and upper socioeconomic strata because it is already known that the magnitude of variation between the social classes has escalated of late due to transition. This fact is also confirmed from the results of two recent studies carried out in two transitional countries. Firstly, in Brazil, positive secular trend in the form of lowering of mean age at menarche is reported to have occurred among the girls of lower strata in a more intense way than girls living in the upper social strata (Junqueira Do Lago et al., 2003). Secondly, the Chilean girls from all socioeconomic strata are stated to have manifested significant declining trends in mean age at onset of menarche (Amigo et al., 2012). These two evidences are therefore well enough to justify the importance of performing growth and maturation studies on children from all social strata in order to monitor the rate of secular changes and the time of its final cessation in different ethnic groups of India during the transitional era. It is to be further emphasised that this small scale study has been aimed to focused the importance of one of the transitional processes namely, socioeconomic, in changing growth and nutrition characteristics of contemporary urban Bengali children. But the studies on the impact of other three major transitional processes (stated earlier) in changing growth and nutrition profile of contemporary children, are equally important and may be explored in the years to come. Therefore, it is hoped that the researchers of the new generation would be involved to formulate the appropriate strategies and approaches to face these primary challenges of Auxology research in India.

Reviewing published literature on Auxology of Indian population it becomes quite clear that the number of studies undertaken in this field during the transition period of the country are still inadequate in number in relation to the area of the country and its population size. The transitional era therefore demands their rapid increase in infants, children, adolescents and young adults of different ethnic groups living in varied physical and socio-cultural environments of this country. Monitoring of primary health and nutritional status should be the principal goal of these studies which in course of time would be an integral part of the national health programme with the support of the professional auxologists of the country. However, before initiating these studies the most fundamental task would be to develop countrywide awareness programme about the importance of growth studies (Auxology) to facilitate unhesitating co-operation and support from the people of the country during collection of required growth data. For example, in the context of the present study, when 2,195 Bengali urban girls of Kolkata city have been approached for collection of data on age at onset of menarche, only 444 girls are able to provide reliable retrospective data by recollection. Thus a poor response rate has obviously resulted due to lack of awareness of urban people in keeping this basic information on the girl child. Now if all parents of these girls would have maintained an authenticated record of the exact date of onset of menstruation of their daughters and accordingly reported it to the data collectors, then within a short span of time it would have been successfully possible to generate a reliable data base for at least one indicator of pubertal maturation of contemporary girls of any given population (or the whole country) in relation to different socio-cultural and genetic factors. That is why a countrywide awareness programme on these and other related issues is strongly needed with the intervention of the Ministry of Health, Government of India. The programme needs support and collaboration of medical practitioners, public health scientists, epidemiologists and social workers etc. of the country. China, being one of the neighbouring states of our country has already undertaken a large number of auxological studies throughout the country soon after the implementation of the Economic Globalisation Programme during the early 80s. As a consequence prolific numbers of publications related to transition and auxology of Chinese population have appeared in various scientific journals over the last few decades. An enormous amount of data generated from these investigations have been utilised for monitoring health, growth and nutrition of Chinese children. India, although implemented this programme of economic reforms more than a decade after China, but in the changed socioeconomic scenario of the country, well planned and carefully designed auxological studies with uniform data collection procedure should be carried out countrywide. The outcome of such studies would be useful for generating basic information related to public health situation which will be necessary in framing health policy for the entire country in the globalisation era. Besides this, for fulfilment of various scientific queries related to biology of human population during the transitional era, it seems to be the most appropriate time to set up several research institutes in the country focusing interests in human Auxology, human nutrition, body composition and physical activity etc. It may be expected that the researchers of these institutes from the discipline of Physical Anthropology, Human Physiology, Biochemistry, Human Nutrition and Statistics would collaborate to explore many relevant issues related to transition and human health. These are the new areas of important research that have rapidly emerged in many transitional countries of the world due to implementation of the Economic Globalisation Programme. Although the infrastructural facilities, required to persuade this kind of interdisciplinary research, are not readily available throughout the country at the moment, therefore, the existing public health based research institutes may be reorganised with this goal. But, above all, the primary task would be to develop strong manpower in the country in the respective specialised areas of research in collaboration with the foreign institutions through various academic exchange programmes.

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FIGURES

Fig- 2.2: Location of the state of West Bengal in India and Kolkata city in West Bengal

Fig-2.2

Fig- 2.5: Location of the field areas in Kolkata city

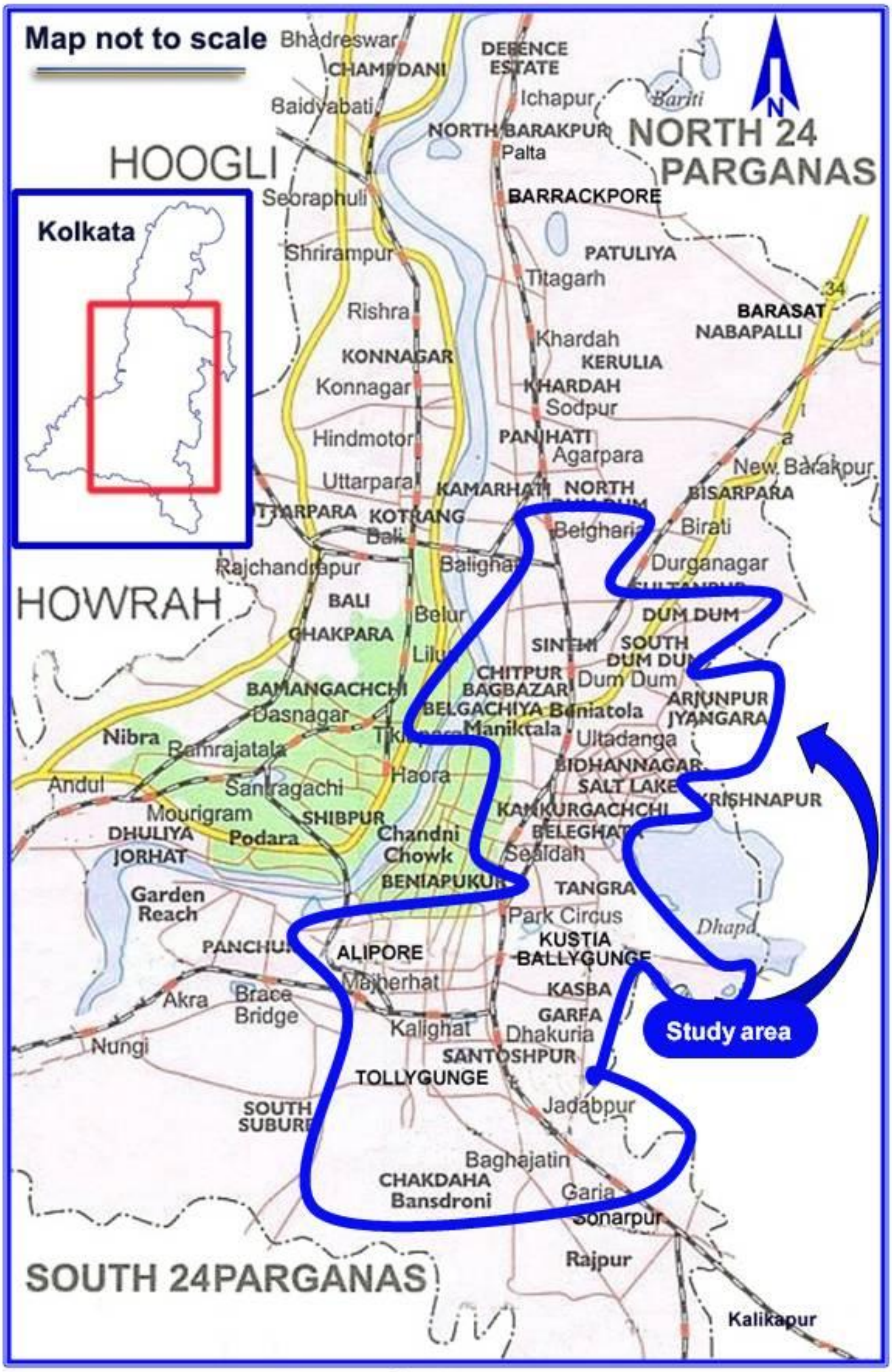


Fig-2.5

Collection of anthropometric data

Standing Height (SHT)

Fig-2.7.ia

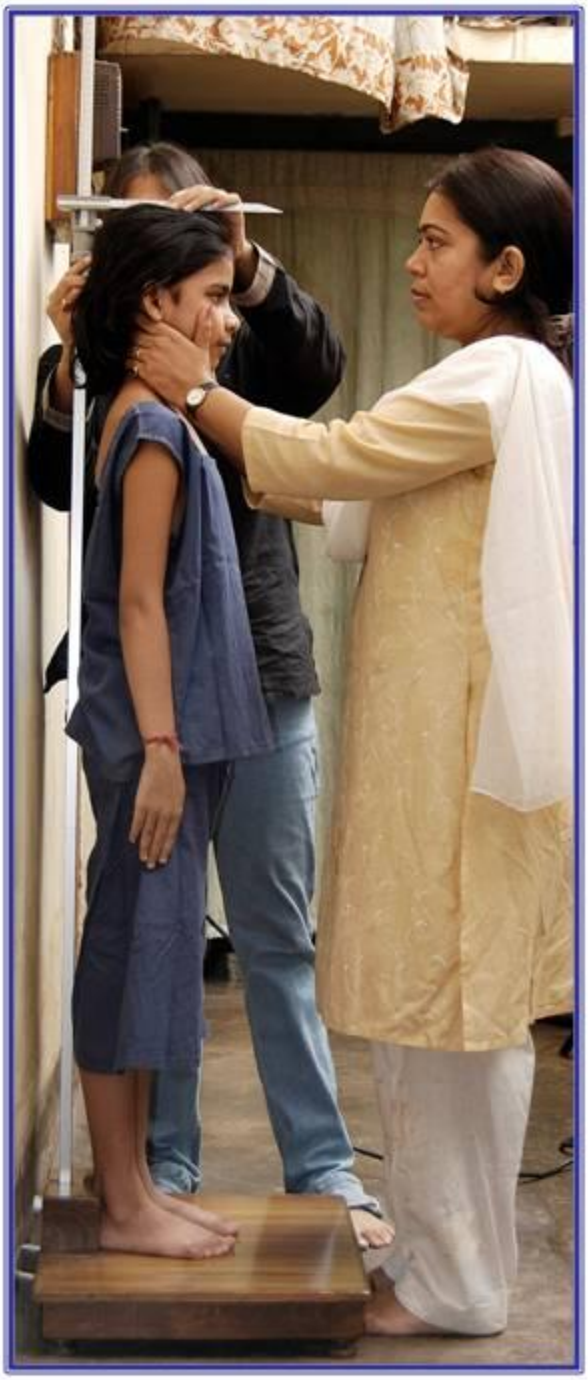


Fig-2.7.ib

Sitting Height (SH)

Fig-2.7.iia

Fig-2.7.iib

Biacromial Diameter (BAD)

Fig-2.7.iiia

Fig-2.7.iiib

Bi-iliocristal Diameter (BID)

Fig-2.7.iva

Fig-2.7.ivb

Total Arm Length (TAL)

Fig-2.7.va

Fig-2.7.vb

Bicondylar Humerus (BH)

Fig-2.7.via

Fig-2.7.vib

Bicondylar Femur (BF)

Fig-2.7.viia

Fig-2.7.viib

Upper Arm Circumference (UAC)

Fig-2.7.viiia

Fig-2.7.viiib

Calf Circumference (CC)

Fig-2.7.ixa

Fig-2.7.ixb

Head Length (HL)

Fig-2.7.xa

Fig-2.7.xb

Head Breadth (HB)

Fig-2.7.xia

Fig-2.7.xib

Head Circumference (HC)

Fig-2.7.xiia

Fig-2.7.xiib

Morphological Facial Height (MFH)

Fig-2.7.xiiia

Fig-2.7.xiiib

Bizygomatic Breadth (BB)

Fig-2.7.xiva

Fig-2.7.xivb

Triceps Skinfold (TS)

Fig-2.7.xva

Fig-2.7.xvb

Biceps Skinfold (BS)

Fig-2.7.xvia

Fig-2.7.xvib

Subscapular Skinfold (SSS)

Fig-2.7.xviia

Fig-2.7.xviib

Suprailiac Skinfold (SIS)

Fig-2.7.xviiia

Fig-2.7.xviiib

Medial Calf Skinfold (MCS)

Fig-2.7.xixa

Fig-2.7.xixb

Abdominal Skinfold (ABS)

Fig-2.7.xxa

Fig-2.7.xxb

Body Weight (WT)

Fig-2.7.xxia

Fig-2.7.xxib

Collection of household data

Fig-2.7.xxiia

Fig-2.7.xxiib

Fig-3.3b.1a: 10th percentile lines of body mass index of boys for three study periods

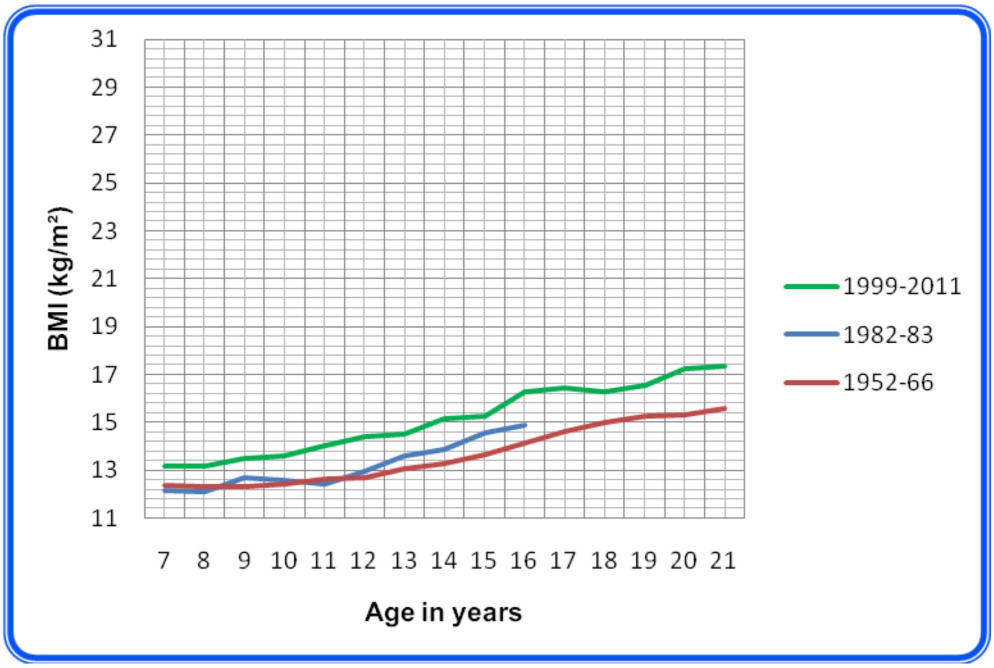


Fig-3.3b.1b: 50th percentile lines of body mass index of boys for three study periods

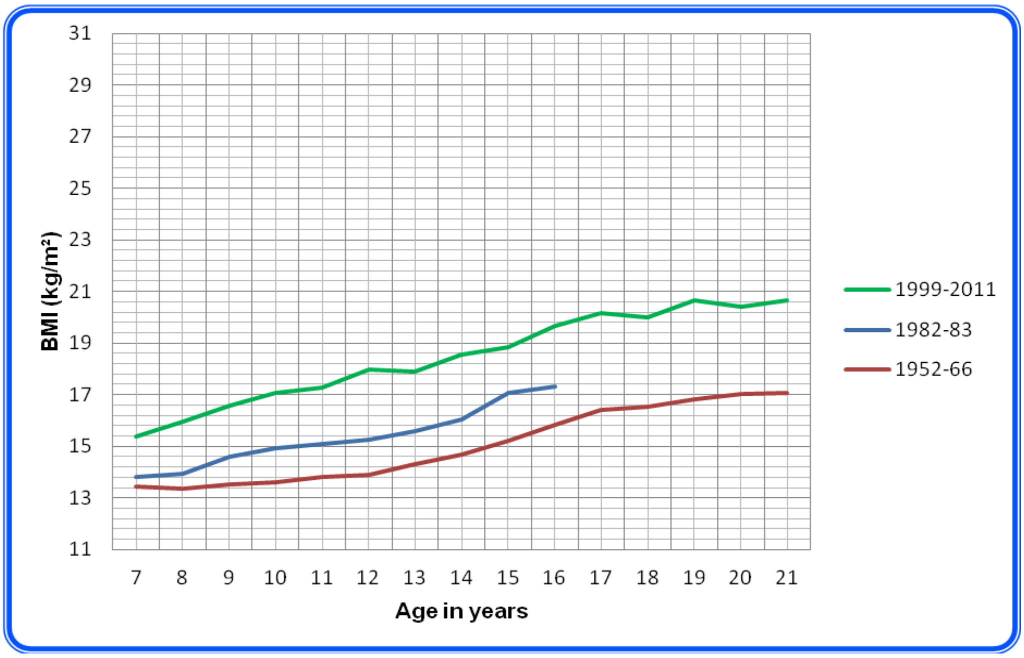


Fig-3.3b.1c: 97th percentile lines of body mass index of boys for three study periods

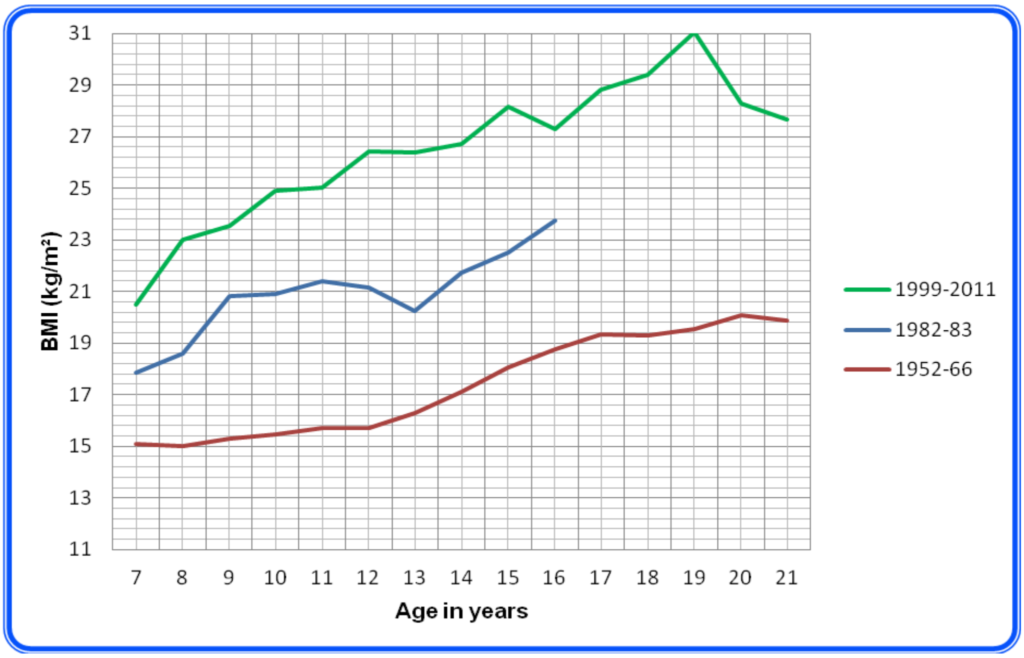


Fig-3.3b.1d: 50th percentile lines of body mass index of boys obtained from three study periods in comparison to the same from the WHO (2007)

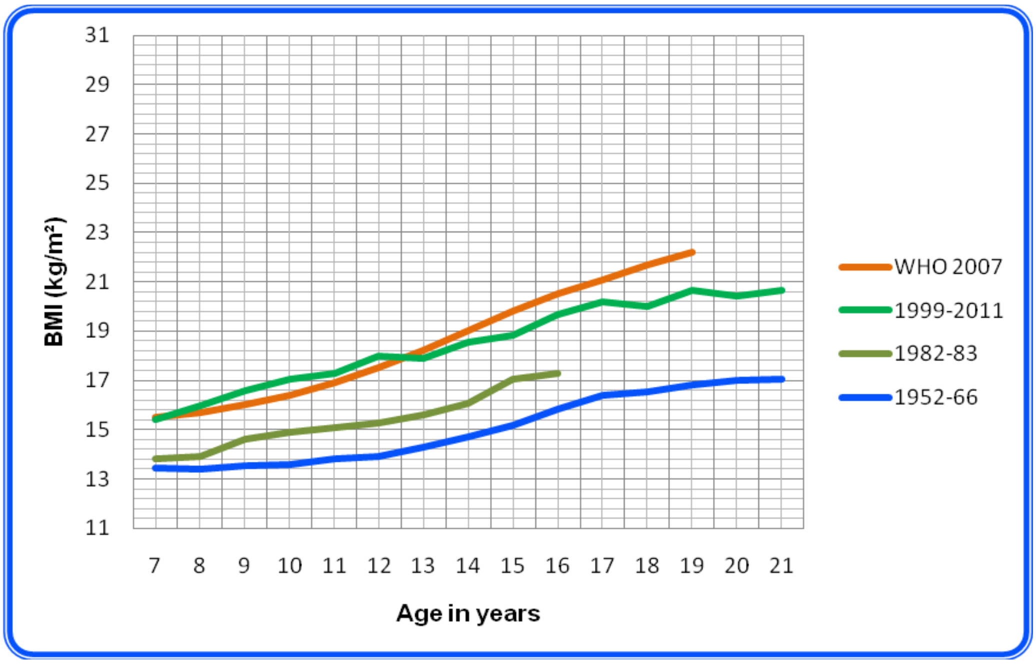


Fig-3.3b.2a: 10th percentile lines of body mass index of girls for two study periods

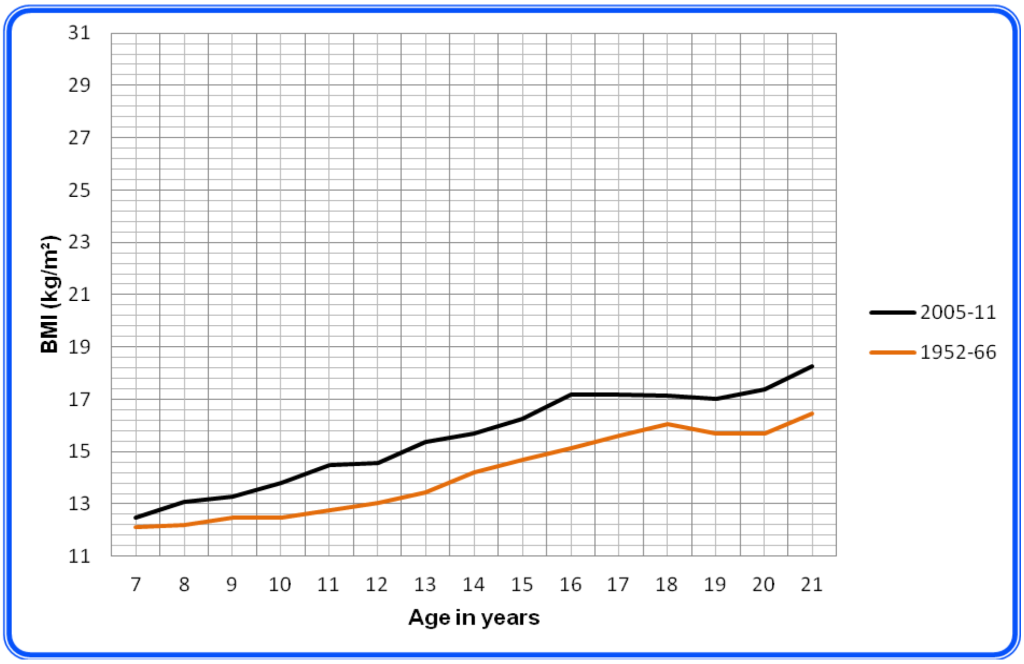


Fig-3.3b.2b: 50th percentile lines of body mass index of girls for two study periods

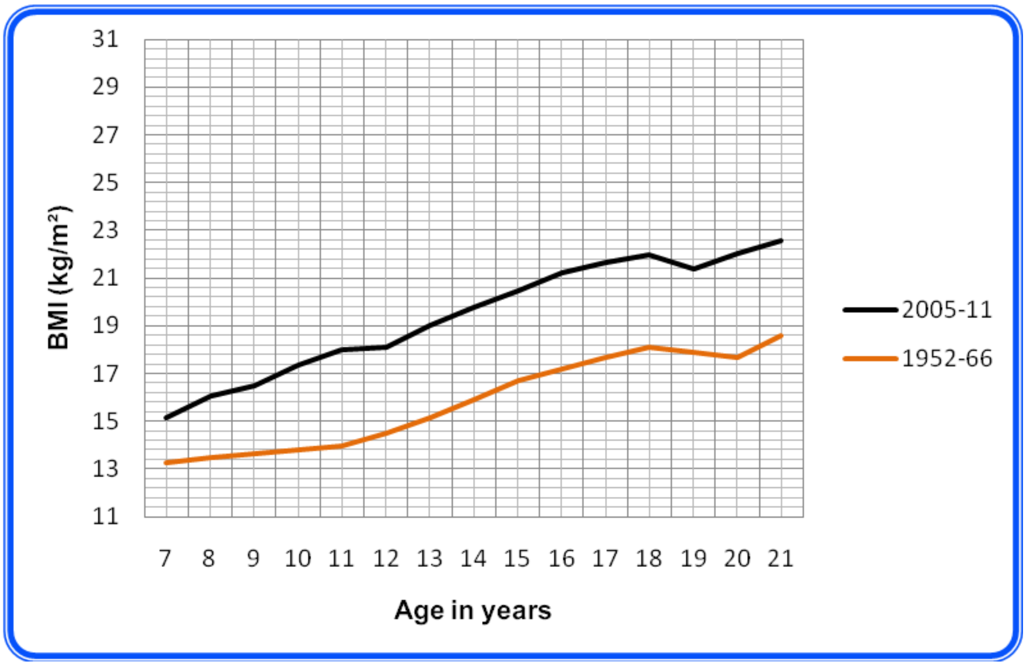


Fig-3.3b.2c: 97th percentile lines of body mass index of girls for two study periods

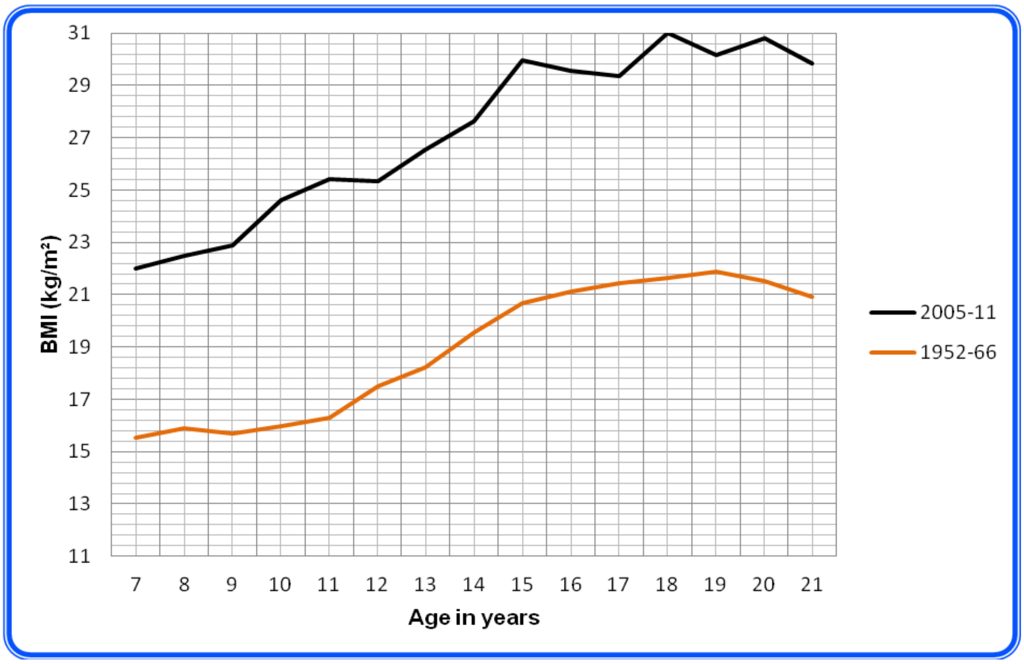


Fig-3.3b.2d: 50th percentile lines of body mass index of girls obtained from two study periods in comparison to the same from the WHO (2007)

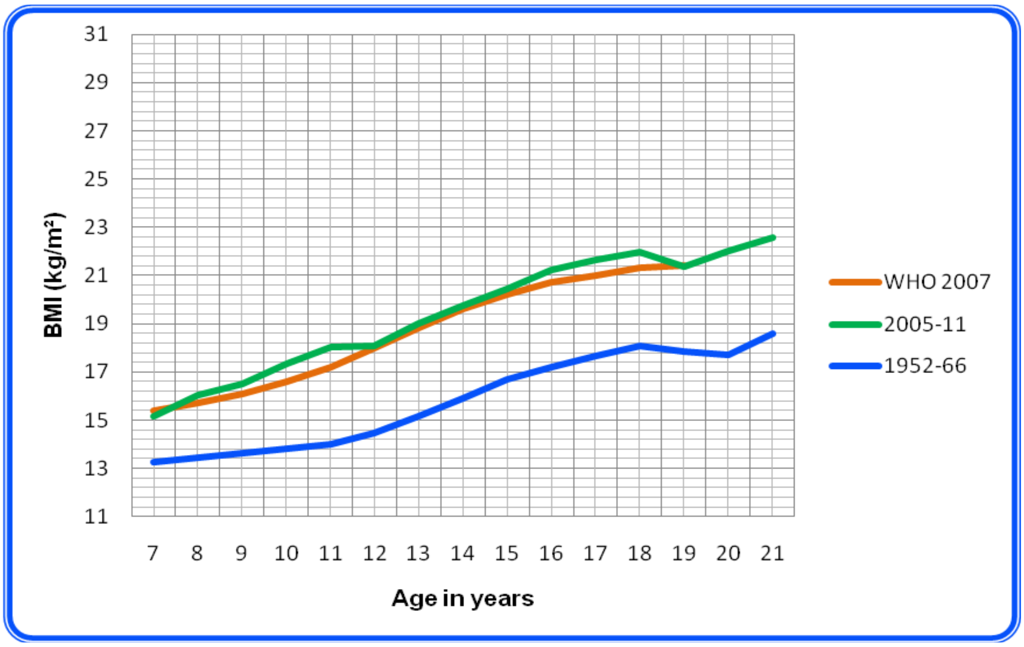


Fig-3.3d.i: 10th, 50th and 97th percentile lines of triceps skinfold thickness of boys over two study periods

Fig-3.3d.ii: 50th percentile lines of triceps skinfold thickness of boys obtained from two study periods compared with the same from the WHO (1995)

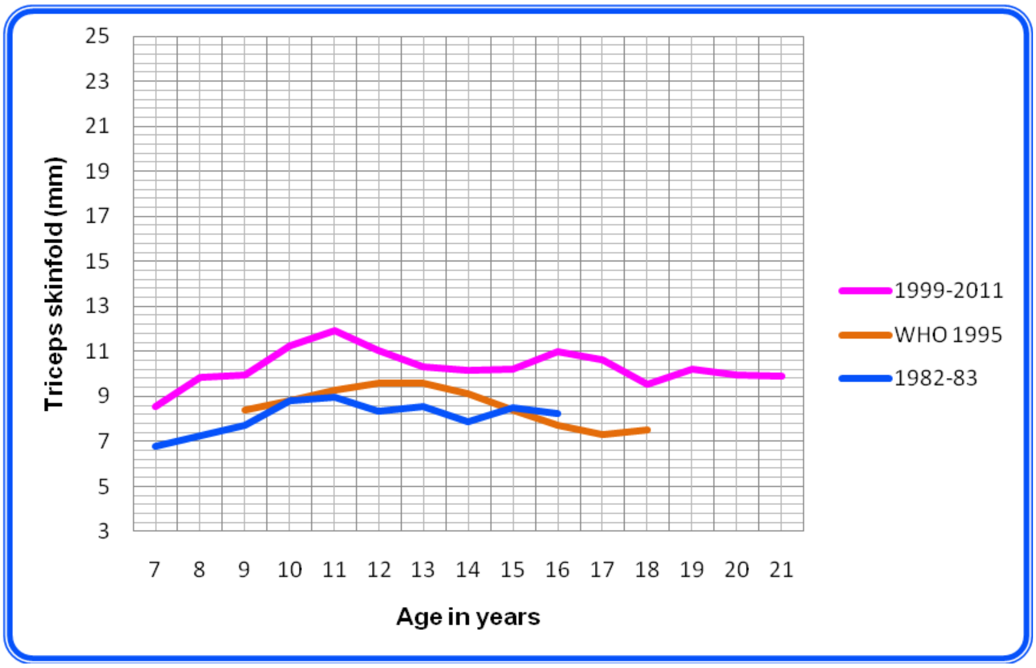


Fig-3.3d.iii: 10th, 50th and 97th percentile lines of subscapular skinfold thickness of boys over two study periods

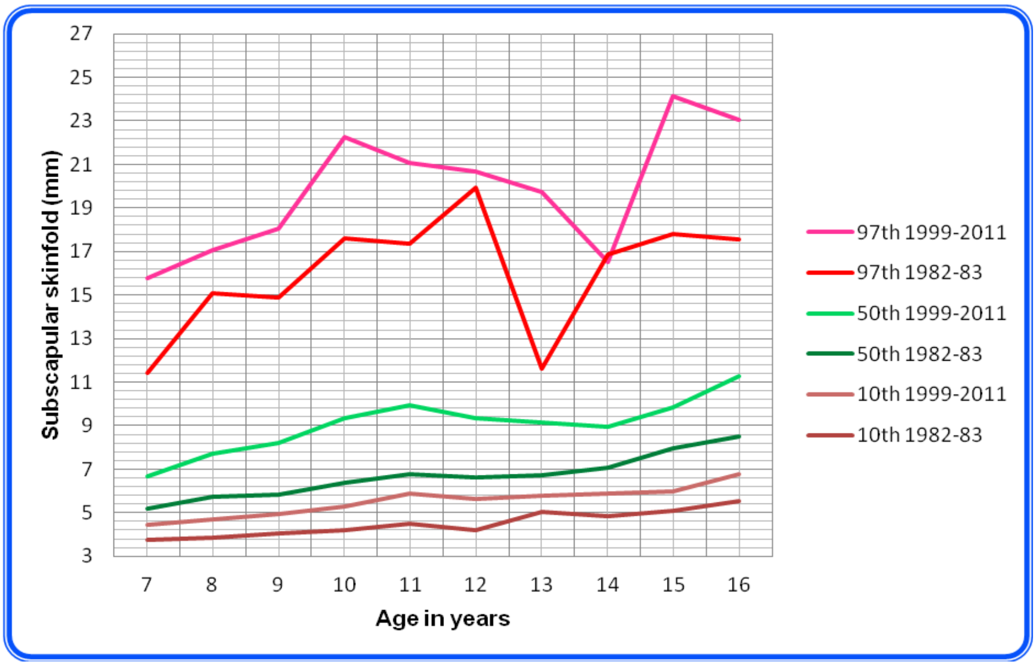


Fig-3.3d.iv: 50th percentile lines of subscapular skinfold thickness of boys obtained from two study periods compared with the same from the WHO (1995)

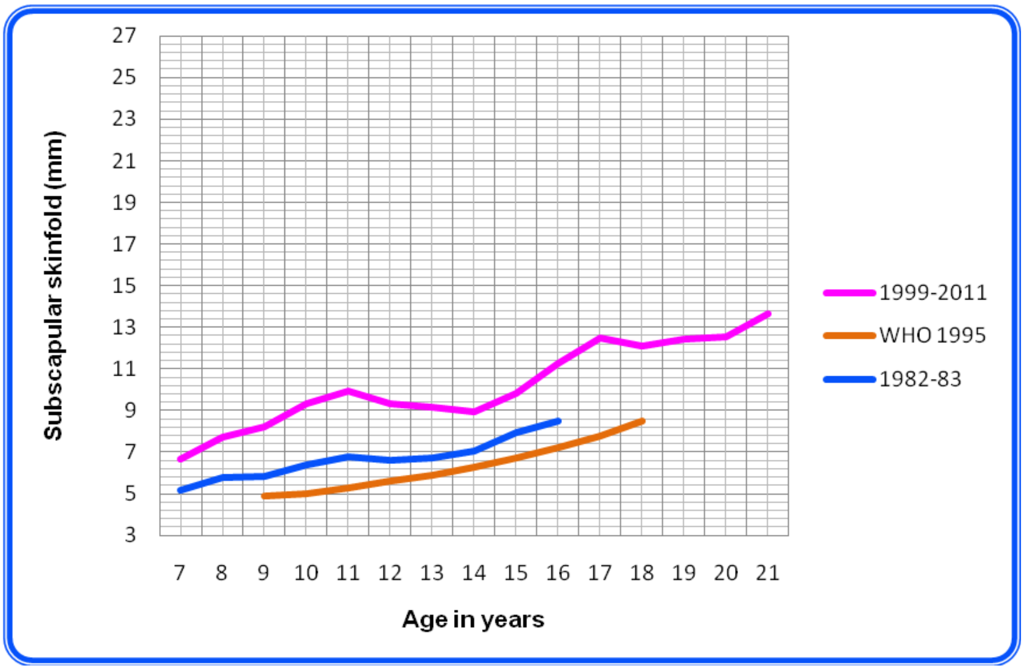


Fig: 3.4.i: Estimation of median age at menarche of Bengali girls from status-quo data by Probit analysis (Finey, 1952)

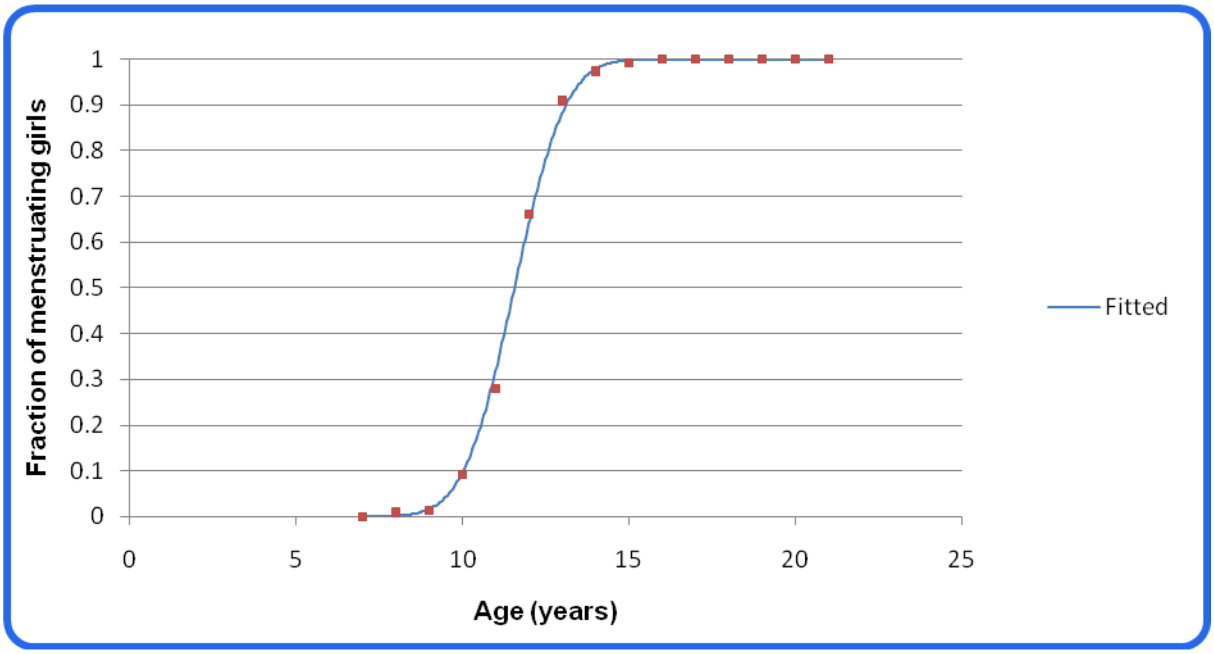


Fig: 3.4.ii: Fitting of inverse Probit on the occurrence of menarche

Fig: 3.4.iii: Histogram of the distribution of menarcheal age of Bengali girls from the retrospective data (n=444)

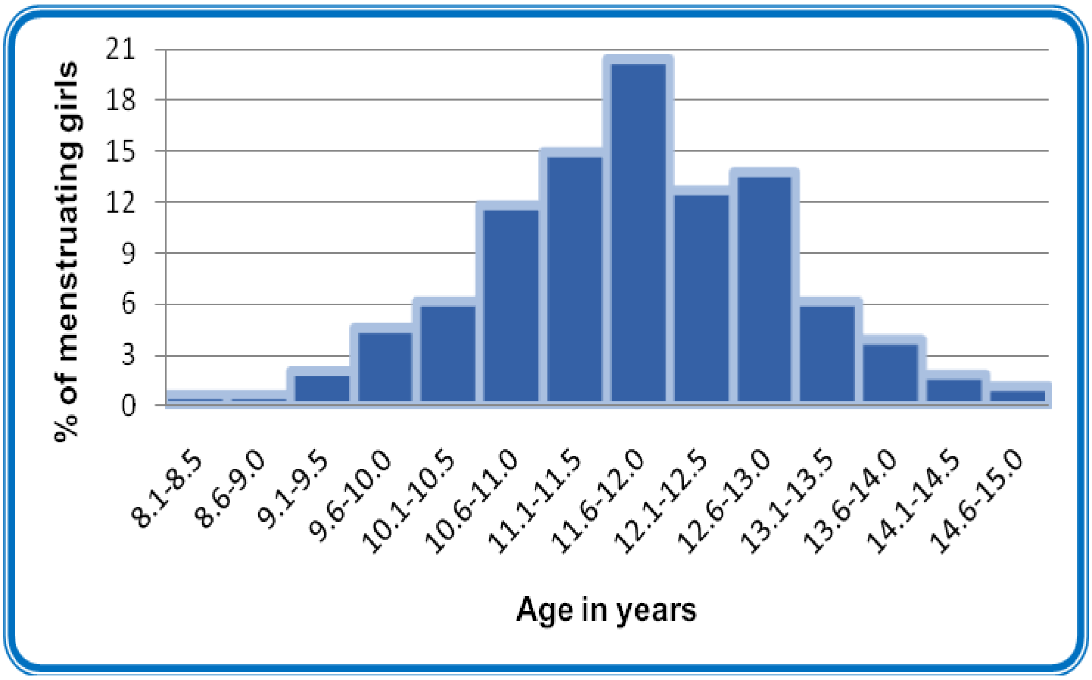
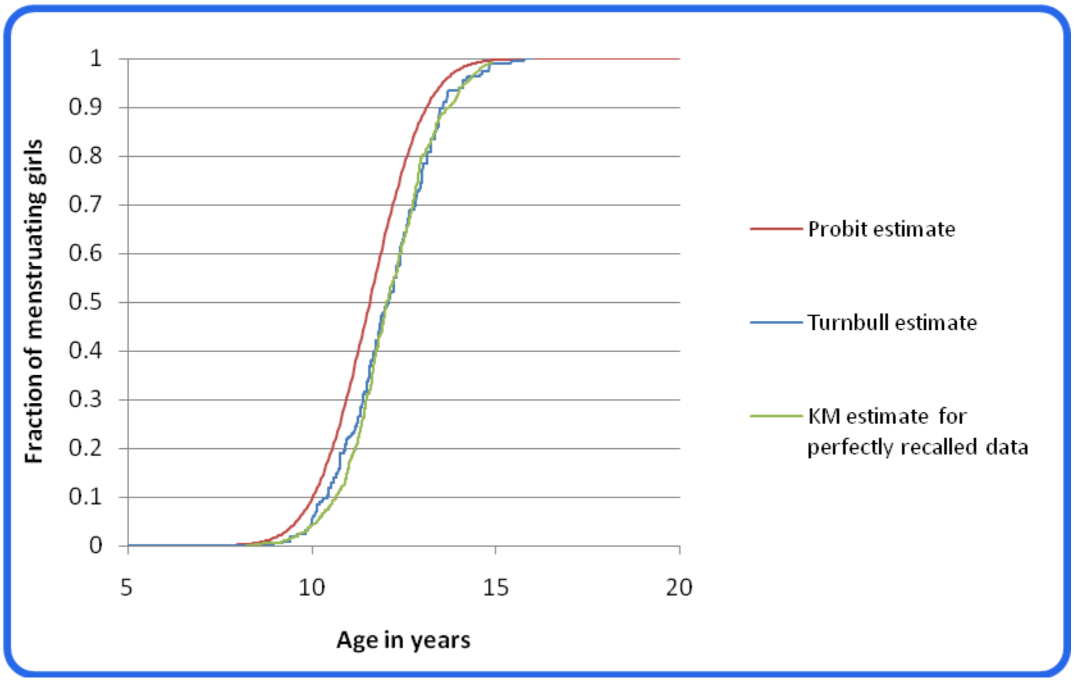


Fig: 3.4.iv: Estimation of the median age at onset of menarche of Bengali girls of 2005-2011 study by three different methods



APPENDIX 1

BIOLOGICAL ANTHROPOLOGY UNIT
INDIAN STATISTICAL INSTITUTE, KOLKATA

ANTHROPOMETRIC MEASUREMENTS OF THE SCHOOL / COLLEGE STUDENT

School/College:____

Identification no.:……………………………Schedule no.:……………………………………

Name of the student:…………………………………………………………………………

Class: ……………………….Roll:……………………….Date of birth:………………………

Sl. no.	Anthropometric measurements	Date: Time:
1	STANDING HEIGHT (cm)	
2	SITTING HEIGHT (cm)	
3	BIACROMIAL DIAMETER (cm)	
4	BI-ILIOCRISTAL DIAMETER (cm)	
5	TOTAL ARM LENGTH (cm)	
6	UPPER ARM CIRCUMFERENCE (cm)	
7	BICONDYLAR HUMERUS(cm)	
8	BICONDYLAR FEMUR (cm)	
9	CALF CIRCUMFERENCE (cm)	
10	TRICEPS SKINFOLDS (mm)	
11	BICEPS SKINFOLDS (mm)	
12	SUBSCAPULAR SKINFOLDS (mm)	
13	SUPRAILIAC SKINFOLDS (mm)	
14	MEDIAL CALF SKINFOLDS (mm)	
15	ABDOMINAL SKINFOLDS (mm)	
16	BIZYGOMATIC BREADTH (cm)	
17	MORPHOLOGICAL FACIAL HEIGHT (cm)	
18	HEAD CIRCUMFERENCE (cm)	
19	HEAD BREADTH (cm)	
20	HEAD LENGTH (cm)	
21	BODY WEIGHT (kg)	

Menarche: Occurred / Not Occurred?
If occurred, exact date of occurrence ……………………….............
(day / month / year)

Remarks (if any):	
Investigator:	Date:

APPENDIX 2

BIOLOGICAL ANTHROPOLOGY UNIT
INDIAN STATISTICAL INSTITUTE, KOLKATA

SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF THE SCHOOL AND COLLEGE STUDENTS

School/College:____

Name:…………………………………………………………………………………......

Class:………Roll:…….Address:………….………………………………………………
……………………………………………...………Date of investigation:………………

Father's name:……………………..………..
Age…………Marital status……...................
Place of work………………………………..

Mother's name:…………………..……
Age…………Marital status……...........
Place of work……………………………

<u>Father's Educational Qualification:</u>
School / Matric or Higher secondary/ College / Graduate/Post graduate / Doctoral / Post-doctoral………………..

<u>Mother's Educational Qualification:</u>
School / Matric or Higher secondary / College / Graduate /Post graduate/ Doctoral / Post-doctoral………………

<u>Father's Occupation:</u>
Doctor / Engineer / Lawyer / Chartered accountant /University teacher / College teacher /School teacher / Govt. officer / Clerk /Administrative officer / Business / Shop owner / Police officer / Army official /Medical representative / Scientist / Artist /Landlord / others (specify)………………..........................
Primary:…………………………………..
Secondary:………………………………..
Designation:………………………………

<u>Mother's Occupation:</u>
Doctor / Engineer / Lawyer / Chartered accountant/ University teacher/ College teacher / School teacher / Govt. officer / Clerk / Administrative officer / /Business / Shop owner / Police officer / Army official / Medical representative / Scientist / Artist / Landlady / others (specify)………………........................
Primary:…………………………………
Secondary:……………………………...
Designation:…………………………….

<u>Per month total family expenditure (INR):</u>…………………………………………...

Range < Rs. 1000 / Rs. 1001- Rs. 2000 / Rs. 2001 – Rs. 3000 / Rs. 3001 – Rs. 4000 / Rs. 4001 – Rs. 5000 / Rs. 5001 – Rs. 6000 / Above Rs. 6001 (Please specify)……………………

Family type: Simple / Joint

Number of household members: ……….

Size of sib ship ……

Number of earning members: …………..

Religion: …………………………. Caste / Social group: …………………...............

Duration of stay at the present address: ………………………………………………………..

Previous address: ………………………………………………………………………….…

Date of birth (of the student):…………………….…Parity / Birth order:……………………..

No. of younger: (i) Brother(s)…………………. (ii) Sister(s)……………………...

No. of elder: (i) Brother(s)…………………. (ii) Sister(s)…………………......

General health condition: Normal / Sickly / Suffered / Suffering from chronic diseases / genetic disease (please specify)…………………………………………………………………

Guardian's assessment of condition of health of the student: ………………………………….

Participation in outdoor games: Nil / Occasional / Regular / Irregular / ……………………….

Physical exercise / physical activity habit: Nil / Occasional / Irregular / Regular (please specify: at home, at gymnasium, yoga etc.)…………………………………………………….

Eye sight: Defective / Normal / Use spectacles………………………………………………...

Aptitude for fine arts: Nil / Present / Practicing / Proficient …………………………………...

<u>Household condition, household assets, ownership and community facilities:</u>

Type of possession: Owned / owned by relation / Office quarters / rental / others (please specify)…………………………………………………

Nature of dwelling unit: One storied / Two storied / Multi storied / Flat / Slum / Hut / Mess, Boarding / others (specify, if any)……………………….

If rented, amount of monthly rent: (in rupees) …………………………………………….

Total covered area of the residential plot ………………………………………………..Sq. ft.

Total number of rooms (excluding bathroom but including kitchen) ………………………….

<u>Household assets:</u> Television / Air conditioner / Air cooler / Water purifier / VCR / VCD / DVD / Music system / Almirah / Book-shelves / Camera / Carpet / Clock / Crockery / Geyser / Refrigerator / Electric iron / Micro oven / Mixer-grinder / Personal computer / Telephone / Mobiles / Showcase / Sofa-set / Wardrobe / Washing machine / others (specify, if any)…..

<u>Toilet:</u> (a) Type: connected with the sewer system / septic tank / pit / service privy open space / others (specify, if any)……………………………

(b) Number of toilets: ……………….

(c) Nature of ownership: exclusive for household / shared with other household

<u>Portable water:</u> (a) Source: own tap / community tap / own tube well / community tube well / own well / community well / tank / others…………………………….

(b) Distance of source from the household (Nil, if within the house premises)

(c) Whether water supply is adequate: Yes/ No

Type of kitchen: (a) Separate / kitchen in the living room / kitchen shared with others / other place…………………………………………………...……………..

(b) Fuel used for lighting: Electricity / Kerosene oil / others (specify)……..

(c) Fuel used for cooking: Dunk cake / fire wood / coal / gas / kerosene oil / electricity / others (specify)…………………………………………….

Community facilities:

Area of open space, if any, possessed by the household…………………………..……sq.ft.

Whether park / play ground nearby: Yes / No

Whether area gets water logged after heavy rain several times a year: Yes / No

Whether mosquito net required: Very much / Sometimes / No / Never

Distance from residence to the nearest

(a) Primary school: ………………

(b) Secondary school: ……………

(c) Hospital / Health centre: ……..

(d) Private nursing home: ………..

Note of the investigator if any:

Investigator:	Date:

APPENDIX 3

QUESTIONNAIRE ON KINDS AND FREQUENCIES OF FOODS EATEN

Food Items	Early Morning	Breakfast	Lunch	School Tiffin	After School	Evening	Dinner	Total	Weekly	Remarks
Rice										
Wheat (Hand made bread)										
Maida (Wheat flour)										
Suji (Semolina)										
Flattened rice										
Puffed rice										
Machine made bread										
Milk										
Curd										
Panner (Local cheese)										
Sweet / Confectionery										
Fish										
Egg										
Meat										
Pulses										
Chola (Gram)										
Nut										
Soyabean										
Vegetable leaves										
Potato										
Vegetables (specify)										
Fruits (specify)										
Ghee (Clarified butter)										
Butter										
Tea										
Vegetable oil										
Coffee										
Health drinks										
Cornflakes										
Sugar										
Molasses										
Jam / Jelly										
Others (specify)										

Note:

Investigator:	Date: