Changes in body size, shape and nutritional status of Middle-Class Bengali boys of Kolkata, India, 1982–2002

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Abstract

Growth changes over time among school-aged boys in Kolkata, India, have been investigated using two surveys: 1982–1983 ($n = 816$) and 1999–2002 ($n = 1187$). The two surveys were implemented according to highly similar protocols which strongly adds to the reliability and accuracy of the results of the study. Age-specific average height, weight and BMI all increased during these two decades (by respectively, 3.2 cm, 6.1 kg and 2.1 kg/m^2), while relative sitting height and sitting height-subischial leg length ratio decreased for almost all ages between 7.0 and 16.0 years. Moreover, the prevalence of stunting and thinness declined (stunting from 11.2% to 4.9%, $p < 0.01$, thinness from 50.5% to 22%, $p < 0.01$), while the prevalence of overweight increased (from 4.7% to 17.2%, $p < 0.01$). Through analysis of variance, the relationships between various socio-economic factors and anthropometric traits are analyzed. Factors strongly related with positive changes in anthropometric traits are maternal education and family expenditure.

JEL classification : I12; I31

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1. Introduction

Over the last few decades the countries of South and South-East Asia, Africa and Latin America are passing through the phases of developmental transition in varying rates (Caballero

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and Popkin, 2002). Transition is observed in all aspects of human lives such as disease patterns (epidemiological transition), demographic structure, dietary habits, nutritional status, lifestyles and activity patterns, and socio-economic and ecological conditions. India, being one of the low-income countries of the world, is also experiencing a similar transition in accordance with its acceptance of new liberal economic policies in the early 1990s (Thankappan, 2001). Though in its early phase, the country has already started manifesting most of the typical features of the transitional society as evident from results of the recently conducted studies from the urban areas in particular (Popkin, 2002). Some of the major consequences of this transition are observed to be rapid spread of urbanization, increased magnitude of socio-economic differences (Baten and Fraunholz, 2004), and coexistence of malnutrition and obesity (Shetty, 1999; Chatterjee, 2002; Gillespie and Haddad, 2003). In many urban areas of India increased consumption of energy and fat in conjunction with reduced levels of physical activity was found to be associated with escalation of adolescent and adult obesity. Countrywide escalation of non-communicable diseases like non-insulin dependent diabetes, hypertension, coronary heart disease and other metabolic disorders are also reported (Gopinath et al., 1994; Chadha et al., 1997; Drewnowski and Popkin, 1997; Shetty, 1999; Kapil et al., 2002; Khadilkar and Khadilkar, 2004). According to one prediction 20% of Indian females and 16% of males will be overweight by the year 2020 (Gillespie and Haddad, 2003), and the incidence of chronic diseases is expected to increase (Gopalan, 1998). All these transformations are said to be connected to the implementation of new liberal economic policies (Gopalan, 1992; Shetty and Gopalan, 1998).

A country's developmental progress and overall changes in socio-economic structure are reflected in the outcome of secular trend studies on physical growth, development, and rate of maturation of children (Tanner, 1986). Though largely carried out in the industrialized and developed countries of the world (van Wieringen, 1986), the occurrence of secular phenomena in these measures is generally observed to be linked with the changes in socio-economic, hygienic, health and nutritional conditions of the respective populations over a considerable lapse of time (Bielicki, 1986; Fogel, 1986; Malina, 1990; Brennan et al., 1994, 1995; Komlos and Baten, 1998; Bodzsár and Susanne, 1998).

The observation that various socio-economic factors play a role in the phenomena of secular growth can be put within the framework of Sen's capability approach (Sen, 1993). The concepts of endowments, entitlements, capabilities and functionings, as developed by Sen and others, bring to expression the fact that the determinants of living standards and of overall levels of people's well-being are multidimensional, involving not only individual characteristics and choices, but also many external factors, at the level of the community and the society to which people belong (Nussbaum and Sen, 1993; Sen, 1993). In Sen's capability approach, individual well-being may be assessed in terms of 'capability sets' that describe what individuals are free to do or to be (functionings) (Cookson, 2005). In terms of health and nutrition, this may be translated in identifying those factors which need to be available or accessible and what conditions need to be fulfilled for an individual to achieve a certain level of health or nutritional status. For example, improved sanitary conditions may be a requirement for reducing exposure to disease pathogens, which in turn may be translated by individuals to better health and better growth of infants and children. Thus, with respect to nutrition it is now widely acknowledged that it is not only availability and household level access to food that determines nutritional status and growth of children, but that factors such as education, sanitation, access to water, accessibility and quality of health services, and also cultural attitudes and beliefs, are equally important determining factors (Drèze and Sen, 1989). In the Indian context, a special case is the State of Kerala, which is known for its relatively favourable record in terms of health and nutrition, as expressed by a high life expectancy, low rates

of infant and child mortality, and low levels of child undernutrition (IIPS, 2000; Véron, 2001; Borooah, 2004). For example, with an average life expectancy of 70.3 years, Kerala has the highest average life expectancy of all Indian states, more than 5 years longer than the country's average of 64.3 years (Planning Commission India, 2001). These achievements are presumed to be the result of the strong emphasis given over past decades on, among others, accessibility and quality of health and educational services (and in particular women's education). Yet, it should be noted that sustainability of Kerala's high level of social services, including a continued high coverage of the public food distribution scheme (PDS), has been questioned in view of stagnating economic growth, partially as a result of economic reform and implementation of WTO rules (Thankappan, 2001; Suryanarayana, 2001).

School aged children and adolescents are very vulnerable to socio-economic changes and therefore highly suited for undertaking secular investigations (Eveleth and Tanner, 1990; Leslie, 1995). A major reason is that adolescence is a period of rapid changes in physical growth and maturation, and also in psychosocial development (World Health Organization, 1995). Presently, there exists abundance of literature from the population of the Southeast Asian countries pertaining to the role of different socio-economic and secular factors on physical growth and related variables of children and adolescents (Saha, 2004). Most of the authors of these studies highlighted their findings in the context of the transition, as experienced by the respective countries. Similar reports are also available from China (Zhang and Huang, 1988; Popkin, 1993; Popkin et al., 1993), Vietnam (Thang and Popkin, 2003a,b), Thailand (Sungthong et al., 1999), Taiwan (Huang and Malina, 1995), Pakistan (Hakeem, 2001), Indonesia (Jaruratanasirikul et al., 1997) and other countries of this region.

In the Indian context, the majority of growth studies concern children under five or under two years of age, and there are very few studies that report on secular growth of children in the State of West Bengal (Brennan et al., 2004; Borooah, 2005). Over the period 1975–1990 the National Institute of Nutrition (NIN) conducted repetitive nutrition surveys, particularly on the pre-school children (World Health Organization, 2006). On the basis of data collected in rural households in eight states, the prevalence of children with a low height-for-age decreased over that period from 72.3% to 62.1%, and the prevalence of low weight-for-age from 71.3% to 63.9%. Of more recent data are the DHS-surveys which report for children under 3 years of age between 1992/93 and 1998/99 a decline in the prevalence of low weight-for-age from 51.7% to 47% and of height-for-age from 47.1% to 45.5% (age group adjusted results). For West Bengal the prevalence of low weight-for-age was 56.8% in 1992/93 (children below 4 years) and 48.7% in 1998/99 (children below 3 years) (IIPS, 1995, 2000).

As regards children aged 5–18 years of age, one study reports growth parameters on over 20,000 children from 23 schools in various cities in India (Agarwal et al., 1992). The sample covered relatively well-to-do families. For the city of Delhi a secular trend is reported for the period 1970–1989, and reveals an increase in average height of 2.1 cm for boys, and 2.7 cm for girls per decade at 17 and 14 years, respectively. Besides this study, only a handful of small-scale studies are available for the period of adolescence over the past three decades, i.e. from 1950 to 1980 (Sidhu et al., 1982; Easwaran and Devadas, 1984; Singh, 1995; Dasgupta and Das, 1997). From this small number of published studies, only one was reported from the state of West Bengal, the place of the present investigation, which demonstrated the occurrence of a positive secular trend among Bengali boys between ages 7–16 years (Dasgupta and Das, 1997). In that study, physical growth data from two surveys, namely, the Sarsuna-Barisha mixed-longitudinal study (Hauspie et al., 1980) and the Calcutta cross-sectional Growth study (Pakrasi et al., 1988; Dasgupta, 1989/90; Dasgupta, 1998; de Onis et al., 2001; Rebato et al., 2001) confirmed positive

secular trends, as manifested in increased age specific mean height (a maximum of 11.4 cm at 13 years), decreased mean age at peak growth velocity (−1.26 years), and increased final size for height (+4.2 cm), weight (+10.5 kg), sitting height (+1.6 cm) and biacromial diameter (+1.2 cm), over a period of about 2 decades (1952–1966 to 1980–1982). Such a comparison, though first of its kind, was found to have some limitations. Firstly, the secular comparison was restricted up to 16.0 years, i.e. without covering the entire period of adolescence. Secondly, for secular studies on growth, cross-sectional and longitudinal surveys are not always fully comparable, for example as a result of the fact that the two types of studies may be subject to different types of sample bias (Klerman, 2006). Thirdly, due to lack of reliable data on the changed socio-economic, nutritional, and overall hygienic conditions of the state population between the decades compared, the causative factors responsible for the occurrence of positive secular trends could not be established. And finally, there is no information available on growth of adolescents after 1982. Therefore, in the context of the prevailing transitional state of the country, further investigation on secular and socio-economic changes in body size, body shape and nutritional status of the school aged and adolescent population appears to be important from the perspectives of public health of the city population of the state of West Bengal, India.

2. Objectives

The present communication is based on the comparison of the growth data collected from 1187 boys aged 7.0–16.0 years during the period of 1999–2002 with the growth data collected from 816 boys in the previous Calcutta Growth Survey (1982–1983), with the objective to investigate[1]: (i) secular phenomena in age specific standing height, body weight, body mass index (BMI), body shape and nutritional status; (ii) relative impact of household factors on height, weight and BMI.

3. Methodology

Two similar cross-sectional growth surveys were carried out among the students of a boy's school of Kolkata (formerly Calcutta), West Bengal, with an interval of about 20 years (1982–1983 and 1999–2002). The school, known as Scottish Church Collegiate School (established 1830), is in the northern part of the city of Kolkata, and accommodates about 3000 students from class I to X, who predominantly belong to middle class Bengali families.[2] Both samples cover about one third of the total (boys) school population. The age distribution of the two samples is given in Table 1.[3]

The participants of the two surveys were volunteers who gave their consents by filling-out the socio-economic schedules administered to them through the school authorities. Similar socio-economic and anthropometric data were collected in the two surveys, including information on parental age, parental education, parental occupation, monthly family total expenditure, order of birth of the subject, sibship size and household size. In addition, data were collected on frequencies

[1] Data on girls are not available; in currently ongoing research data on girls are now also being collected.

[2] The Bengali population in the state of West Bengal is a heterogeneous group of Caucasoid, Proto-Australoid and Mongoloid admixture (Risley, 1891).

[3] In the earlier survey, at some ages the sizes of the sample for the various anthropometric measures vary somewhat, but the difference was generally small and rarely more than 5 individuals.

Table 1
Composition of samples of boys in 1982–1983 survey and 1999–2002 survey

Age (years)	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	All
Number of boys 1982–1983	63	87	96	75	97	96	98	93	75	36	816
Number of boys 1999–2002	102	102	110	105	122	140	160	139	106	101	1187

Table 2
World Health Organization (1995) classification for the assessment of nutritional status

Indicator	Anthropometric variables	Cut-off points
Stunting	Height for age	<3rd Percentile, or <-2 z-scores
Thinness	Body mass index for age	<5th Percentile
Overweight	Body mass index for age	≥85th Percentile
Obesity	Body mass index for age *and*	≥85th Percentile
	Triceps skinfold for age *and*	≥90th Percentile
	Subscapular skinfold for age	≥90th Percentile

Source: World Health Organization, 1995.

and qualities of foods and drinks taken by the subject in the last 24 h, following the International Biological Programme questionnaire method (Weiner and Lourie, 1969).[4] Such food frequency recalls, based on individuals' own reporting, have their limitations and cannot provide detailed quantitative information on usual food intake, but they are nevertheless considered to give reliable information on prevailing food consumption patterns (Harrison, 2004).

Two categories were created with respect to per capita monthly family expenditure levels: in the 1982–1983 study the cut-off value is Rs. 250, and for the 1999–2002 study, the cut-off point is Rs. 880.[5] The latter is about the equivalent of the former value two decades earlier on the basis of the Consumer Price Index for Kolkata.[6] Households below the cut-off point were classified as Category I households, those above the cut-off point as Category II households. Anthropometric measurements (standing height (cm), body weight (kg), and sitting height (cm)) were taken in both surveys, following the same protocol of the International Biological Programme (Weiner and Lourie, 1969). Subischial leg length (cm) has been derived by subtracting sitting height from height. Measurements in both surveys were taken on or around birth dates of the boys with prior verifications (±3 days of tolerance). The following measures were derived: body mass index = [weight (kg)/height^2 (meter)], sitting height–height ratio = [(sitting height/height) × 100], sitting height-subischial leg length ratio = [(sitting height/subischial leg length) × 100]. Measures of nutritional status (stunting, thinness, overweight and obesity) were assessed according to the classification of the World Health Organization (1995), shown in

[4] In dietary habits the urban Bengali middle class people are generally non-vegetarian and usually take two principal meals per day, which includes cereal based foods like rice and bread, associated with non-vegetarian proteins (meat, fish, egg), and green and leafy vegetables. Two secondary meals, one at breakfast and the other in the afternoon or evening, include milk and derivatives, beverages, home made foods, seasonal fruits and recently introduced fast foods.

[5] The exchange rates of Indian Rupee with US Dollar in 1982–1983 was US$ 1 = 9.5 INR. Between the years 1999–2001, the rate is US$ 1 = 45.0 INR. Accordingly, the cut-off for the first survey would be 250/9.5 = US$ 26.3 and for the second survey 880/45 = US$ 19.6).

[6] 1984–1985 is the base year, as the 1982–1983 values are not available. Tne Consumer Price Indexes are taken from the Annual Publications of the Labour Bureau, Simla, Ministry of Labour, Government of India.

Table 2. For stunting (height for age) two cut-off points were used, namely <3rd percentile and <-2z scores of the reference value (World Health Organization, 1983). Prevalence rates of thinness, overweight and obesity were assessed only for the ages 9.0–16.0 years since the cut-off values for the other ages were not available in the said classification.

The various anthropometric measurements considered in this study are to some extent interrelated, but each of them has its own interpretation. Height is the result of linear growth, the

Table 3
Socio-economic and demographic characteristics of the 1982–1983 and 1999–2002 survey sample

Socio-economic and demographic attributes	1982–1983 (%)	1999–2002 (%)
Education of fathers		
Below matriculate (<10 years of schooling)	18.3	7.4
Matriculate to below graduate (10–14 years of schooling)	44.9	31.3
Graduate and above (>14 years of schooling)	36.9	61.3
Education of mothers		
Below matriculate (<10 years of schooling)	36.3	13.9
Matriculate to below graduate (10–14 years of schooling)	44.1	48.7
Graduate and above (>14 years of schooling)	19.6	37.4
Occupation of fathers		
Administrative, executive and managerial workers	24.1	20.2
Clerical and related workers	29.6	75.0
Manual workers and others	46.3	4.8
Occupation of mothers		
Administrative, executive and managerial workers	2.5	2.3
Clerical and related workers	1.0	4.4
Housewife	95.0	92.5
Manual workers and others	1.5	0.8
Per capita monthly expenditure[a]:		
I	58.2	17.4
II	41.8	82.6
Order of birth		
1	54.0	72.0
1+	46.0	28.0
Sibship size		
No sibs	23.3	50.2
With one sibs	46.8	46.9
With more than one sibs	29.9	2.9
Religious background		
Hinduism	100.0	100.0
Caste distribution		
Upper caste	57.6	51.7
Middle caste	25.3	29.2
Lower caste	17.1	19.1
Family type		
Nuclear type	49.3	61.8
Extended family	50.7	38.2
Sample size (no. of boys)	816	1187

[a] Per Capita Monthly Expenditure, 1982–1983, I < 250, II ≥ 250; 1999–2002, I < 880, II ≥ 880 (see footnote 5 for conversion into USD).

body mass index provides information on weight relative to height, and is for example related to risk of certain diseases (hypertension, diabetes, cardiovascular disease). Sitting height and subischial leg length provide further information on body shape, and have their own physiological interpretations, for example in relation to the occurrence of obesity and coronary heart disease (Dangour et al., 2002; Torres et al., 2003; Zhang et al., 2004; Velasquez-Melendez et al., 2005). For example, it has been argued that short leg length, but not trunk length, in adulthood is significantly associated with an increased risk of coronary heart disease mortality (Gunnell et al., 1998). Also, already some 50 years ago it was proposed that leg length would be a more sensitive indicator of malnutrition than total stature (Thomson and Duncan, 1954).

For analyzing the effects of socio-economic and demographic variables, categorization was done in accordance with Table 3, except for the multiple regression where per capita monthly family expenditure was treated as a continuous variable. The software used for analysis was MS-Excel, S-Plus and SPSS.

4. Results

4.1. Changes in socio-economic and demographic characteristics of the boys over two decades

With respect to parental education, the frequencies of the least educated group (below matriculate) have declined considerably over the two decades for both mothers and fathers. With respect to occupation, considerable change is noticed among fathers but not among mothers. In terms of religious background, in both surveys hundred percent of the families profess Hinduism. In the two surveys there was a rather equal distribution of households over different castes (Table 3).

With respect to per capita monthly family expenditure, the frequency of households in category I has declined in the later survey. An increase in the frequency of first-born babies is noticed in the later survey. Finally, in the second survey the percentage of households of the nuclear family type had somewhat increased in comparison with the first survey, this at the expense of households of the extended family type (Table 3).

Information on dietary frequencies, especially the intake of protein foods, has been analyzed for the two surveys in relation to the per capita family expenditure level of the households. In Category I households, 50% of the boys in the 1982–1983 survey consumed fish more than five days a week, while this was the case for only 8.8% of the boys in the 1999–2002 survey. And in Category II households, more than 70% of the boys in the 1982–1983 survey consumed fish more than five days a week, against only 8.5% of the boys in the 1999–2002 survey. These results indicate a marked overall decrease in fish consumption. With respect to the frequency of consumption of meat, respectively, 51% and 43.2% of the boys in Category I households consumed meat less than once a week in the two surveys. In Category II households, respectively, 34% and 33.8% of the boys consumed meat less than once a week in the two surveys. With respect to eggs, the consumption patterns were almost identical in both expenditure categories in the two surveys (these results are not reported here).

4.2. Trends in age specific average body size

The significance of the difference of the anthropometric variables in the two samples was tested by a *t*-test at the level of 1% and 5%. Standard errors of means have been calculated from standard deviations (σ), according to the formula S.E. $= \sigma/\sqrt{n}$. As weight and BMI values are not

Table 4
Trends in mean standing height (cm) and mean and median body weight (kg) of the Bengali boys aged 7.0–16.0 years between two survey periods 1982–1983 and 1999–2002

Age (years)	Mean standing height cm ± S.E.		Mean body weight kg ± S.E.		Median body weight kg ± S.E.	
	I	II	I	II	I	II
7.0	119.3 ± 0.9	120.8 ± 0.5	20.32 ± 0.56	22.75 ± 0.38*	19.50 ± 0.71	22.50 ± 0.48**
8.0	124.1 ± 0.6	127.0 ± 0.5**	21.99 ± 0.48	26.45 ± 0.65**	21.00 ± 0.59	25.00 ± 0.82**
9.0	128.5 ± 0.6	132.3 ± 0.5**	25.00 ± 0.63	29.33 ± 0.65**	23.00 ± 0.79	28.50 ± 0.81**
10.0	133.0 ± 0.6	136.8 ± 0.6**	26.03 ± 0.67	32.61 ± 0.74**	25.50 ± 0.84	32.50 ± 0.93**
11.0	138.4 ± 0.7	141.5 ± 0.7**	29.84 ± 0.80	35.61 ± 0.79**	28.50 ± 1.01	34.00 ± 0.99**
12.0	141.6 ± 0.9	147.5 ± 0.7**	31.58 ± 0.82	40.45 ± 0.81**	30.50 ± 1.17	39.50 ± 1.01**
13.0	151.5 ± 0.8	154.2 ± 0.6**	36.49 ± 0.65	43.83 ± 0.78**	36.25 ± 0.81	43.00 ± 0.98**
14.0	157.1 ± 0.9	161.1 ± 0.6**	40.40 ± 0.86	49.17 ± 0.90**	40.00 ± 1.08	46.50 ± 1.12**
15.0	162.4 ± 0.7	165.0 ± 0.7**	45.56 ± 0.94	51.44 ± 1.02**	44.00 ± 1.18	49.25 ± 1.28**
16.0	165.7 ± 0.9	167.5 ± 0.6	48.97 ± 1.66	55.79 ± 1.04**	47.00 ± 2.08	54.00 ± 1.30**

I—1982–1983 survey, II—1999–2002 survey; $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, for tests on differences between survey I and survey II.

normally distributed, therefore in addition to means, the median values were also calculated for the two surveys and the significance of the difference in medians over the stated age periods were tested by using the asymptotic distribution of sample median (Lehmann, 1983). Standard errors of medians were calculated according to the formula S.E. = $1.253 \times \sigma/\sqrt{n}$. Age specific prevalence rates of stunting, thinness, overweight and obesity in the two surveys were compared by χ^2 analyses to test the significance of the differences between the two studies, at 1% and 5% levels.

4.2.1. Standing height

Table 4 shows that in the 1999–2002 survey boys are taller than in the 1982–1983 survey at all 10 ages. The maximum increase of 5.87 cm is observed at 12.0 years. For eight of the 10 ages the differences are statistically significant at the 1% level. The average increase in height is 3.2 cm.

Table 5
Trends in mean and median body mass index (kg/m^2) of Bengali boys aged 7.0–16.0 years between two survey periods 1982–1983 and 1999–2002

Age (years)	Mean BMI ± S.E.		Median BMI ± S.E.	
	I	II	I	II
7.0	13.95 ± 0.28	15.53 ± 0.21**	13.80 ± 0.35	15.15 ± 0.26**
8.0	14.20 ± 0.22	16.27 ± 0.31**	13.73 ± 0.28	15.89 ± 0.39**
9.0	14.95 ± 0.25	16.63 ± 0.29**	14.30 ± 0.31	15.90 ± 0.37**
10.0	15.21 ± 0.30	17.32 ± 0.33**	14.41 ± 0.38	16.74 ± 0.41**
11.0	15.44 ± 0.31	17.60 ± 0.29**	14.81 ± 0.39	17.15 ± 0.37*
12.0	15.22 ± 0.34	18.46 ± 0.30*	14.99 ± 0.43	17.90 ± 0.37**
13.0	15.81 ± 0.19	18.33 ± 0.28**	15.74 ± 0.24	17.65 ± 0.35**
14.0	16.33 ± 0.23	18.87 ± 0.30**	15.85 ± 0.29	18.31 ± 0.38**
15.0	17.28 ± 0.31	18.83 ± 0.33**	16.80 ± 0.39	18.20 ± 0.41*
16.0	17.76 ± 0.50	19.85 ± 0.33**	17.18 ± 0.62	19.09 ± 0.42**

I—1982–1983 survey, II—1999–2002 survey, $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, for tests on differences between survey I and survey II.

4.2.2. Body weight

Table 4 also shows that in the 1999–2002 survey boys are heavier than in the 1982–1983 survey. The maximum difference in means (8.87 kg) and medians (9.00 kg) are also observed at age of 12.0 years. At all ages the increments of the means and medians in the later survey are statistically significant at the 1% level. The average increase in mean and median body weight is, respectively, 6.1 and 5.95 kg.

4.3. Trends in age specific average body shape

4.3.1. Body mass index (BMI)

Table 5 shows that in the 1999–2002 survey boys have higher BMI's than in the 1982–1983 survey. The maximum difference in means (3.24 kg/m^2) and medians (2.91 kg/m^2) is observed at age of 12.0 years. For the means the differences are statistically significant at all ages at the 1% level, except at 12.0 years (5% level).

4.3.2. Sitting height/standing height ratio

Table 6 shows that in the 1999–2002 survey boys tend to have lower relative sitting height ratios in comparison with the 1982–1983 survey.

4.3.3. Sitting height/-subischial leg length ratio

Table 6 also shows that in the 1999–2002 survey boys tend to have lower sitting height/subischial leg length ratios in comparison with the 1982–1983 survey.

4.4. Trends in the measures of nutritional status

4.4.1. Prevalence of stunting

Prevalence of stunting assessed on the basis of the first criterium (<3rd percentile) shows that at all ages it has declined, at three ages significantly at the 1% or 5% level (Table 7). By using the

Table 6
Trends in mean relative sitting height ratio and in mean sitting height/subischial leg length ratio of Bengali boys aged 7.0–16.0 years between two survey periods 1982–1983 and 1999–2002

Age (Years)	Mean relative sitting height ratio ± S.E.		Mean sitting height-subischial leg length ratio ± S.E.	
	I	II	I	II
7.0	54.18 ± 0.18	53.98 ± 0.11	118.46 ± 0.83	117.41 ± 0.53
8.0	53.55 ± 0.12	53.59 ± 0.10	115.43 ± 0.57	115.56 ± 0.47
9.0	53.10 ± 0.11	52.69 ± 0.11**	113.34 ± 0.51	111.48 ± 0.49**
10.0	52.61 ± 0.13	52.04 ± 0.12**	111.45 ± 0.69	108.64 ± 0.54**
11.0	51.90 ± 0.13	51.46 ± 0.13*	108.23 ± 0.60	106.18 ± 0.52*
12.0	51.18 ± 0.31	51.23 ± 0.10	106.19 ± 0.54	105.14 ± 0.41
13.0	51.36 ± 0.15	51.04 ± 0.09	106.03 ± 0.72	104.35 ± 0.39*
14.0	51.21 ± 0.18	51.05 ± 0.10	105.26 ± 0.69	104.42 ± 0.42
15.0	51.45 ± 0.14	51.43 ± 0.14	106.33 ± 0.65	106.07 ± 0.57
16.0	51.91 ± 0.16	51.40 ± 0.13*	108.05 ± 0.70	105.90 ± 0.53*

I—1982–1983 survey, II—1999–2002 survey, $^*p \leq 0.05$, $^{**}p \leq 0.01$, for tests on differences between survey I and survey II. *Note*: relative sitting height ratio = [(sitting height/height) × 100], sitting height/subischial leg length ratio = [(sitting height/subischial leg length) × 100].

Table 7
Trends in the prevalence of stunting (%) of Bengali boys aged 7.0–16.0 years between two survey periods 1982–1983 and 1999–2002

Age (years)	<3rd percentile of height for age (%)		Decline in prevalence rate (%)	<-2 z score of height for age (%)		Decline in prevalence rate (%)
	I	II		I	II	
7.0	14.29	3.92	10.37*	12.70	2.94	9.76*
8.0	5.75	1.96	3.79	5.75	1.96	3.79
9.0	9.38	4.55	4.83	7.29	3.64	3.65
10.0	8.00	4.76	3.24	6.67	2.86	3.81
11.0	11.34	6.56	4.78	10.31	6.56	3.75
12.0	21.88	6.43	15.45**	18.75	5.00	13.75**
13.0	7.14	3.75	3.39	7.14	3.13	4.01
14.0	13.98	2.16	11.82**	10.75	2.16	8.59*
15.0	6.67	6.60	0.07	4.00	3.77	0.23
16.0	13.89	8.91	4.98	11.11	7.92	3.19
All ages	11.15	4.89	6.26**	9.44	3.96	5.48**

I—1982–1983 survey, II—1999–2002 survey, $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, χ-square tests on differences between survey I and survey II.

second criteria (<-2z score), stunting has also declined on the basis of this indicator at all ages. The decline is statistically significant, at the 1% or 5% level, at three ages. For both criteria the maximum decline is at 12.0 years.

4.4.2. *Prevalence of thinness*

As in stunting, the prevalence of thinness has also declined between the same time periods and at all ages, with a maximum at 12.0 years (Table 8). The prevalence as well as the decline is considerably greater for thinness than for stunting.

Table 8
Trends in the prevalence of thinness (%) and the prevalence of overweight (%) in Bengali boys aged 9.0–16.0 years between two survey periods 1982–1983 and 1999–2002; Prevalence of obesity in 1999–2002 survey

Age (years)	% <5th percentile of BMI for age (thinness)		% >85th percentile of BMI for age (overweight)		Obesity[a]
	I	II	I	II	II
9.0	43.01	19.09**	7.53	26.36**	15.74
10.0	50.00	21.90**	10.81	24.76*	9.52
11.0	50.00	20.49**	7.29	18.85*	4.20
12.0	56.38	17.14**	5.32	22.14**	1.83
13.0	50.00	26.25**	0.0	14.38	0.74
14.0	58.06	21.58**	1.08	14.39**	0.00
15.0	45.95	30.19*	2.70	8.49	1.92
16.0	47.22	17.82**	2.78	7.92	1.00
All ages	50.46	21.87**	4.71	17.19**	4.15

I—1982–1983 survey, II—1999–2002 survey, $^{*}p \leq 0.05$, $^{**}p \leq 0.01$, χ-square tests on differences between survey I and survey II.

[a] For definition obesity, see Table 1; in survey I obesity was non-existent.

4.4.3. Prevalence of overweight

The prevalence of overweight shows an increasing trend between the two surveys (Table 8). At all ages the prevalence has increased, with a maximum at 9.0 years. For five of the eight ages the increase in the prevalence is statistically significant at the 1% or 5% level.

4.4.4. Prevalence of obesity

In 1982–1983 none of the boys measured were assessed to be obese. Therefore, Table 8 only provides results on the prevalence of obesity in the 1999–2002 survey. The prevalence of obesity is highest at 9.0 years, after which it declines to nil or 1–2%. This pattern is somewhat similar to the pattern for overweight, which also declines with age.

4.5. Role of socio-economic and demographic factors in the two surveys

Multiple analysis of variance (MANOVA) was performed for analyzing the effects of various socio-economic and demographic factors on height, weight and BMI together. Significant effects

Table 9
Results of MANOVA to examine the effects of socio-economic and demographic variables on mean height, weight and BMI jointly in the two surveys

	Degrees of freedom	Survey I		Survey II	
		Wilk's lambda	*p*-Value of Wilk's lambda	Wilk's lambda	*p*-Value of Wilk's lambda
(i) Father's education					
Age	9	0.139	0.000	0.129	0.000
Father's education	2	0.987	0.146	0.996	0.544
Age:father's education interaction	18	0.925	0.298	0.957	0.608
(ii) Mother's education					
Age	9	0.138	0.000	0.128	0.000
Mother's education	2	0.977	0.007	0.984	0.005
Age:mother's education interaction	18	0.901	0.013	0.960	0.733
(iii) Father's occupation					
Age	9	0.142	0.000	0.131	0.000
Father's occupation	2	0.995	0.713	0.993	0.239
Age:father's occupation interaction	18	0.921	0.202	0.973	0.994
(iv) Per capita monthly family expenditure					
Age	9	0.144	0.000	0.130	0.000
Per capita monthly family expenditure	1	0.983	0.004	0.992	0.029
Age:per capita monthly family expenditure interaction	9	0.943	0.012	0.981	0.732
(v) Birth order					
Age	9	0.143	0.000	0.129	0.000
Birth order	1	0.984	0.006	0.997	0.344
Age:Birth order interaction	9	0.924	0.000	0.959	0.006
(vi) Sibship size					
Age	9	0.139	0.000	0.129	0.000
Sibship size	2	0.945	0.000	0.990	0.065
Age:Sibship size interaction	18	0.904	0.015	0.952	0.352

I—1982–1983 survey, II—1999–2002 survey.

Table 10
Results of two way ANOVA for effects of socio-demographic variables on height, weight and BMI independently for the two surveys

Socio-economic & demographic variables	Survey I (*F*-ratio)			Survey II (*F*-ratio)		
	Height	Weight	BMI	Height	Weight	BMI
Age	371.85 (*0.0000*)	128.89 (*0.0000*)	14.95 (*0.0000*)	663.38 (*0.0000*)	172.20 (*0.0000*)	17.93 (*0.0000*)
Mother's education (given age)	6.91 (*0.0011*)	7.01 (*0.0010*)	3.56 (*0.0289*)	4.79 (*0.0085*)	4.11 (*0.0167*)	3.17 (*0.0425*)
Per capita monthly family expenditure (given age)*	4.99 (*0.0258*)	10.27 (*0.0014*)	10.87 (*0.0010*)			
Birth order (given age)	3.26 (*0.0716*)	10.20 (*0.0015*)	11.73 (0.0006)	1.17 (*0.2801*)	3.20 (*0.0740*)	2.79 (*0.9520*)
Age:Birth order interaction	1.60 (*0.1113*)	1.27 (*0.2498*)	1.41 (*0.1785*)	1.55 (*0.1264*)	1.40 (*0.1847*)	1.21 (*0.2829*)
Sibship size (given age)*	9.54 (*0.0001*)	15.62 (*0.0000*)	12.87 (*0.0000*)			

I—1982–1983 survey, II—1999–2002 survey. Values in parentheses are p values.
* Effects are significant ($p < 0.01$) only in the first survey as revealed from MANOVA Table 9.

Table 11
Regression analysis of effects of per capita monthly family expenditure and age on height, weight and BMI

Variables	Height (cm)				Weight (kg)				BMI (kg/m^2)			
	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value	Coefficient	*p*-Value
	Survey I[a]		Survey II		Survey I		Survey II		Survey I		Survey II	
Intercept	117.50	0.0000	118.29	0.0000	18.53	0.0000	18.23	0.0000	13.49	0.0000	14.16	0.0000
Age code 1[b]	4.52	0.0001	6.16	0.0000	1.62	0.1730	3.64	0.0031	0.16	0.6878	0.72	0.1125
Age code 2	4.87	0.0000	5.34	0.0000	3.30	0.0021	2.95	0.0147	0.85	0.0223	0.38	0.4001
Age code 3	4.33	0.0001	4.57	0.0000	1.89	0.0861	3.37	0.0050	0.25	0.5125	0.71	0.1105
Age code 4	5.45	0.0000	4.70	0.0000	2.94	0.0076	2.97	0.0011	0.23	0.5420	0.28	0.5196
Age code 5	4.60	0.0000	5.96	0.0000	2.76	0.0075	4.86	0.0000	0.10	0.7747	0.87	0.0320
Age code 6	8.94	0.0000	6.73	0.0000	3.74	0.0003	3.35	0.0010	0.23	0.5263	-0.14	0.7100
Age code 7	5.66	0.0000	6.85	0.0000	4.02	0.0001	5.22	0.0000	0.55	0.1247	0.50	0.1852
Age code 8	5.33	0.0000	3.97	0.0000	5.11	0.0000	2.39	0.0346	0.94	0.0149	0.00	0.9944
Age code 9	2.92	0.0393	2.28	0.0129	3.07	0.0347	4.09	0.0009	0.39	0.4402	0.94	0.0386
Per capita monthly family expenditure (Rs.)	0.0069	0.0002	0.0020	0.0004	0.0062	0.0009	0.0037	0.0000	0.0018	0.0061	0.0011	0.0001
R-statistic	0.8115		0.837		0.5854		0.578		0.1522		0.1325	
F-statistic	345.6		603.9		113.7		161.1		14.29		17.96	
p-Value	0		0		0		0		0		0	

[a] I—1982–1983 survey, II—1999–2002 survey.

of the socio-economic and demographic factors (1% level) as revealed from MANOVA were further treated for two-way ANOVA for these three anthropometric traits independently. Subsequently, multiple regression analysis was performed to examine the effect of the socio-economic and demographic attributes (independent variables) on height, weight and BMI (dependent variables). Since the effect of age on these variables is known to be non-linear and no parametric model for such effect is used at this stage, the age variable has been used as a factor. As 10 age points (7.0–16.0 years) have been considered as the first factor, the S-Plus software generated the nine age codes during multiple regression analysis. Socio-economic and demographic traits, which showed a level of significance lower than 1% were used in the regression analysis.

Results of MANOVA show for the 1982–1983 survey significant effects at the 1% level of age, mother's education, per capita monthly family expenditure, birth order and sibship size on height, weight and BMI jointly (Table 9). However, with respect to the later survey, in presence of the effect of age only mother's education is found to be significant at the 1% level and per capita monthly family expenditure at the 5% level. Interestingly, in both surveys the effects of father's education and occupation were found to be not significant.

Table 10 shows the results of two-way ANOVA for those socio-economic and demographic factors, which revealed significant effects at the 1% level in MANOVA (considering age as the first factor). Here, only mother's education is found to be significantly affecting the three traits individually in both surveys.

In the MANOVA and ANOVA per capita monthly family expenditure was changed into a binary variable (Category I and Category II households) so that it could be used as a factor together with age. The full impact of this variable can be assessed in a multiple regression analysis of height, weight and BMI, taken one at a time as a dependant variable, where per capita monthly family expenditure is used as a continuous independent variable and the other household variables are brought in subsequently into the model (Table 11). For all the three dependant variables, the per capita monthly family expenditure emerges as the most important predictor of the anthropometric variables in the presence of age. This means that in the presence of the age factor and the per-capita monthly family expenditure no other independent variables (including mother's education which happened to be most significant in MANOVA in the absence of the expenditure factor) turns out to be significant. With the nine age-codes and coefficients, Table 11 gives for each year the increase in height, weight and BMI, with per capita monthly family expenditure kept fixed (for example, a boy 8 years old is 4.52 cm taller than a boy 7 years old at same level of per capita monthly family expenditure).

5. Discussion and conclusion

Two growth studies in a large middle class boys' school in Kolkata, India, implemented in the years 1982–1983 and 1999–2002, document an increase in body size (height, weight), and also changes in measures of body shape (BMI, relative sitting height ratio, sitting height subischial leg length ratio). As regards the magnitude of the changes in height, these tend to be at the lower end of the range when compared with the few earlier Indian studies that provide detailed quantitative information on growth trends in adolescents. For example, the present result of a *maximum* height increase of 3.2 cm per decade is lower than the result of approximately 4.5 cm per decade as reported for the period 1952/1966–1982/1983 on the basis of the combined data of the Sarsuna-Barisha study and the Calcutta-study (Dasgupta, 1998). Furthermore, the *mean* height increase of approximately 1.8 cm per decade as reported in this study, is also lower than those reported by

Sidhu (1982) and by Easwaran (1984)—respectively, 3.0 and 2.5 cm per decade. In the study by Agarwal et al. (1992), the reported mean height increases per decade are for Delhi and Varanasi, respectively, 2.1 and 1.5 cm, while Singh (1995) reports for three different social strata from Delhi increases in height of, respectively, 3.5, 2.7 and 1.4 cm per decade.[7] With respect to indicators of nutritional status, results show simultaneously a decrease in the prevalence of stunting and thinness, an increase in the prevalence of overweight, and the emergence of obesity. While the reduction in stunting and thinness can be considered as an indicator of better health and nutrition, the increase in overweight and the emergence of obesity is, from a health point of view, a less favourable development. Thus, this urban-based study has manifested the typical characteristics of the societies undergoing transition due to modernization, i.e. coexistence of decreasing levels of stunting and thinness with increasing levels of overweight and obesity (Popkin, 1994; Osmani and Sen, 2003).

The largely similar protocols of the 1982–1983 and the 1999–2002 studies render the collected information highly suitable for the analysis of changes in growth as the similarity of the study protocols strongly adds to the reliability and accuracy of reported results. Reported results may therefore also serve as a well documented base line data for future growth studies. Yet, the study also has its limitations. Firstly, it is important to note that it is assumed that over the approximately 20-year period between the first and the second survey, the school has maintained its relative socio-economic position and that the sample of boys in both surveys represent a more or less similar segment of the middle class Bengali society. It is on the basis of this assumption that conclusions on the occurrence of growth trends are being made. Secondly, participation of the boys in the study was made on a voluntary basis, which means that some bias in sample composition cannot be fully excluded. Thirdly, for an analysis of trends the sample sizes of both studies were relatively small.

For the observed positive trends in growth, overall improvement in the standard of living of the inhabitants of Kolkata over the last two decades may be held as one of the primary causative factors. Several health-related and socio-economic factors reflect the improvement in the standard of living of the Kolkata inhabitants over the study period. For example, infant mortality rate, one of the important indicators of health conditions, declined from 44 per 1000 in 1981 to 25 per 1000 in 1991 (Census of India, 2001). In the economic sphere, information on per capita income before 1991 is not readily available, but between 1991–1992 and 1995–1996, yearly income of the city population increased from Rs. 4108 to Rs. 4581 (corrected for inflation). In the educational sphere, the general literacy rate of the city population increased from 71% in 1981 to 76% in 1991 (Dutta Ray, 2002). Moreover, due to changes in the political, economic and social environment, various other aspects of the living conditions of the Kolkata population might also have been affected.

With respect to the relative role of socio-economic and demographic variables, MANOVA and ANOVA results reveal a significant effect of mother's education on height, body weight and BMI in both surveys. Results of multiple regression analysis indicate a statistically significant association between per capita monthly family expenditure and, respectively, height, body

[7] It is important to note that making quantitative comparisons between the findings of the present study and earlier studies is complex. This is largely caused by the fact that the various studies differ strongly in terms of age groups being covered, data being collected, and the ways in which results are being presented. In addition, the large cultural diversity of the Indian population is another reason which limits comparability between the various studies in different parts of India. It is for this reason that the quantitative comparisons are restricted to changes in height, for the other variables there is even less consistency in methods of reporting.

weight, and BMI. Here the effect of mother's education is no longer significant, which may be partially explained by the fact that the variables 'expenditures' and 'mother's education' are significantly correlated with each other ($r = 0.13$).

The importance of maternal education in reducing child malnutrition has been shown in various studies, both in India as well as in other countries (Arya and Devi, 1991; Gupta et al., 1991; Wachs, 2005). In many of these studies improved maternal education was found to be associated with positive secular trends in physical growth of body size (Islam et al., 1994; Monteiro et al., 1994; Huang and Malina, 1995; Padez and Johnston, 1999) together with a decline in the prevalence of stunting and thinness (Ruel et al., 1992; Monteiro et al., 1994). Furthermore, also from Asian, African, Latin American and Middle East countries, an association of maternal education with child growth has been found (de Onis, 2001). In Benin such effects have been found to be more intense in middle class families than in the families from higher and lower classes (Niameogo, 1993; Reed et al., 1996). According to the authors, education prepares the mothers to take better decisions about the allocation of available resources to the benefit of their children. And in a study in 63 countries maternal education came out as the strongest determinant of child nutritional status (Smith and Haddad, 2000). Thus in the present context, such observations may lead to the need for strengthening woman's literacy programmes in the population of the developing countries like India which are undergoing transition. Increased per capita levels of income (Chinn et al., 1989) and decreased sibship size (Fredriks et al., 2000) were also found to be major causative factors responsible for positive secular trends in physical growth of children.

Furthermore, changes in overall socio-economic factors are also found to be responsible for the secular decline in both relative sitting height and subischial leg length ratios in children and adults of many south-east Asian and Latin American countries (Kondo and Eto, 1975; Tanner et al., 1982; Zhang and Huang, 1988; Gurri and Dickinson, 1990; Bolzan et al., 1993; Ali et al., 2000; Ashizawa, 2002; Tanaka et al., 2004). Finally, the observed increase in prevalence of overweight and the emergence of obesity is in line with reports from other Indian, in particular urban, settings, and has been attributed to changing lifestyles, including more sedentary types of work, reduced levels of physical activity in leisure time, and changing dietary patterns (Khadilkar and Stanhope, 2006; Greydanus and Bhave, 2004).

In conclusion, the present findings on changes in growth in adolescent boys from middle-class Bengali boys, Kolkata, over the period 1982–2002, may be considered an important baseline data in monitoring and assessing the effects of transition on human well-being. Future large-scale national (state/countrywide) surveys should be performed at regular intervals to effectively evaluate the consequences of epidemiological transition, which have still largely remained unattempted in this vast country. Such studies would possibly reveal different effects on different socio-economic segments of the population. Depending on the nature of the observed transitional changes and their subsequent interpretation, programmes and policies need to be developed or adjusted in order to enhance the benefits of transition and prevent or reduce possible negative effects.

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References

Agarwal, D.K., Agarwal, K.N., Upadhyay, S.K., Mittal, R., Prakash, R., Rai, S., 1992. Physical and sexual growth pattern of affluent Indian children from 5 to 18 years of age. Indian Pediatr. 29, 1203–1282.

Ali, M.A., Uetake, T., Ohtsuki, F., 2000. Secular changes in relative leg length in post-war Japan. Am. J. Hum. Biol. 12, 405–416.

Arya, A., Devi, R., 1991. Influence of maternal literacy on the nutritional status of preschool children. Indian J. Pediatr. 58, 265–268.

Ashizawa, K., 2002. Leg length increase/decrease in Japanese in the latter half of the 20th Century. Anthropol. Sci. 110, 279–292.

Baten, J., Fraunholz, U., 2004. Did partial globalization increase inequality? The case of Latin American periphery, 1950–2000. CESifo Economic Studies 2004 50, 45–84.

Bielicki, T., 1986. Physical growth as a measure of the economic well being of populations: the twentieth century. In: Falkner, F., Tanner, J.M. (Eds.), Human Growth: A Comprehensive Treatise—volume 3. Methodology: Ecological, Genetic and Nutritional effects on Growth. second ed. Plenum Press, New York, pp. 283–305.

Bodzsár, B.E., Susanne, C., 1998. Secular Growth Changes in Europe. Eotvos University Press, Budapest.

Bolzan, A.G., Guimarey, L.M., Pucciarelli, H.M., 1993. Crecimiento y dismorfismo sexual de escolares segun la ocupacion laboral paterna. Archivos Latinoamericanos de Nutricion 43, 132–138.

Borooah, V.K., 2004. On the incidence of diarrhoea among young Indian children. Econ. Hum. Biol. 2, 119–138.

Borooah, V.K., 2005. The height-for-age of Indian children. Econ. Hum. Biol. 3, 45–65.

Brennan, L., McDonnald, J., Shlomowitz, R., 1994. The heights and economic well-being of North Indians under British rule. Soc. Sci. Hist. 18 (2), 271–307.

Brennan, L., McDonald, J., Shlomowitz, R., 1995. The Variation in Indian Height. Man India 75-4 S. 327–337.

Brennan, L., McDonald, J., Shlomowitz, R., 2004. Infant feeding practices and chronic child malnutrition in the Indian states of Karnataka and Uttar Pradesh. Econ. Hum. Biol. 2, 139–158.

Caballero, B., Popkin, B.M., 2002. The Nutrition Transition. Diet and Disease in the Developing World. Academic Press, London.

Census of India, 2001. Provisional Population totals. Directorate Operations, West Bengal.

Chadha, S.L., Gopinath, N., Shekawat, S., 1997. Urban rural differences in the prevalence of coronary heart diseases and its risk factors in Delhi. Bull. World Health Organization 75, 31–38.

Chatterjee, P., 2002. India sees parallel rise in malnutrition and obesity. The Lancet 360, 1948.

Chinn, S., Rona, R.J., Price, C.E., 1989. The secular trends in height of primary school children in England and Scotland, 1972–79 and 1979–86. Ann. Hum. Biol. 16, 387–395.

Cookson, R., 2005. Qaly's and the capability approach. Health Econ. 14, 817–829.

de Onis, M., 2001. Child growth and development. In: Semba, R.D., Bloem, M.W. (Eds.), Nutrition and Health in Developing Countries. Humana Press Inc., Totowa, pp. 71–91.

de Onis, M., Dasgupta, P., Saha, R., Sengupta, D., Blossner, M., 2001. The National Centre for Health Statistics reference and the growth of Indian adolescent boys. Am. J. Clin. Nutrit. 74, 248–253.

Dangour, A.D., Schilg, S., Hulse, J.A., Cole, T.J., 2002. Sitting height and subischial leg length centile curves for boys and girls from Southeast England. Ann. Hum. Biol. 29, 290–305.

Dasgupta, P., 1989/90. A cross-sectional growth study of transverse and anteroposterior dimensions in Bengali boys of Calcutta, India. Anthropologiaii Kozlemenyek 32, 225–229.

Dasgupta, P., Das, S.R., 1997. A cross-sectional growth study of trunk and limb segments of the Bengali boys of Calcutta. Ann. Hum. Biol. 24, 363–369.

Dasgupta, P., 1998, Study on physical growth and body composition of the bengali boys of Calcutta: effects of secular trends and socio-economic status. Indian Science Congress, Anthropology and Archeology Section, 85th Session, Hyderabad.

Drewnowski, A., Popkin, B.M., 1997. The nutrition transition: new trends in the global diet. Nutrit. Rev. 55, 31–43.

Drèze, J., Sen, A., 1989. Hunger and Public Action, WIDER Studies in Development. Clarendon Paperbacks, Clarendon Press, Oxford.

Dutta Ray, S., 2002. Manab Unnayan: Paschim Banger Jelachitra (in Bengali). Seriban Publishers, Kolkata.

Easwaran, P.P., Devadas, R.P., 1984. Growth performance and secular trends among school children of Coimbatore. Indian J. Nutrit. Dietetics 21, 355–371.

Eveleth, P.B., Tanner, J.M., 1990. Worldwide Variation in Human Growth, second ed. Cambridge University Press, Cambridge.

Fogel, R.W., 1986. Physical growth as a measure of the economic well-being of populations: the eighteenth and nineteenth centuries. In: Falkner, F., Tanner, J.M. (Eds.), Human Growth: A Comprehensive Treatise—volume 3. Methodology: Ecological, Genetic and Nutritional Effects on Growth. second ed. Plenum Press, New York, pp. 263–281.

Fredriks, A.M., van Buuren, S., Wit, J.M., Verloove-Vanhorick, S.P., 2000. Body index measurements in 1996–7 compared with 1980. Arch. Dis. Childhood 82, 107–112.

Gillespie, S., Haddad, L.J., 2003. The Double Burden of Malnutrition in Asia. Causes, Consequences and Solutions. Sage Publications, New Delhi.

Gopalan, C., 1992. Nutrition in Developmental Transition in South-east Asia. Regional Health Paper, SEARO No. 21. World Health Organization. New Delhi: Regional Office for South East Asia.

Gopalan, C., 1998. Demographic and developmental transition in India: its impact on nutrition related chronic diseases. In: Shetty, P., Gopalan, C. (Eds.), Diet, Nutrition and Chronic Disease—An Asian Perspective. Smith-Gordon-Nishimura Company Limited, London/Niigata-Shi, pp. 1–6.

Gopinath, N., Chadha, S.L., et al., 1994. An epidemiological study of obesity in adults in the urban population of Delhi. J. Assoc. Phys. India 42, 212–215.

Greydanus, D.E., Bhave, S., 2004. Obesity and adolescents: time for increased physical activity! Indian Pediatr. 41, 545–550.

Gunnell, D.J., Davey Smith, G., Frankel, S.J., Nanchahal, K., Braddon, F.E., Pemberton, J., Peters, T.J., 1998. Childhood leg length and adult mortality: follow up of the Carnegie (Boyd Orr) survey of diet and health in pre-war Britain. J. Epidemiol. Commun. Health 52, 142–152.

Gupta, M.C., Mehrotra, M., Arora, S., Saran, M., 1991. Relation of childhood malnutrition to parental education and mothers' nutrition related KAP. Indian J. Pediatr. 58, 269–274.

Gurri, F.D., Dickinson, F., 1990. Effects of socio-economic, ecological and demographic conditions on the development of the extremities and the trunk: a case study with adult females from Chipas. J. Hum. Ecol. 1, 125–138.

Hakeem, R., 2001. Socio-economic differences in height and body mass index of children and adults living in the urban areas of Karachi, Pakistan. Eur. J. Clin. Nutrit. 55, 400–406.

Harrison, G.G., 2004. Methodologic considerations in descriptive food-consumption surveys in developing countries. Food Nutrit. Bull. 25, 415–419.

Hauspie, R.C., Das, S.R., Preece, M.A., Tanner, J.M., 1980. A longitudinal study of the growth in height of boys and girls of West Bengal (India) aged six months to 20 years. Ann. Hum. Biol. 7, 429–441.

Huang, Y., Malina, R.M., 1995. Secular changes in the stature and weight of Taiwanese children, 1964–1988. Am. J. Hum. Biol. 7, 485–496.

IIPS, 1995. National Family Health Survey (MCH and Family Planning), India 1992–93. International Institute for Population Sciences, Mumbai, India.

IIPS, 2000. National Family Health Survey (NFHS-2), 1998–1999, India, International Institute for Population Sciences, Mumbai, India/ORC Macro Calverton, Maryland, USA.

Islam, M.A., Rahman, M.M., Mahalanabis, D., 1994. Maternal and socio-economic factors and the risk of severe malnutrition in a child: a case-control study. Eur. J. Clin. Nutrit. 48, 416–424.

Jaruratanasirikul, S., Mo-Suwan, L., Lebel, L., 1997. Growth pattern and age at menarche of obese girls in a transitional society. J. Pediatr. Endocrinol. Metab. 10, 487–490.

Kapil, U., Singh, P., Pathak, P., Nand Dwivedi, S., Bhasin, S., 2002. Prevalence of obesity amongst affluent adolescent school children in Delhi. Indian Pediatr. 39, 449–452.

Khadilkar, V.V., Khadilkar, A.V., 2004. Prevalence of obesity in affluent schoolboys in Pune. Indian Pediatr. 41, 857–858.

Khadilkar, V.V., Stanhope, R.G., 2006. Secular trends in puberty. Indian Pediatr. 43, 475–478.

Klerman, L.V., 2006. Risk of poor pregnancy outcomes: Is it higher among multiparous teenage mothers? J. Adolescent Health 38, 761–764.

Komlos, J., Baten, J., 1998. The biological standard of living in comparative perspective. In: Contributions to the Conference held in Munich. January 18–22, 1997 for the XIIth Congress of the Economic History Association, Stuttgart, Franz Steiner Verlag.

Kondo, S., Eto, M., 1975. Physical growth studies on Japanese American children in comparison with native Japanese. In: Horvath, S.M., Kondo, S., Matsui, H., Yoshimena, H. (Eds.), Comparative studies on Human Adaptability of Japanese, Caucasians and Japanese-Americans. Japanese International Biological Programme, Tokyo.

Lehmann, E.J., 1983. Theory of Point Estimation. John Wiley, New York.

Leslie, J., 1995. Improving the nutrition of Women in the Third World. In: Andersen, P., Pelletier, D., Alderman, H. (Eds.), Child Growth and Nutrition in Developing Countries—Priorities for Action. Cornell University Press, Ithaca and London, pp. 117–138.

Malina, R.M., 1990. Research on secular trends in Auxology. Anthropologischer Anzeiger 48, 209–227.

Monteiro, C.A., Benicio, M.H., Gouveia Nda, C., 1994. Secular growth trends in Brazil over three decades. Ann. Hum. Biol. 21, 381–390.

Niameogo, C., 1993. Maternal Education, Knowledge of Child Nutrition and Disease and Child Nutritional Status in the District of Ouidah, Benin. Dissertation-Cornell University, New York.

Nussbaum, M., Sen, A., 1993. The Quality of Life. Clarendon Press, Oxford.

Osmani, S., Sen, A., 2003. The hidden penalties of gender inequality: fetal origins of ill-health. Econ. Hum. Biol. 1, 105–121.

Padez, C., Johnston, F., 1999. Secular trends in male adult height, 1904–1966, in relation to place of residence and parents' educational level in Portugal. Ann. Hum. Biol. 26, 287–298.

Pakrasi, K.B., Dasgupta, P., Dasgupta, I., Majumder, P.P., 1988. Growth in height, weight and skinfold thickness of the Bengali boys of Calcutta. Anthropologischer Anzeiger 46, 1–18.

Planning Commission of India, 2001. National Human Development Report India, 2001, Government of India.

Popkin, B.M., 1993. Nutritional patterns and transitions. Populat. Dev. Rev. 19, 138–157.

Popkin, B.M., 1994. The nutrition transition in low-income countries: an emerging crisis. Nutrit. Rev. 52, 285–298.

Popkin, B.M., 2002. An overview on the nutrition transition and its health implications: the Bellagio Meeting. Public Health Nutrit. 5, 93–103.

Popkin, B.M., Keyou, G., Zhai, F., Guo, X., Ma, H., Zoohori, N., 1993. The nutrition transition in China: a cross-sectional analysis. Eur. J. Clin. Nutrit. 47, 333–346.

Rebato, E., Rosique, J., Pietrobelli, A., Chatterjee, M., Chatterjee, S., Saha, R., Dasgupta, P., 2001. Subcutaneous adipose tissue distribution in 7- to 16-year old boys of Calcutta in relation to socio-economic level. In: Dasgupta, P., Hauspie, R.C. (Eds.), Perspectives in Human Growth, Development and Maturation. Kluwer Academic Publishers, Dordrecht, pp. 91–108.

Reed, B.A., Habicht, J.P., Niameogo, C., et al., 1996. The effects of maternal education on child nutritional status depend on socio-environmental conditions. Int. J. Epidemiol. 25, 585–592.

Risley, H.H., 1891. Tribes and Castes of Bengal—Ethnographic Glossary 1 and 2. Bengal Secretariat Press, Calcutta.

Ruel, M.T., Habicht, J.P., Pinstrup-Andersen, P., Grohn, Y., 1992. The mediating effect of maternal nutrition knowledge on the association between maternal schooling and child nutritional status in Lesotho. Am. J. Epidemiol. 135, 904–914.

Saha, R., 2004. An investigation on secular changes and socio-economic factors in physical growth, maturation and nutritional status of the Bengalee boys of Calcutta. Ph.D. Thesis. University of Calcutta (Unpublished).

Sen, 1993. Capability and Well-being. In: Nussbaum, Martha, Sen, Amartya (Eds.), The Quality of Life. Clarendon Press, Oxford, pp. 30–53.

Shetty, P.S., 1999. Obesity in children in developing societies: Indicator of economic progress or a prelude to a health disaster? Indian Pediatr. 36, 11–15.

Shetty, P., Gopalan, C., 1998. Diet, Nutrition and Chronic Disease: An Asian Perspective. Smith-Gordon-Nishimura Company Limited, London/Niigata-Shi.

Sidhu, L.S., Bhatnagar, D.P., Dubey, A.P., 1982. Secular trends in the heights and weights of Punjabi boys. Anthropologischer Anzeiger 40, 187–192.

Singh, R., 1995. Secular increase in body size and nutritional anthropometric measurements of Indian children. In: Hauspie, R., Lindgren, G., Falkner, F. (Eds.), Essays on Auxology. Castlemead Publications, Welwyn Garden City, pp. 322–333.

Smith, L.C., Haddad, L., 2000. Explaining child malnutrition in developing countries: a cross-country analysis. Research Report 111, IFPRI, Washington DC.

Sungthong, R., Mo-Suwan, L., Chongsuvivatwong, V., Geater, A.F., 1999. Secular increases in height, weight and body mass index among schoolchildren of Hat-Yai, Thailand: a 5 years follow-up study. South East Asian J. Trop. Med. Public Health 30, 532–538.

Suryanarayana, M.H., 2001. Economic reform versus food security: Kerala's Gordian Knot. J. Int. Dev. 13, 239–253.

Tanaka, C., Murata, M., Homma, M., Kawahara, T., 2004. Reference charts of body proportion for Japanese girls and boys. Ann. Hum. Biol. 31, 681–689.

Tanner, J.M., 1986. Growth as the mirror of the condition of society: secular trends and class distinctions. In: Demirjian, A. (Ed.), Human Growth: A Multi-disciplinary Review. Taylor and Francis, London, pp. 3–34.

Tanner, J.M., Hayashi, T., Preece, M.A., Cameron, N., 1982. Increase in length of leg relative to trunk in Japanese children and adult from 1957 to 1977: comparison with British and with Japanese American. Ann. Hum. Biol. 9, 411–423.

Thang, N.M., Popkin, B., 2003a. Child malnutrition in Vietnam and its transition in an era of economic growth. J. Hum. Nutrit. Dietetics 16, 233–244.

Thang, N.M., Popkin, B., 2003b. In an era of economic growth, is inequality holding back reductions in child malnutrition in Vietnam? Asia Pacific J. Clin. Nutrit. 12, 1–6.

Thankappan, K.R., 2001. Some health implications of globalization in Kerala, India. Bull. World Health Organization 79, 892–893.

Thomson, A.M., Duncan, D.L., 1954. The diagnosis of malnutrition in man. Nutrit. Abstracts Rev. 24, 11–18.

Torres, L.A., Martinez, F.E., Manco, J.C., 2003. Correlation between standing height, sitting height, and arm span as an index of pulmonary function in 6-10-year-old children. Pediatr. Pulmonol. 36, 202–208.

van Wieringen, J.C., 1986. Secular growth changes. In: Falkner, F., Tanner, J.M. (Eds.), Human Growth: A Comprehensive Treatise—volume 3. Methodology: Ecological, Genetic and Nutritional Effects on Growth. second ed. Plenum Press, New York, pp. 307–331.

Velasquez-Melendez, G., Silveira, E.A., Allencastro-Souza, P., Kac, G., 2005. Relationship between sitting-height-to-stature ratio and adiposity in Brazilian women. Am. J. Hum. Biol. 17, 646–653.

Véron, R., 2001. The "New" Kerala model: lessons for sustainable development. World Dev. 29, 601–617.

Wachs, T.D., 2005. Linking nutrition and education: a cross-generation model. Food Nutrit. Bull. 26 (2 (Suppl. 2)), S159–S167.

Weiner, J.S., Lourie, J.A., 1969. Human Biology: A Guide to Field Methods. Blackwell Scientific Publications, Oxford.

World Health Organization, 1983. Measuring Change in Nutritional Status. World Health Organization, Geneva.

World Health Organization, 1995. Physical Status: The Use and Interpretation of Anthropometry. Report of a WHO Expert Committee. Technical Report Series No. 854. Geneva: World Health Organization.

World Health Organization, 2006. Global database on child growth and malnutrition, (http://www.who.int/gdgm/p-child_pdf/ind.pdf and http://www.who.int/gdgm/p-child_pdf/ind_ref.pdf).

Zhang, X., Huang, Z., 1988. The second national growth and development survey of children in China, 1985: children 0 to 7 years. Ann. Hum. Biol. 15, 289–305.

Zhang, X., Shu, X.O., Gao, Y.T., Yang, G., Mattews, C.E., Li, Q., Li, H., Jin, F., Zheng, W., 2004. Anthropometric predictors of coronoray heart disease in Chinese women. Int. J. Obesity Relat. Disorders 28, 734–740.