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Associations between Anthropometric Characteristics, Nutritional Status, and Socio-Economic Status among Bengalee Adolescents Living in Darjeeling District, West Bengal, India

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Abstract

Socio-economic status affects the overall growth and development of children and adolescents. The present study examines the relation between anthropometric characteristics, nutritional status, and the socioeconomic status of adolescents. This cross-sectional study was conducted among 300 adolescents (boys and girls) aged 10-15 years residing in Darjeeling district of West Bengal. Five anthropometric variables were used to describe anthropometric characteristics, growth pattern and nutritional status of the adolescents: height, weight, mid-upper arm circumference (MUAC), biceps skinfold (BSF), and triceps skinfold (TSF). The adolescents were grouped into five socio-economic class sub-categories: lower, lower middle, middle, upper middle, and upper. Adolescents belonging to the middle socio-economic group were the most affected group in terms of unsatisfactory growth and nutritional status. Most measurements, (except BMI, BSF and TSF) were found to be significantly associated with socio-economic class of boys. Irrespective of socio-economic class, boys were taller and heavier than girls whereas adiposity measures (BSF, TSF) were higher in girls. The overall findings suggest association of better growth with better living standards.

Keywords: Adolescents, Anthropometry, Socio-economic status, Nutritional status

1 Introduction

Besides socioeconomic status, or “standard of living”, the factors that affect the way children and adolescents grow up include family, neighbourhood, and school. The quality and nature of these factors have a profound influence on adolescents’ chances of leading a successful adult life (Escarce, 2003). Community-level socioeconomic factors play a crucial role in the incidence of malnutrition (Ahmad et al., 2020), which can affect the physical and even mental growth of children and adolescents. A correlation between height and socio-economic position (SEP) has been found where lower family or community SEP is associated with shorter stature and higher stunting rate (Luo & Song, 2022). Both growth and socio-economic status directly or indirectly affect the health as well as the cognitive and academic attainment of children (Bradley & Corwyn, 2002). Adolescence is defined as the phase between childhood and adulthood between the ages of 10 and 19 years when an individual goes through characteristic physical and mental changes (Dey et al., 2010; WHO, 1995).

Anthropometry has been considered the most effective method for determining the growth patterns of children and adolescents (Banerjee et al., 2009; Chakrabarty & Bharati, 2008; Debnath et al., 2017; Debnath & Khatun, 2024; WHO, 1995). Many researchers in different time periods conducted studies on growth, development, and socioeconomic status of children and adolescents from different parts of the world (Bradly & Corwyn, 2002; Freitas et al., 2007; Gültekin et al., 2006; Kocaoğlu & Köksal, 1985; Maji & Biswas, 2020). As per our search strategy, we did not find any research related to a possible *sex-specific* relationship between growth and socio-economic status along with the nutritional status among adolescents

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of Darjeeling district in West Bengal, India. Objectives of the present study were to examine sex differences in anthropometric measurements and growth pattern according to socio-economic class, and to examine the relationships of growth as defined by anthropometric measurements with socio-economic status of the Bengalee adolescents in Darjeeling.

1.1 Hypotheses of this study

1. There will be significant sex difference between anthropometric parameters, depending on socio-economic class (H1).
2. There will be significant associations between anthropometric growth parameters and socio-economic class (H2).
3. There is an association between nutritional status and socio-economic class (H3).

2 Materials and methods

2.1 Study area and participants

The present study was cross-sectional, carried out in *Matigara* Block (located at 26°43′0″N 88°23′0″E at an elevation of 127m above sea level) of Darjeeling district, West Bengal. The age of the study participants was 10-15 years. Written consent was obtained from two Bengali medium government high schools located in the study area. Date of birth was confirmed from either birth certificate or identity cards. Apparently healthy participants were selected for this study. A total of 300 adolescents were selected (50% boys and 50% girls) using a stratified random sampling. No specific sample size was calculated for the study as the time for data collection was limited, but special attention was given to having equal numbers of boys and girls in each age group. The time of data collection was July-August, 2023. Verbal consent was taken from each participant before data collection.

2.2 Determination of socio-economic status

To determine the socio-economic status of the participants, the updated scale of B.G. Prasad for 2024 (Javalkar et al., 2024) was used. This scale collects data from the participants related to number of family members and monthly income of the family. Then the income is divided by the number of family members to get the monthly per capita income (MPCI) of the participants. Based on the range of the MPCI as given by the updated BG Prasad scale, their socio-economic class (SEC) was categorized into: upper, upper middle, middle, lower middle, and lower socio-economic classes. Table 1 represents the number of adolescents (gender- and age-wise) in different SECs. Table 2 represents the mean age and frequency distribution (n) of the adolescents based on their socio-economic status. From the table, it is seen that few adolescents belonged to lower (n=18) and upper (n=13) classes compared to the other three SECs. The total mean ages of the participants from each SEC were almost the same (except the upper class). Gender-specific mean ages were essentially the same in each SEC category (except the lower SEC).

Table 1: Frequency distribution (numbers) of the adolescents based on age, gender, and socio-economic class

Age (years)	Sex	Socio-economic class				
		Lower (n=18)	Lower middle (n=104)	Middle (n=101)	Upper middle (n=64)	Upper (n=13)
10	Boys	–	–	13	9	3
	Girls	3	6	8	6	2

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Age (years)	Sex	Socio-economic class				
		Lower (n=18)	Lower middle (n=104)	Middle (n=101)	Upper middle (n=64)	Upper (n=13)
11	Boys	–	14	9	2	–
	Girls	3	15	4	–	3
12	Boys	–	2	14	9	–
	Girls	1	10	7	6	1
13	Boys	–	4	8	10	3
	Girls	–	6	8	11	–
14	Boys	2	10	7	6	–
	Girls	7	15	2	1	–
15	Boys	–	8	13	4	–
	Girls	2	14	8	–	1

Table 2: Mean age (in years) and distribution of adolescents according to their socio-economic status

Social class	Boys ($n = 150$)		Girls ($n = 150$)		Total ($n = 300$)	
	N	Mean age $\pm$SD	N	Mean age $\pm$SD	N	Mean age $\pm$SD
Lower	2	14.00 $\pm$0.007	16	12.70 $\pm$1.877	18	12.84 $\pm$1.812
Lower Middle	38	12.91 $\pm$1.641	66	12.78 $\pm$1.720	104	12.83 $\pm$1.685
Middle	64	12.43 $\pm$1.790	37	12.45 $\pm$1.807	101	12.44 $\pm$1.788
Upper Middle	40	12.38 $\pm$1.622	24	12.06 $\pm$1.310	64	12.26 $\pm$1.510
Upper	6	11.55 $\pm$1.636	7	11.45 $\pm$1.716	13	11.50 $\pm$1.609

2.3 Anthropometric measurements and data management

To assess growth patterns, with particular attention to body size and adiposity, five anthropometric measurements were taken: height (HT), weight (WT), mid-upper arm circumference (MUAC), biceps skinfold (BSF), and triceps skinfold (TSF).Height and weight were measured following standard protocol and using standard instruments (Lohman et al., 1988). Non-elastic tape was used for circumference measurement. All skinfold measurements were taken with a Holtain skinfold caliper. BMI was calculated using the (WHO, 1995) formula. The cut-off values given by (Cole et al., 2000; Cole et al., 2007) were used to assess the nutritional status of the participants.

All data were first entered and coded in MS-Excel and then transferred to SPSS (v. 26) for statistical analysis. Mean and standard deviation were calculated. The independent t-test was used for the sex difference. Pearson correlation was used for the relationship between growth status and socio-economic status of the participants.

3 Results

3.1 Anthropometric profile of the participants

Anthropometric profiles of the participants and their sex differences are shown in Table 3 in relation to socio-economic class. One-way ANOVA showed significant social class differences only for height of boys. With the exception of lower class, which had only two boys, average ages of boys and girls were very

similar in the different SES groups. The boys had higher values than girls on measures of body size (height, weight), whereas girls had higher values for measures of adiposity (skinfolds).

Table A1 in the appendix provides the result of multiple regression analysis predicting anthropometric variables with age and sex. The findings clearly indicate that both age and gender were associated with height, while gender was strongly associated with MUAC, BSF and TSF. Tables A2-A7 in the appendix represent the age-wise descriptive statistics for the anthropometric variables according to the five SEC categories and sex. For each age group, the anthropometric variables were low for middle SEC.

Table 3: Anthropometric profile of adolescents belonging to different socio-economic classes

Anthropometric variables	Gender	Socio-economic class					F-value / t-value
		Lower (B=2 G=16)	Lower middle (B=38 G=66)	Middle (B=64 G=37)	Upper middle (B=40 G=24)	Upper (B=6 G=7)	
Height (cm)	Boys	138.50 ± 7.78	150.09 ± 13.67	149.87 ± 14.28	155.87 ± 11.90	160.51 ± 4.96	5.540***
	Girls	147.35 ± 6.01	148.17 ± 6.92	146.07 ± 6.92	146.38 ± 6.46	150.95 ± 5.34	1.257
	t-value	2.031	-0.949	-1.511	-3.591**	-3.321**	-
Weight (kg)	Boys	34.10 ± 12.58	42.13 ± 14.87	42.34 ± 14.63	48.21 ± 12.42	51.78 ± 6.52	1.299
	Girls	44.19 ± 9.66	42.17 ± 10.45	39.47 ± 10.23	41.91 ± 9.46	48.30 ± 7.63	1.700
	t-value	1.364	0.017	-1.052	-2.135*	-0.875	-
MUAC (cm)	Boys	21.90 ± 4.38	23.47 ± 4.06	23.44 ± 4.58	25.13 ± 4.25	25.76 ± 2.90	0.650
	Girls	23.75 ± 2.79	22.90 ± 3.39	22.12 ± 3.38	23.75 ± 3.59	29.91 ± 2.94	1.773
	t-value	0.845	-0.767	-1.524	-1.322	-1.137	-
BMI (kg/m^2)	Boys	17.49 ± 4.58	18.19 ± 3.72	18.34 ± 3.80	19.59 ± 3.49	20.13 ± 2.75	1.205
	Girls	20.19 ± 4.01	19.09 ± 4.18	18.30 ± 3.57	19.47 ± 3.79	21.22 ± 3.25	1.242
	t-value	0.889	1.099	-0.052	-0.127	0.641	-
BSF (mm)	Boys	5.90 ± 1.56	5.83 ± 2.48	5.74 ± 3.46	6.16 ± 3.15	6.88 ± 4.23	2.224
	Girls	9.74 ± 3.07	7.46 ± 2.69	6.74 ± 2.63	8.22 ± 4.21	8.92 ± 2.52	1.528
	t-value	1.708	3.056**	1.515	2.226*	1.086	-
TSF (mm)	Boys	9.50 ± 4.95	9.67 ± 4.12	9.76 ± 3.38	9.85 ± 4.05	11.63 ± 5.68	1.035
	Girls	15.38 ± 4.84	12.99 ± 4.76	11.49 ± 4.15	13.50 ± 5.02	15.61 ± 3.47	1.069
	t-value	1.618	3.589**	2.096*	3.188**	1.551	-

* $p < .05$, ** $p < .01$, *** $p < .001$ *Note.* B = Boys, G = Girls.

Table 4 depicts the association of anthropometric variables with socio-economic class through linear regression analysis. All three body size measures (HT, WT and MUAC) were found to have significant association with socio-economic class among the boys only. There was no significant association between body adiposity measures with SEC. BSF showed a negative association with age among the boys.

Table 4: Linear regression analysis to show the association between anthropometric variables and socio-economic class among the studied participants

Variable	**Gender**	**Predictors**	**B coefficient**	**Std. error (B)**	**β coefficient**	**t value**	**95% CI (B)**
HT (cm)	Boys	SEC	4.359	1.233	0.276	3.536**	1.925–6.795
		Age	2.334	0.616	0.295	3.787***	1.116–3.152
	Girls	SEC	-0.065	0.549	-0.010	-0.118	-1.150–1.021
		Age	0.517	0.330	0.130	1.567	-0.135–1.170
WT (kg)	Boys	SEC	3.742	1.341	0.227	2.790**	1.091–6.392
		Age	0.964	0.670	0.117	1.438	-0.361–2.289

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Variable	Gender	Predictors	B coefficient	Std. error (B)	β coefficient	t value	95% CI (B)
	Girls	SEC	0.179	0.823	0.018	0.217	-1.448–1.806
		Age	0.507	0.495	0.086	1.025	-0.471–1.485
MUAC (cm)	Boys	SEC	0.884	0.420	0.174	2.106*	0.055–1.714
		Age	0.038	0.210	0.015	0.183	-0.376–0.453
	Girls	SEC	0.124	0.274	0.038	0.452	-0.417–0.664
		Age	0.146	0.164	0.074	0.889	-0.179–0.471
BMI (kg/m^2)	Boys	SEC	0.653	0.355	0.151	1.836	-0.050–1.355
		Age	-0.145	0.178	-0.067	-0.816	-0.496–0.206
	Girls	SEC	0.082	0.321	0.039	0.256	-0.553–0.717
		Age	0.089	0.193	0.022	0.460	-0.293–0.471
BSF (mm)	Boys	SEC	0.064	0.298	0.018	0.216	-0.525–0.654
		Age	-0.451	0.149	-0.246	-3.025**	-0.746–(-)0.156
	Girls	SEC	-0.088	0.252	-0.029	-0.347	-0.587–0.411
		Age	0.096	0.152	0.053	0.634	-0.204–0.396
TSF (mm)	Boys	SEC	0.138	0.389	0.029	0.355	-0.631–0.908
		Age	-0.374	0.195	-0.159	-1.921	-0.759–0.011
	Girls	SEC	-0.110	0.385	-0.024	-0.286	-0.872–0.651
		Age	0.098	0.232	0.035	0.423	-0.360–0.556

* $p < .05$, ** $p < .01$, *** $p < .001$

3.2 Nutritional status of the participants

According to the BMI cut-off values given by Cole et al. (2000) and Cole et al. (2007) for children and adolescents, both thinness (one form of undernutrition) and overnutrition were found in the studied population. Hence, the overall nutritional status implicates that double burden of malnutrition was more prevalent among boys (48.7%) than girls (Figure 1). Figure 2 depicts that the middle SEC group was the most effected by undernutrition (thinness). The percentage of overweight and obese individuals was high in the upper SEC category. Significant associations of nutritional status with gender and socio-economic status were found.

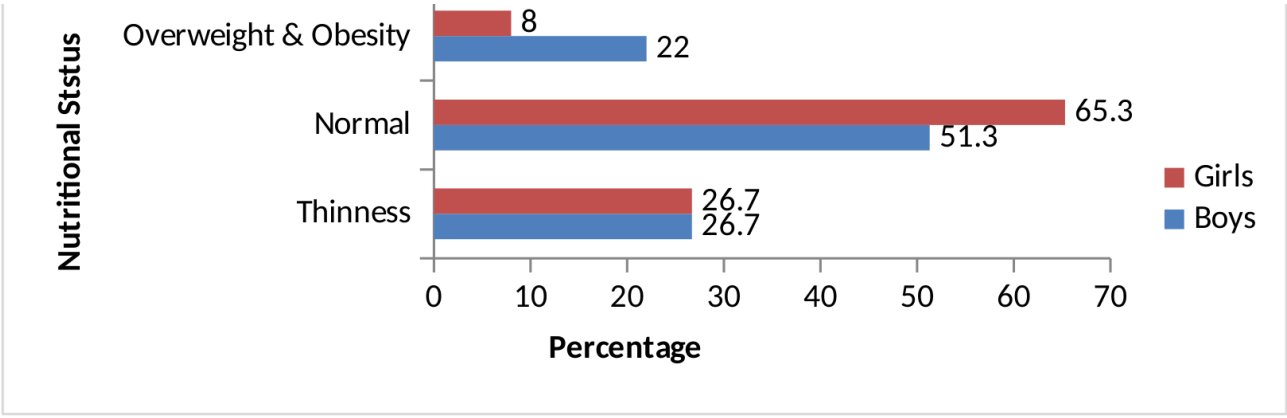

Figure 1: Gender-specific nutritional status of the studied adolescents

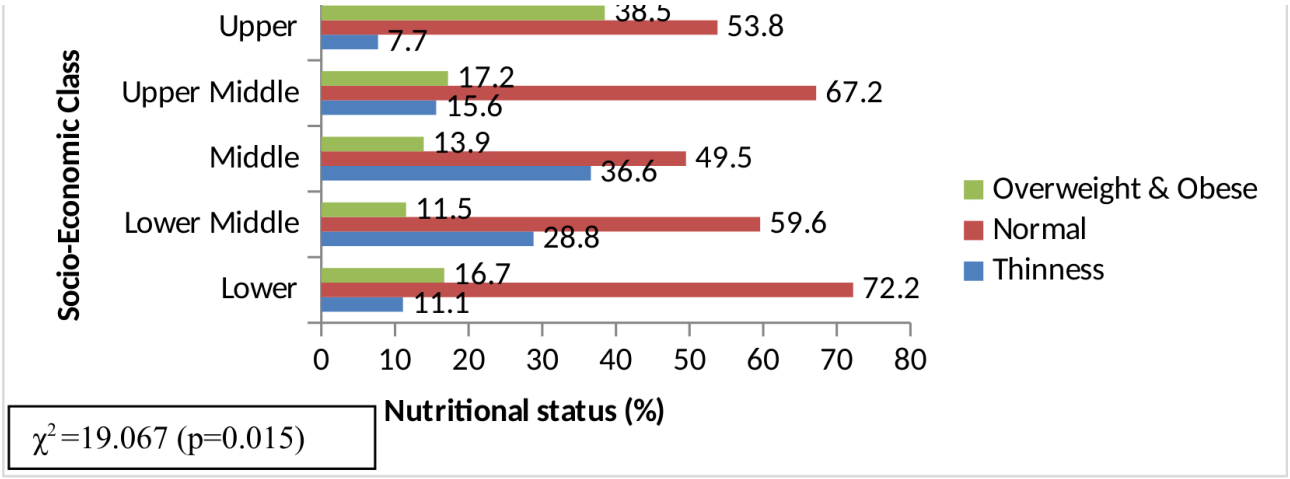

Figure 2: Nutritional status (%) of the studied participants according to their socio-economic status

4 Discussion

The present study was conducted with the aim to assess the relationship between growth status (with reference to growth pattern) and socioeconomic status of the adolescents. As per the findings very few individuals belonged to “upper” and “lower” socio-economic classes suggesting the possibility of range restriction in the sample.

4.1 Growth and socio-economic status

A study conducted by Maji and Biswas (2020) reported a positive relation between anthropometric growth pattern and high socio-economic status, which indicates high socio-economic status helps to promote the physical growth of the individual. The present study also found higher values of some of the anthropometric measurements of the participants (such as MUAC, BSF) in the upper and upper middle socio-economic classes. All these measurements indicate larger body size in the higher SES groups (height, weight) and also adiposity (skinfolds). Abubakar et al. (2008) found significant associations between socio-economic status and anthropometric status (such as MUAC, HC, height-for age, and weight-for-age), among Kenyan children. This study also reported that the anthropometric status of children under 3 years old living in relative poverty shows an indirect association with SES.

Some studies (De, 2016; Herzog et al., 2016) contradicted those findings, finding instead that participants with lower socio-economic status gain more weight and waist circumference than those with higher socio-economic status (Germany) or that socio-economic status has no significant relation to anthropometry (West Bengal, India). As per our findings (Table 3), it is clear that the values of most of the anthropometric measurements were lower in participants from the middle socio-economic group compared to the lower or lower middle class groups. Hence, from our findings it can be said that the growth status of the lower and lower middle class group adolescents were, if anything, better than the middle class group. Nutritional shifts may be responsible for such differences in growth between different SES groups. Lifestyle factors and physical activity can play a role here. Our study also supports that in the Indian context, children and adolescents from middle-class background may face growth challenges in terms of stunting and wasting. A recent study (Jain et al., 2024) found that over the last three decades, the prevalence of stunting and wasting increased among children in higher socio-economic groups in comparison to those of lower socio-economic groups. On the other hand, the measurements of the participants from the upper middle and upper class categories indicated larger body size and stronger growth than in the other three socioeconomic class categories, at least among boys (see Table 3). This finding indicates that these individuals are living under conditions that promote better growth. The sample sizes for the lower (n=18)

and upper (n=13) class groups were too small for any strong conclusions, but comparing lower middle to upper middle class, the findings suggest that better living standard is associated with better growth among adolescents.

No specific growth trends according to socio-economic class were observed in reference to the anthropometric measurements for both genders. Mizuta et al. (2016) reported a positive association of low economic status and higher BMI among Japanese girls. A recent Indian study using National Family Health Surveys IV and V data (Petrikova & Kumar, 2025) supports the fact that among Indian children obesity is shifting from higher to lower socio-economic groups. Another study (Joseph & Sendhil, 2026) reported that children from higher socio-economic groups tend to be taller than those of lower SES. Our Indian sample may be in the process of transition between these two patterns as significant associations with SES are observed only for some growth measurements (HT, WT, MUAC & BMI) and among boys only. In Madeira, Portugal, boys and girls from high socioeconomic groups were found to be taller, heavier, and fatter than their peers from average and low groups (Freitas et al., 2007). Our study findings are in line with this study. Another study conducted among children living in the outskirts of Ankara (Gültekin et al., 2006) found that lower class children had lower mean values for height and weight than did the upper class children. However, no clear relationship of growth with parents' education and father's professional status was observed (except for height of girls). Al-Hussaini et al. (2022) conducted a study among Saudi Arabian children and found that short stature was significantly more frequent among children in the lower SES category. Gomula et al. (2024) conducted a longitudinal study among Polish adolescents to assess variation in age at peak height velocity associated with several indicators of SES and found a sex-dependent effect of socioeconomic status on age at peak height velocity. They reported that those from higher SES reached peak height velocity at a significantly younger age than their peers from lower SES, highlighting the influence of favourable socioeconomic conditions on the timing of growth and maturation.

Skinfold thickness is generally used as a measure of subcutaneous fat. In our study population, the biceps skinfold (BSF) was higher among girls than boys in each socio-economic class and there was a trend of BSF to be higher in the higher SES categories. The findings were similar for triceps skinfold (TSF). In Hungary, Zsakai and Bodzsar (2014) reported that the subcutaneous fat accumulation of children and adolescents from better socio-economic backgrounds was significantly smaller than it was in the low-SES category. Our findings suggest that in our Indian sample, high socio-economic status tends to promote better anthropometric growth in terms of weight, MUAC, BMI and BSF.

4.2 Nutrition and socio-economic status

Several studies had been conducted to study the relationship between socio-economic status and nutritional status among adolescents of different regions of India as well as in the world. Dey et al. (2010) reported that thinness was more prevalent in lower SES (21.3%) than higher SES (1.3%) adolescents from West Bengal. They also found that thinness was more prevalent among girls than boys from lower SES. A study from Rajasthan (Mahajani & Bhatnagar, 2014) found no significant difference between socio-economic groups in height/age classification, but there was a difference between SES groups in weight/age. Bharti et al. (2020) reported that the percent of undernutrition was high among girls with illiterate mothers from Banka district, Bihar. A study from Coimbatore (A. & N., 2021) among adolescents reported a high prevalence of obesity among upper middle income class (41%) compared to upper (22%), middle/lower middle (16%) and lower/upper lower socio-economic class (21%). Moazzam et al. (2025) found 65.5% of the studied adolescents from lower-middle socio-economic background in Lahore, Pakistan were underweight, as were 22.6% of those of upper-middle SES.

Zsakai and Bodzsar (2014) found that in their sample of Hungarian children and adolescents, underweight was significantly more prevalent in those from relatively poor socio-economic background, although also overnutrition was higher in the relatively poor socio-economic subgroups.The present findings (Figure 1, 2) show the prevalence of thinness was the same for both boys and girls (26.7%), while overnutrition was more prevalent among boys (22%) than girls (8%). Undernutrition (in terms of thinness) was most prevalent in the middle SEC, and overnutrition in upper SEC. The present findings are in line

with those of Lum et al. (2025) among Malaysian children, where children from middle-income households were found to be more undernourished. This may be due to changing food habits, changing lifestyle, socio-economic transition, and lack of awareness regarding nutrition. This Malaysian study also showed that adolescents from lower SES had a higher prevalence of undernutrition than adolescents belonging to lower-middle and middle SES. The reason for the difference is not clearly explained from this cross-sectional study, but consumption of low-cost "junk food", low prevalence of recreational resources in the low SES groups, stress, and low social support are possible reasons (Watts et al., 2016).

Hence from the above findings it can be stated that H1 is partially accepted as significant sex differences were observed for height, weight, BSF, and TSF (Table 3). According to table 4, H2 is also partially accepted. From the chi-square value of 19.067 ($p < .05$), we found H3 is also accepted.

4.3 Limitations of the study

The findings of the present study are important as they show how socioeconomic status is related to anthropometric growth status among the Bengali adolescents of the studied region. However, the study has some drawbacks: The cross-sectional nature of this study could find no explanation for why the anthropometric measures of the middle socioeconomic class group are lower than those of the lower and lower middle class groups as additional data were missing. Another major limitation is the small sample size of the lower and upper SEC groups. Again, this study did not include any dietary pattern or lifestyle related data of the participants that may explain why there is such a difference between the socioeconomic categories.

5 Conclusion

Present study findings indicate the presence of a double burden of malnutrition in the studied group. On many of the measures, adolescents of the middle-class group were the most growth-impaired and nutritionally affected group among the socioeconomic categories. This study concluded that there is a need to carry out more longitudinal studies to know the reason for such differences, and to include measures of nutritional and lifestyle factors that are hypothesized to affect growth.

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Conflict of interest

None to declare.

References

A., P., & N., S. (2021). Correlative analysis of obesity and socio economic status of the selected adolescents (13-15 years) in the schools of Coimbatore (east zone). *Indian Journal of Nutrition and Dietetics*, 100–109. https://doi.org/10.21048/ijnd.2021.58.s1.27543

Abubakar, A., Van de Vijver, F., Van Baar, A., Mbonani, L., Kalu, R., Newton, C., & Holding, P. (2008). Socioeconomic status, anthropometric status, and psychomotor development of Kenyan children from resource-limited settings: A path-analytic study. *Early Human Development*, *84*(9), 613–621. https://doi.org/10.1016/j.earlhumdev.2008.02.003

Ahmad, D., Afzal, M., & Imtiaz, A. (2020). Effect of socioeconomic factors on malnutrition among children in Pakistan. *Future Business Journal*, *6*(1), 1–11. https://doi.org/10.1186/s43093-020-00032-x

Al-Hussaini, A., Bashir, M. S., Khormi, M., Alkhamis, W., Alrajhi, M., & Halal, T. (2022). Prevalence and socioeconomic correlates of growth impairment among Saudi children and adolescents. *Saudi Journal of Gastroenterology*, *28*(4), 288–295. https://doi.org/10.4103/sjg.sjg_338_21

Banerjee, S. R., Chakrabarty, S., Vasulu, T. S., Bharati, S., Sinha, D., Banerjee, P., & Bharati, P. (2009). Growth and nutritional status of Bengali adolescent girls. *Indian Journal of Pediatrics*, *76*(4), 391–399. https://doi.org/10.1007/s12098-009-0015-3

Bharti, K., Kumar, M., & Prasad, P. (2020). Impact of socio-economic status (SES) and nutrition health education on nutritional status of adolescent girls. *Food Science Research Journal*, *11*(2), 134–139. https://doi.org/10.15740/has/fsrj/11.2/134-139

Bradley, R. H., & Corwyn, R. F. (2002). Socioeconomic status and child development. *Annual Review of Psychology*, *53*(1), 371–399. https://doi.org/10.1146/annurev.psych.53.100901.135233

Chakrabarty, S., & Bharati, P. (2008). Physical growth and nutritional status of the Shabar tribal adolescents of Orissa, India: A cross-sectional study. *Malaysian Journal of Nutrition*, *14*(1), 101–112. https://doi.org/10.3109/03014460903234742

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ*, *320*(7244), 1240–1243. https://doi.org/10.1136/bmj.320.7244.1240

Cole, T. J., Flegal, K. M., Nicholls, D., & Jackson, A. A. (2007). Body mass index cut offs to define thinness in children and adolescents: International survey. *BMJ*, *335*(7612), 194. https://doi.org/10.1136/bmj.39238.399444.55

De, K. (2016). Influence of socio-economic status on the nutritional status of rural adolescent girls. *Anthropology*, *4*(3), 2–5. https://doi.org/10.4172/2332-0915.1000168

Debnath, M., & Khatun, A. (2024). A cross-sectional study on physical growth and body composition among Bengali adolescents of north Bengal, West Bengal (India). *Human Biology Review*, *13*(3), 243–264.

Debnath, S., Mondal, N., & Sen, J. (2017). Use of upper arm anthropometry, upper arm muscle area-by-height (UAMAH) and midupper- arm-circumference (MUAC)-for-height as indicators of body composition and nutritional status among children. *Anthropological Review*, *80*(1), 85–102. https://doi.org/10.1515/anre-2017-0004

Dey, S. K., Masanta, N. C., & Bisai, S. (2010). A comparative study of anthropometric and nutritional status of high and low socio-economic groups of adolescents. *International Journal of Current Research*, *6*, 11–13.

Escarce, J. J. (2003). Socioeconomic status and the fates of adolescents. *Health Services Research*, *38*(5), 1229–1233. https://doi.org/10.1111/1475-6773.00173

Freitas, D., Maia, J., Beunen, G., Claessens, A., Thomis, M., Marques, A., Crespo, M., & Lefevre, J. (2007). Socio-economic status, growth, physical activity and fitness: The Madeira growth study. *Annals of Human Biology*, *34*(1), 107–122. https://doi.org/10.1080/03014460601080983

Gomula, A., Nowak-Szczepanska, N., Králik, M., Malina, R. M., Zareba, M., & Koziel, S. (2024). Age at peak height velocity in Polish adolescents: Effect of socio-economic factors. *American Journal of Human Biology*, *36*(9), e24083. https://doi.org/10.1002/ajhb.24083

Gültekin, T., Hauspie, R., Susanne, C., & GüleÇ, E. (2006). Growth of children living in the outskirts of Ankara: Impact of low socio-economic status. *Annals of Human Biology*, *33*(1), 43–54. https://doi.org/10.1080/03014460500424050

Herzog, B., Lacruz, M. E., Haerting, J., Hartwig, S., Tiller, D., Medenwald, D., Vogt, S., & Kluttig, A. (2016). Socioeconomic status and anthropometric changes—a meta-analytic approach from seven German cohorts. *Obesity (Silver Spring, Md.) 24*(3), 710–718. https://doi.org/10.1002/oby.21366

Jain, A., Kim, R., Swaminathan, S., & Subramanian, S. (2024). Socioeconomic inequality in child health outcomes in India: Analyzing trends between 1993 and 2021. *International Journal for Equity in Health*, *23*(1), 149. https://doi.org/10.1186/s12939-024-02218-z

Javalkar, S. R., H., S., B. Davalagi, S., & G. S., V. (2024). Socio-economic status assessment in India: History and updates for 2024. *International Journal of Community Medicine and Public Health*, *11*(3), 1369–1377. https://doi.org/10.18203/2394-6040.ijcmph20240648

Joseph, J., & Sendhil, R. (2026). Nutritional status of children in rural and urban India based on National Family Health Surveys. *Discover Public Health*, *23*(1), 220. https://doi.org/10.1186/s12982-026-01467-3

Kocaoğlu, B. A., & Köksal, O. (1985). The effect of socio-economic condition on growth, development and obesity among adolescents in Turkey. *Beslenme ve Diyet Dergisi / Journal of Nutrition & Dietetics*, *14*, 25–37.

Lohman, T. G., Roche, A. F., & Martorell, R. (1988). *Anthropometric Standardization Reference Manual*. Human Kinetics Books.

Lum, P. T., Chia, J. S. M., Yeo, G. S., Lim, S. M., Sameeha, M. J., Wong, J. E., Safii, N. S., Khouw, I., & Poh, B. K. (2025). Socioeconomic disparities and its association with food security, diet quality, and growth among Malaysian children aged 6 months to 12.9 years. *Frontiers in Public Health*, *13*, 1709696. https://doi.org/10.3389/fpubh.2025.1709696

Luo, D., & Song, Y. (2022). Socio-economic inequalities in child growth: Identifying orientation and forward-looking layout. *Lancet Regional Health - Western Pacific*, *21*, 100412. https://doi.org/10.1016/j.lanwpc.2022.100412

Mahajani, K., & Bhatnagar, V. (2014). Effects of socio economic status on nutritional profile of adolescent girls of Hanumangarh (Rajasthan). *Trends in Biosciences*, *7*(11), 1018–1026.

Maji, R., & Biswas, S. (2020). A relationship study between socioeconomic status and growth status of school students. *International Journal of Physiology, Nutrition and Physical Education*, *5*(1), 146–150. https://doi.org/10.36106/gjra/9809690

Mizuta, A., Fujiwara, T., & Ojima, T. (2016). Association between economic status and body mass index among adolescents: A community-based cross-sectional study in Japan. *BMC Obesity*, *3*(1), 47. https://doi.org/10.1186/s40608-016-0127-z

Moazzam, M., Raza, Q., Khan, M., Sohail, Z., Rasheed, R., Batool, R., Imran, K., Khalid, S., Younis Mallhi, I., & Bashar, S. (2025). Linking socioeconomic status with adolescent nutrition: Analyzing dietary patterns and micronutrient deficiencies among adolescents aged 13-17 years in Lahore. *Cureus*, *17*(5), e83622. https://doi.org/10.7759/cureus.83622

Petrikova, I., & Kumar, N. (2025). Progress in child nutrition outcomes: Insights from India's recent experience. *BMC Public Health*, *25*(1), 3179. https://doi.org/10.1186/s12889-025-24436-y

Watts, A. W., Mason, S. M., Loth, K., Larson, N., & Neumark-Sztainer, D. (2016). Socioeconomic differences in overweight and weight-related behaviors across adolescence and young adulthood: 10-year longitudinal findings from project EAT. *Preventive Medicine*, *87*, 194–199. https://doi.org/10.1016/j.ypmed.2016.03.007

WHO (1995). Physical status: The use and interpretation of anthropometry: Technical report no. 854 [WHO].

Zsakai, A., & Bodzsar, E. B. (2014). The relationship between body structure and the socio-economic status in Hungarian children and adolescents. *Collegium Anthropologicum*, *38*(2), 479–485.

Appendix

Table A1: Multiple regression to show the relationship between anthropometric variables with age and sex among the studied participants

Anthropometric variables	Predictors	Unstandardized B	β coefficient	t-value	95% CI (B)
HT (cm)	Age	1.230	0.193	3.454**	0.529–1.930
	Sex	4.330	0.199	3.564***	1.939–6.721
WT (kg)	Age	0.560	0.078	1.349	−0.257–1.376
	Sex	2.152	0.088	1.520	−0.635–4.939
MUAC (cm)	Age	0.047	0.021	0.359	−0.212–0.307
	Sex	0.988	0.126	2.196*	0.103–1.874
BMI (kg/m^2)	Age	−0.060	0.164	−0.464	−0.315–0.195
	Sex	−0.478	−0.063	−1.084	−1.347–0.390
BSF (mm)	Age	−0.175	−0.092	−1.659	−0.382–0.033
	Sex	−1.791	−0.276	−4.980***	−2.499– (−)1.083
TSF (mm)	Age	−0.136	−0.050	−0.912	−0.429– 0.157
	Sex	−3.245	−0.347	−6.391***	−4.244– (−)2.246

* $p < .05$, ** $p < .01$, *** $p < .001$

Table A2: Descriptive statistics (mean±SD) of anthropometric variables among 10 years old adolescents belonging to different socio-economic classes

		Socio-economic class				
Variables	Sex	Lower	Lower middle	Middle	Upper middle	Upper
Height	Boys	-	-	149.16±11.56	158.10±7.62	162.06±3.52
	Girls	148.40±7.34	145.95±6.35	146.47±3.49	146.73±4.26	151.75±6.29
	t-value	-	-	-0.636	-3.296**	-2.439
Weight	Boys	-	-	40.51±12.41	52.52±15.36	57.06±2.02
	Girls	44.60±6.25	42.86±14.04	40.10±11.17	45.98±3.44	55.80±10.32

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Variables	Sex	Socio-economic class				
		Lower	Lower middle	Middle	Upper middle	Upper
	t-value			-0.077	-1.013	-0.224
MUAC	Boys	-	-	22.83±3.68	27.57±6.57	27.33±3.17
	Girls	23.83±1.89	23.41±4.32	21.55±3.95	24.95±1.96	26.00±4.94
	t-value			-0.753	-0.941	-0.379
BMI	Boys	-	-	17.85±3.51	20.85±5.20	21.77±1.75
	Girls	20.53±4.97	20.04±6.08	18.57±4.60	21.42±2.33	24.10±2.48
	t-value	-	-	0.408	0.250	1.264
BSF	Boys	-	-	6.03±2.65	7.85±4.20	7.33±5.77
	Girls	8.40±2.62	8.20±3.47	7.02±3.66	8.00±2.90	10.40±3.67
	t-value			0.716	0.073	0.650
TSF	Boys	-	-	9.93±3.73	11.42±4.15	11.93±7.15
	Girls	14.53±4.04	14.53±4.04	12.72±5.87	13.86±3.68	17.75±3.46
	t-value			1.340	1.166	1.031

* $p < .05$, ** $p < .01$, *** $p < .001$

Table A3: Descriptive statistics (mean±SD) of anthropometric variables among 11 years old adolescents belonging to different socio-economic classes

Variables	Sex	Socio-economic class				
		Lower	Lower middle	Middle	Upper middle	Upper
Height	Boys	-	146.40±11.98	138.68±9.08	147.60±14.70	-
	Girls	143.00±3.40	146.02±8.04	148.00±9.83	-	149.16±7.49
	t-value	-	-0.101	1.667	-	-
Weight	Boys	-	42.65±16.86	34.23±9.01	47.85±17.32	-
	Girls	37.03±5.33	39.03±9.76	39.37±9.57	-	43.13±4.40
	t-value	-	-0.713	0.933	-	-
MUAC	Boys	-	23.96±4.78	22.25±5.37	27.00±4.24	-
	Girls	22.13±1.62	22.37±3.34	21.82±2.63	-	22.63±1.95
	t-value	-	-1.044	-0.150	-	-
BMI	Boys	-	19.19±4.51	17.94±5.24	21.49±3.65	-
	Girls	18.11±2.58	18.14±3.69	17.71±2.18	-	19.59±3.93
	t-value	-	-0.692	-0.085	-	-
BSF	Boys	-	7.08±2.45	5.26±2.77	7.40±1.41	-
	Girls	8.06±2.01	6.73±1.89	8.10±3.11	-	7.43±1.35
	t-value	-	-0.434	1.642	-	-
TSF	Boys	-	11.17±4.54	8.31±3.96	13.40±0.56	-
	Girls	12.23±3.61	11.34±3.07	11.75±3.73	-	13.00±0.80
	t-value	-	0.118	1.467	-	-

Table A4: Descriptive statistics (mean±SD) of anthropometric variables among 12 years old adolescents belonging to different socio-economic classes

		Socio-economic class				
Variables	Sex	Lower	Lower middle	Middle	Upper middle	Upper
Height	Boys	-	137.75±1.76	147.59±15.86	150.56±11.26	-
	Girls	150.70	147.55±7.52	144.54±7.10	145.71±8.68	153.70
	t-value	-	1.766	-0.751	-0.889	-
Weight	Boys	-	34.05±7.42	43.85±18.83	40.04±11.44	-
	Girls	62.80	38.53±7.39	34.98±8.56	36.23±12.89	51.00
	t-value	-	0.782	-0.146	-0.601	-
MUAC	Boys	-	22.50±3.53	23.83±6.33	22.05±2.14	-
	Girls	26.20	21.77±2.49	20.97±3.07	20.71±3.63	25.50
	t-value	-	-0.360	-0.237	-0.903	-
BMI	Boys	-	17.89±3.45	19.10±4.60	17.34±2.72	-
	Girls	27.65	17.63±2.93	16.59±2.97	16.75±4.46	21.58
	t-value	-	-0.115	0.244	-0.318	-
BSF	Boys	-	6.90±1.55	7.58±6.04	4.68±2.01	-
	Girls	15.00	6.90±2.04	5.17±1.35	6.51±2.94	11.80
	t-value	-	0.000	1.483	1.435	-
TSF	Boys	-	11.40±0.84	11.37±4.61	7.17±2.79	-
	Girls	26.20	12.22±3.97	10.02±2.66	11.36±5.76	20.80
	t-value	-	0.280	0.960	1.896	-

Table A5: Descriptive statistics (mean±SD) of anthropometric variables among 13 years old adolescents belonging to different socio-economic classes

		Socio-economic class			
Variables	Sex	Lower middle	Middle	Upper middle	Upper
Height	Boys	153.67±24.13	146.16±9.15	150.62±10.73	158.96±6.47
	Girls	151.30±5.28	142.80±8.74	145.67±6.22	-
	t-value	-0.240	-0.751	-1.308	-
Weight	Boys	46.72±27.26	38.86±8.65	46.18±7.71	46.50±4.33
	Girls	48.61±8.42	38.17±10.14	40.57±5.06	-
	t-value	0.163	-0.146	-1.988	-
MUAC	Boys	23.70±6.42	22.41±2.51	24.50±2.45	24.20±1.98
	Girls	25.01±3.14	22.06±3.39	24.04±2.95	-
	t-value	0.438	-0.237	-0.373	-
BMI	Boys	18.29±4.82	18.06±2.71	20.33±2.61	18.50±2.80
	Girls	21.20±3.24	18.43±3.42	19.18±2.76	-
	t-values	1.151	0.244	-0.971	-
BSF	Boys	4.95±2.11	5.17±1.99	7.52±3.34	6.40±3.30
	Girls	9.06±3.44	6.75±2.24	8.03±2.39	-
	t-values	2.116	1.483	0.351	-
TSF	Boys	8.75±4.21	9.42±3.25	11.64±4.86	11.33±5.41

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Variables	Sex	Socio-economic class			
		Lower middle	Middle	Upper middle	Upper
	Girls	16.48±5.84	11.17±3.99	13.40±4.21	-
	t-values	2.264	0.960	0.887	-

Table A6: Descriptive statistics (mean±SD) of anthropometric variables among 14 years old adolescents belonging to different socio-economic classes

Variables	Sex	Socio-economic class			
		Lower	Lower middle	Middle	Upper middle
Height	Boys	138.50±7.77	147.25±10.05	153.74±14.83	168.58±1.28
	Girls	148.71±7.28	150.44±7.41	147.14±8.55	156.20
	t-value	1.732	0.915	-2.203*	-8.915*
Weight	Boys	34.10±12.58	35.67±6.34	44.61±19.15	58.46±5.42
	Girls	46.20±10.34	43.66±8.86	39.30±1.27	66.40
	t-value	1.411	2.455*	-0.817	1.354
MUAC	Boys	21.90±4.38	21.63±2.56	24.44±4.72	27.91±1.88
	Girls	24.70±3.41	23.02±2.74	24.35±4.73	31.50
	t-value	0.979	1.280	-0.699	1.763
BMI	Boys	17.49±4.58	16.47±2.80	18.25±4.62	20.55±1.73
	Girls	20.80±3.69	19.22±3.24	18.20±1.52	27.21
	t-value	1.076	2.182*	0.825	3.559*
BSF	Boys	5.90±1.55	4.60±2.75	5.34±1.83	4.70±1.42
	Girls	10.72±2.77	7.78±2.75	5.70±0.42	22.00
	t-value	2.285	2.837*	3.852**	11.203**
TSF	Boys	9.50±4.94	8.16±3.86	10.74±4.52	8.46±2.90
	Girls	16.27±3.52	13.05±4.93	11.20±0.00	25.40
	t-value	2.247	2.636*	1.957	5.406**

* $p < .05$, ** $p < .01$, *** $p < .001$

Table A7: Descriptive statistics (mean±SD) of anthropometric variables among 15 years old adolescents belonging to different socio-economic classes

Variables	Sex	Socio-economic class				
		Lower	Lower middle	Middle	Upper middle	Upper
Height	Boys	-	161.38±10.33	161.00±14.09	161.00±18.27	-
	Girls	149.85±0.21	148.10±5.22	149.05±7.42	-	152.00
	t-value	-	**-4.036***	**-2.203***	-	-
Weight	Boys	-	49.00±10.84	49.41±13.72	46.77±14.78	-
	Girls	38.00±4.10	43.46±13.17	44.20±12.67	-	46.10
	t-value		-1.007	-0.817	-	-
MUAC	Boys	-	25.06±2.87	24.53±3.88	23.05±3.19	-
	Girls	21.50±2.12	23.03±4.13	23.35±3.59	-	22.00

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Variables	Sex	Socio-economic class				
		Lower	Lower middle	Middle	Upper middle	Upper
	t-value		-1.180	-0.699	-	-
BMI	Boys	-	18.61±2.70	18.49±2.51	17.56±2.26	-
	Girls	16.92±1.87	19.73±5.64	19.68±4.19	-	19.95
	t-value		0.521	0.825	-	-
BSF	Boys	-	5.35±1.79	4.38±0.84	3.90±0.73	-
	Girls	8.20±4.52	7.30±3.11	7.42±2.67	-	7.60
	t-value		1.612	**3.852****	-	-
TSF	Boys	-	8.98±3.86	8.56±2.91	8.20±2.43	-
	Girls	12.90±7.21	13.41±6.00	11.80±4.69	14.00	
	t-value		1.867	1.957	-	-

* $p < .05$, ** $p < .01$, *** $p < .001$