A Study of Adolescent Growth in Kolkata and its Determinants

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Abstract

The assessment of growth and development among adolescent children reflects the past, present, and future health as well as social achievement of the locality. This paper comprises of assessment of growth status of (10-16)-year children in Kolkata, India. In this paper, we have tried to find out the growth patterns of height, weight, mid upper arm circumference (MUAC) and waist circumference (WC), its gender differences, and differences of growth pattern with different socio-economic variables. Growth study has been done through height, weight, MUAC and waist circumference with certain explanatory socio-economic variables such as medium of school, type of school and family size. We have restricted our study to only school-going children of class V to X. Sample size consists of 5631children of which 2922 are girls and 2709 are boys from 10 different Bengali medium and 6 English medium schools in Kolkata. The result shows that among boys, adolescent spurt in height and weight are noticed between 11 to 13 years and among girls, 10 to 12 years for height and 11-13 years for weight respectively. So, girls are one year ahead than boys so far as onset of height spurt is concerned. In case of MUAC and WC, marked spurt is not noticed among them. It is seen that medium of school and age of the student have positive association with health status because children at English medium schools have better health status than the students at Bengali medium schools. Household size and type of school have significant association with each of these health parameters though the direction of association on boys and girls are opposite in nature. Analysis shows through the interaction of household size with medium of school that the health condition deteriorates for English medium school girls with large families**.**

Key words: Adolescent growth, anthropometry, Boys, Girls, Socio-economy.

AMS Subject Classification: 91D20.

0. Tribute to Sinha Brothers

We know Professor Bikas Kumar Sinha for a long time. Professor Bimal Kumar Sinha, the twin brother of Professor Bikas Kumar Sinha, is also known to me because he often visited the Indian Statistical Institute.

We admire both because they inspired others to write papers. This is evident from the list of their co-authors. Some of my friends are also co-authors of Professor Bikas Kumar Sinha.

Professor Bikas Kumar Sinha is an excellent teacher. He used to make experiments with sampling to make the students understand the basic of statistics.

We are fortunate that we are able to contribute to this special volume.

1. Introduction

Physical Growth and overall Development supplement each other throughout the life. Biological expression of growth and development of human life are dependent on nutritional and socio-economic variations (Crimmins et al. 2006; Kuh et al. 2006; Barker et al. 2007; Bengtsson et al. 2009). For example, it is known that study of knee-height is used as a bio-marker of health and nutritional status between birth and 10 years of age because, knee height never shrinks with age as does vertebral column (Bogin, 2014). Through the measurement of adult knee height, it is known about the nutrition, physical activity, exposure to infection, inhaling of tobacco, drinking alcohol, economic condition and migration during childhood. So, it is clear that occurrences of adolescent spurt are also dependent on socio-economic status of the society along with the age. Perhaps the socio-economic classes are mostly the result of constant interaction of genes, hormones, nutrients, and other environmental factors. Hence, in growth study it is very much important to know about the past and the present status and infer about the future status of human life.

Human growth and development have been divided into five phases such as infant, childhood, juvenile, adolescence, and adulthood (Bogin, 1988; 1990; 1993). Here, our study has been concentrated about the growth study of adolescent boys and girls. During adolescence, growth is defined through the quantitative increase of size and development means both quantitative and qualitative changes towards ultimate maturity. So, it may be said that human growth and development in the positive directions lead to maturity of human beings.

'Adolescence' is the transition period between childhood and adulthood. Rapid physical and psychological developments start from the onset of puberty and end

to adulthood. The word adolescent comes from the Latin word 'adolescere' means to grow up, which is marked by the growth spurt mainly in height and weight along with the sexual maturation, onset of adult pattern of socio-sexual and economic behavior (Bogin, 1994). Adolescence is a complex, multi-system transitional process involving progression from the innocence and physical and mental dependency of childhood into adult life with the goal and expectation of fulfilled developmental potential, personal agency, and social accountability (Greenfield, Keller, Fuligni, & Maynard, 2003; Graber & Brookes-Gunn, 1996; Modell & Goodman, 1990; Steinberg, 2002). WHO (2015) defines "Adolescent" as individuals belonging to the age group 10 to 19 years. More than half of all adolescents globally live in Asia. In South Asia more adolescents (350 million) are found (UNICEF, 2019). It is followed by East Asia and the Pacific with over 300 million (UNICEF, 2019). In sub-Saharan Africa, adolescents make up the greatest (23 percent) proportion of the population. In India, 20.9 percent of total population comprise of adolescents (Census, 2011). The rural and urban adolescent populations constitute 22 percent and 19 percent of total population respectively (Census, 2011).

Adolescents undergo three primary developmental stages such as early adolescence, middle adolescence, and late adolescence/young adulthood. Early Adolescence occurs between ages 10-14 years. During this developmental period, adolescents experience the beginning stages of puberty. And, in this stage, adolescents have limited interest in the future; they develop deeper moral thinking during the early adolescence stage. During Middle adolescence, puberty is completed for males and females. Physical growth slows down for females but continues for males and they continue to experience a growing capacity for abstract thought. During Late Adolescence/Young Adulthood (Ages 18-24), they experience many changes include physical, behavioral, cognitive, and emotional-social development.

Keeping in mind the stages of development of children, this paper aims to explore the following two points among the adolescent children in Kolkata, West Bengal, to see

    (i)   the growth patterns of height, weight, MUAC and WC separately for each sex, medium of instructions at schools and socio-economic groups through independent 't' test, and

    (ii)   the simultaneous association of sex, medium of instructions and socio-economic groups as well as the interactions of these variables on growth patterns, through linear regression with and without interaction terms.

2. Methodology

Here our population consists of adolescent children of age-group10-16 years. The study area is in Kolkata Corporation and its adjacent area. Due to obvious difficulty of identifying the children of this age group, we have restricted our study only for school-going children. Thus, the data have been collected from secondary sections (Class V- X) of Secondary or Higher Secondary schools of both Bengali and English medium schools.

The study is a micro level cross-sectional study using multistage stratified sampling procedure. The schools have been selected randomly using Simple Random Sampling scheme and thus 16 schools are selected for our study of which 10 of these happen to be Bengali medium schools and the rest 6 schools are English medium schools. Thus, Medium of instructions in schools automatically comes as determining variable taking value 1 for English medium schools and 0 for Bengali medium schools. It is known that upper class or more economically affluent people prefer their children to be admitted at English medium schools rather than at Bengali medium schools. We have also grouped the schools into two categories: Government schools and Others, which consists of semi-government and private schools. The two categories are grouped under the heading of 'type of school' taking value 1 for Government school and 0 for others. The total number of children in the sample is 5631, of which 2922 are girls and 2709 are boys. Besides the medium and type of schools, family size is presumed to have some association on the growth pattern. The children are grouped, according to the household size (hhsize), into two categories:(i) households with less than or equal to four members taking value 0 and (ii) households with more than four members taking value 1. Since growth patterns are expected to be different for boys and girls, sex is taken as a factor. We have taken the value 1 for girls and 0 for boys.

Anthropometric measurements such as Height in centimeter (cm.), Weight in Kilogram (kg.) and MUAC (cm.) and WC (cm.) have been taken from all the children of the selected schools following standard techniques (Weiner and Lourei, 1981).

To see the growth pattern of height, weight, MUAC and waist circumference among children, we have calculated age and gender specific means, standard deviations for each age group and hence carried out independent t-test between the two subsequent age groups. Again, Independent 't' tests has been done to see the difference between boys and girls and between Bengali and English medium schools.

We have not taken Height-for-Age, Weight-for-Age and Weight-for-Height in this paper, simply because it is not our intention to see the nutritional status of the

children. We wanted to see how these parameters, especially height and weight, become higher when age increases during the adolescent period. It is assumed that the relation may not be linear. In other words, the growth will not be same in each year. So, we have thus regressed these indicators on age and age squares through quadratic regressions. The quadratic fit was good for each. To find the association of socio-demographic variables on height, weight, MUAC and WC we have then carried out multiple linear regression separately for each of these four variables. The explanatory variables are household size, medium of school, type of school and age of the children with and without the interaction effects.

We have used by statistical package for social science (SPSS – 18.0 version) for most of the calculations. Significance level p = 0.05 is considered for all statistical tests.

3. Results

Height, Weight, MUAC and WC are expected to have positive associations with age for boys and girls especially in the adolescent period. Age is a variable which cannot be controlled; thus, age is the basic and natural determinant of these anthropometric indicators of health.

Table 1 presents the mean, standard deviation, increment and t-test between two age groups, i.e., between current age group with the previous age group of height, weight, MUAC and waist circumference of both boys and girls of adolescent children in Kolkata. In case of height and weight, there is a steady rise in height and weight among both boys and girls but among the boys, maximum increment is noticed for height and weight between 11 to 13 years and among girls, 10 to 12 years for height and 11-13 years for weight and then followed by ascending tendency upto 16 years though the magnitude of increment goes down. So, it can be said that among boys, adolescent spurt in height and weight occurs in the age between 11 to 13 years and among girls, for height, it is one year ahead i.e. between 10 and 12 years but in case of weight, it is 11-13 years. In case of MUAC and waist circumference, among both boys and girls, though ascending tendency is seen up to 15 years, but no marked spurt is noticed among these. All these maximum increments are statistically significant.

Table 2 presents the same for boys and girls, but among the Bengali medium schools in Kolkata. The data shows that in respect of height and weight, adolescent spurt in height and weight occurs between 11 to 13 years among boys and in case of girls, adolescent spurt of height occurs between 10 to 12 years and for weight, it is between 10 to 13 years. In case of MUAC, there is no marked spurt observed among boys and girls but for waist circumference, it occurs

between 11 to 13 years among boys and between 12 to 14 years among girls. And all these increments are statistically significant.

Table 3 presents the mean, standard deviation, increment and t-test of various anthropometric measurements of height, weight, MUAC and waist circumference of both adolescent boys and girls of English medium schools of Kolkata. Among the boys, adolescent spurt in height and weight occurs from 11-13 years of age. Among girls, spurt starts at earlier age, i.e., between 10 to 11 years for height and 11-13 years for weight. For MUAC, among boys and girls, no spurt is noticed but for waist circumferences, among boys, the spurt occurs between 14 to 15 years as the highest significant increment occurs in this age-group, and among girls, the highest significant adolescent spurt occurs between 12 and 13 years.

Differences in the average values of the four anthropometric growth parameters between boys and girls are shown in Tables 4 through 6 along with the results of statistically significance tests for each age group using independent t-test. The result shows that significant differences of heights exist between boys and girls in the age-groups 10 and 11 years. Most of the results for other anthropometric parameters also are statistically significant between boys and girls. The differences of the anthropometric parameters between the English and Bengali medium schools are found separately for boys and girls in Tables 7 & 8. It is seen that the average height is always significantly different between the English and Bengali medium schools in all age groups for both boys and girls, but weight is found to be significantly different up to 12 years only. No clear picture emerges for MUAC and Waist circumference.

Since it is assumed that the growth will not be same at each age group, we have regressed these four parameters on age and age squares and the result of this quadratic regression is shown in Table 9. The fit is found to be good for each of them. The coefficient of square of age is significant for height of both boys and girls and for weight of girls. However, because of high correlation between age and age-square, the result showed the existence of multicollinearity (See Table A1 in Appendix 1 for details). But it gave us a red signal that inclusion of age-square becomes prohibitive for the multiple linear regressions as we aspire for finding out the association of socio-demographic variables with height, weight, MUAC and WC.

A clear picture emerges from the Figure 1 where age wise means of height, weight, MUAC and waist circumference are plotted along with the fitted value using quadratic trend. Comparing the slopes visually, it is clear from the diagram that growth rates for girls are less than the growth rates of boys for height and weight whereas they are more or less same in the cases of MUAC and WC. The actual values are much less for girls compared to boys. In most of the cases it

shows linear trend. Only in a few cases, the curve slightly shows retardation of growth nearly at the end of adolescent period and that too for girls. This is quite expected as the growth spurt starts for girls at an earlier stage than boys and also ends prior to that of boys.
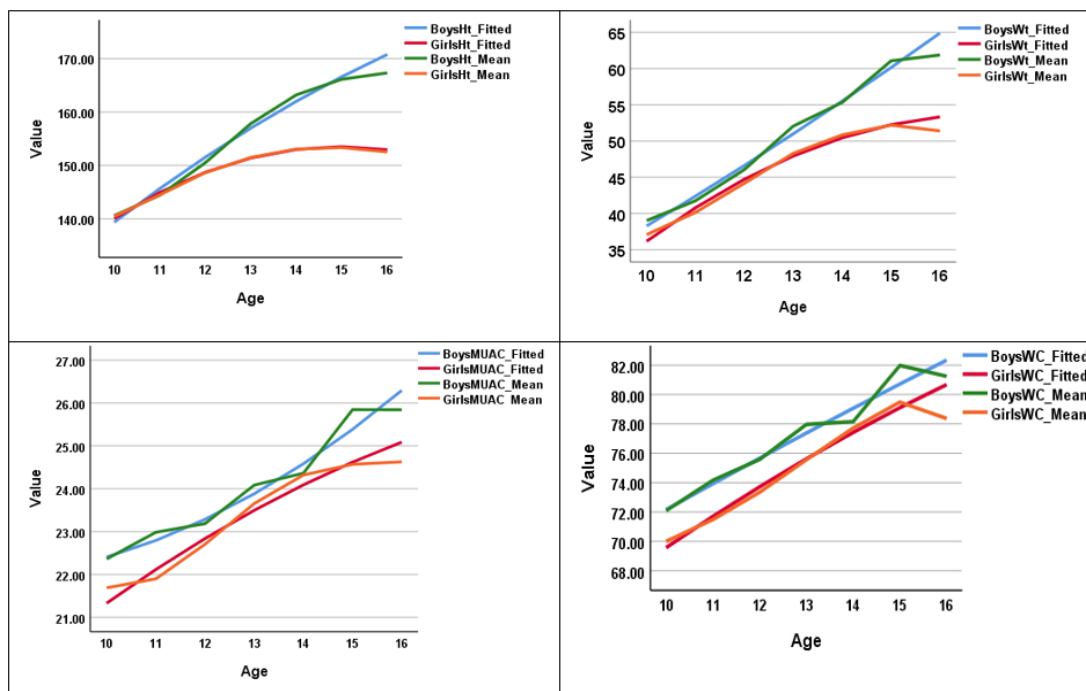
Figure 1: Growth pattern of Height, Weight, MUAC and Waist circumference of Adolescent boys and girls of Kolkata

Results of Linear Regression of Height, Weight, MUAC and WC on Household Size, Medium of Instruction, Type of School and Age among adolescent children in Kolkata are shown in Table 10. All the coefficients are seen to be highly significant implying that they have significant association with the Height, Weight, MUAC and WC. Household size and Type of School have negative association with each of these health parameters. It means that the students from households with number of members five or more have less height on the average than the students from households with less than 5 members, and this is statistically significant. The same is true for students at Private or Sponsored schools compared to the students at Government schools. On the other hand, medium of school and age have significantly positive association with these health parameters. Because students at English Medium schools have better health status than the students at Bengali Medium schools. Again, as age increases by one year,

the height becomes higher by 3.8 cm. weight becomes higher by 3.64 Kgs, MUAC becomes higher by 0.6 units and WC becomes higher by 1.7 units on the average and all these are highly significant.

Table 11 carries out the same regression as done in Table 10, but separately for boys and girls. When we run separate regressions, the associations are more conspicuous in the sense that R^2 values are higher in most of the cases, and we can see the variations between boys and girls. After looking at the table, it transpires that age of the student has positive significant association with all the health measures. In fact, each of the variables has significant association with all the health parameters except household size for boys. The sign never changes for any of the determinants, i.e., if an explanatory variable has positive association with any of the health parameters, then it has positive association with other health parameters. It may however differ between boys and girls.

We shall now try to include the interactions. Since interactions with Age result into severe multicollinearity problem, we have not included these interactions in the regression. Also, if we include medium with type then the main explanatory variable medium is automatically eliminated. So, we exclude this interaction also. Thus, we are left with only two interactions. These are Household size with Medium and Household size with Type. The introduction of interaction terms has not increased the goodness of fit much. Most of the coefficients of the interaction terms are not significant. Only for the interaction of household size with medium of instruction is found to be significant for girl students only. It is known that the growth parameters are negatively affected by household size. Interaction effect says that the growth parameters further deteriorate for English medium schoolgirls with large families. The coefficients of the main explanatory variables remain more or less same.

We have also combined boys and girls and found the associations separately for boys and girls by introducing dummy variable for sex as one of the regressors and taking interactions of this dummy variable with other explanatory variables (See Appendix 2).

4. Discussion and Conclusion

This paper presents us a scenario of adolescent growth among (10-16)-year old children in Kolkata, West Bengal, India. Adolescent spurt in height and weight are noticed between 11 to 13 years among boys and among girls, it is in between 10 to 12 years for height and 11-13 years for weight respectively. Thus, onset of height spurt occurs for girls one year ahead of boys. In case of MUAC and waist circumference, marked spurt is not noticed among them. Medium of instruction in

schools does not affect the onset of growth spurt in height and weight for both boys and girls. The growth curve indicates that growth rates for girls are less than boys for height and weight, but they are more or less same in the cases of MUAC and WC. The students at Private or Sponsored schools have better growth compared to the students at Government schools. When analyzed separately for boys and girls, it is seen that that type of school has positive association for boys and negative association for girls which means that boys have better growth in Government schools, whereas girls have better growth in private schools. Is it because the boys feel more comfortable at Government schools, whereas girls feel more comfortable at Private or Sponsored schools? Students at English Medium schools have better growth status than the students at Bengali Medium schools. The interaction between household size and medium of school is found to be significant for girl students only. This means that the health condition further deteriorates for girls with large families if they are from English medium schools.

Since the data collected is from the schools in Kolkata only, it will not be appropriate to generalize it to whole India or even to other metropolitan cities of India. Each city has its own characteristics regarding habit, tastes and culture. Secondly, we are trying to find the growth pattern using cross-section data. So, the interpretation should be made very cautiously because the effect of time such as economic changes, changes in the food habit, innovations etc. will not be captured in the analysis.

To conclude, let us summarize the main results in a nutshell, (i) the growth spurt occurs for girls about one year ahead of boys and it is more pronounced for height and weight only, (ii) the growth rates of girls are less than that of boys during the adolescent period, (iii) students at English Medium schools have better growth status than the students at Bengali Medium schools, and (iv) household size has negative association with growth and the growth further deteriorates for English medium school girls.

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Table 1: Age and sex wise mean and sd of anthropometric variables among adolescent children in Kolkata

Age groups	Boys																				
	Height					Weight				MUAC					Waist circumference						
	N	mean	Sd	Incre ment	t*	mean	Sd	Incre ment	t*	mean	Sd	Incre ment	t*	mean	Sd	Incre ment	t*				
10	411	140.61	6.69	-	-	39.02	9.93	-	-	22.36	3.65	-	-	72.09	10.67	-	-				
11	534	144.43	7.21	3.82	8.32	41.75	11.49	2.73	3.85	22.98	3.89	0.62	2.50	74.16	11.63	2.07	2.81				
12	573	150.51	8.28	6.08	12.99	46.05	12.12	4.30	6.03	23.18	3.89	0.20	0.85	75.57	11.84	1.41	2.00				
13	459	157.82	8.23	7.31	14.13	52.05	13.50	6.00	7.51	24.08	3.89	0.90	3.68	77.96	12.42	2.39	3.13				
14	414	163.21	7.29	5.39	10.18	55.31	13.33	3.26	3.58	24.36	3.88	0.24	1.05	78.15	12.13	0.19	0.23				
15	259	166.14	6.59	2.93	5.26	61.05	15.66	5.74	5.07	25.84	4.30	1.48	4.62	81.97	13.20	3.82	3.84				
16	59	167.32	6.08	1.18	1.26	61.86	16.72	1.06	0.35	25.84	4.12	0.00	0.00	81.24	13.24	-0.73	0.38				
	Girls																				
10	293	140.46	7.38	-	-	37.08	9.79	-	-	21.69	3.57	-	-	69.99	9.55	-	-				
11	541	144.49	7.21	4.03	7.64	40.15	10.11	4.23	4.23	21.89	3.56	0.20	0.80	71.48	9.91	1.49	2.08				
12	610	148.65	6.65	4.16	10.15	44.17	11.08	6.39	6.39	22.70	3.64	0.81	3.78	73.35	10.44	1.87	3.10				
13	594	151.50	5.98	1.85	7.80	48.29	10.69	6.56	6.56	23.65	3.61	0.95	4.53	75.55	10.11	2.20	3.72				
14	506	153.05	5.99	1.55	4.28	50.83	11.06	3.86	3.86	24.32	3.54	0.67	3.07	77.71	10.52	2.16	3.45				
15	311	153.34	6.27	0.29	0.67	52.18	12.29	1.62	1.62	24.56	3.98	0.24	0.92	79.48	11.37	1.77	2.26				
16	67	152.53	5.39	-0.81	0.98	51.38	11.27	0.48	0.48	24.62	3.73	0.06	0.11	78.36	10.66	-0.71	0.73				

*: Independent t test is done between the current age-group with the previous age-group.

Table 2: Age and sex wise mean and SD of anthropometric variables among adolescent children in Bengali medium schools in Kolkata

Age groups	Boys																				
	Height					Weight				MUAC					Waist circumference						
	N	Mean	SD	Incre ment	t*	Mean	SD	Incre ment	t*	Mean	SD	Incre ment	t*	Mean	SD	Incre ment	t*				
10	213	138.99	5.99	-	-	37.69	9.17	-	-	22.04	3.71	-	-	71.04	10.58	-	-				
11	316	143.23	7.16	4.24	7.11	40.03	11.12	2.34	2.54	22.58	3.77	0.54	1.61	73.12	11.35	2.08	2.15				
12	383	149.57	7.92	6.34	10.97	45.24	11.99	5.21	5.90	22.98	3.89	0.40	1.37	74.71	11.91	1.59	1.79				
13	287	159.89	8.19	10.32	11.65	51.39	14.05	6.15	6.09	23.96	4.03	0.98	3.17	76.94	13.17	2.23	2.29				
14	225	162.01	6.95	2.12	7.49	55.22	13.21	3.83	3.14	24.61	3.88	0.65	1.84	77.23	12.43	0.29	0.25				
15	108	164.30	6.63	2.29	2.84	58.58	15.35	3.36	2.05	25.41	4.39	0.77	1.68	78.94	13.48	1.71	1.13				
16	19	163.90	5.22	-0.40	0.24	59.13	15.21	0.55	0.14	25.63	4.01	0.22	0.20	79.82	13.05	0.88	0.26				
	Girls																				
10	195	140.05	7.45	-	-	37.03	10.17	-	-	21.69	3.68	-	-	69.51	9.47	-	-				
11	423	143.94	7.24	3.89	6.14	40.14	10.40	3.11	3.47	22.00	3.59	0.31	1.00	71.52	10.15	2.01	2.33				
12	492	148.28	6.63	4.34	9.46	44.11	10.69	3.97	5.49	22.75	3.71	0.75	3.09	73.32	10.54	1.80	2.60				
13	442	151.05	5.96	2.77	6.67	47.83	10.69	3.72	5.14	23.55	3.61	0.80	3.31	74.78	10.09	1.46	2.16				
14	373	152.53	5.87	1.48	3.53	50.72	11.27	2.89	3.75	24.32	3.61	0.77	3.05	77.35	10.58	2.57	3.54				
15	204	152.51	6.19	-0.02	0.02	51.94	12.89	1.22	1.18	24.62	4.32	0.30	0.89	79.17	11.76	1.82	1.89				
16	30	152.60	5.99	0.09	0.07	54.68	12.23	2.74	1.09	25.82	3.71	1.20	1.43	80.03	11.52	0.86	0.37				

*: Independent t test is done between the current age-group with the previous age-group.

Table 3: Age and sex wise mean and SD of anthropometric variables among adolescent children in English medium schools in Kolkata

Age groups	Boys																	
	Height					Weight				MUAC				Waist circumference				
	N	Mean	SD	Increment	t*	Mean	SD	Increment	t*	Mean	SD	Increment	t*	Mean	SD	Increment	t*	
10	198	142.34	6.98	-	-	40.44	10.54	-	-	22.70	3.56	-	-	73.25	10.67	-	-	
11	218	146.15	6.93	3.81	5.57	44.25	11.60	3.81	3.49	23.57	3.98	0.87	2.33	75.66	11.88	2.41	2.17	
12	190	152.41	8.66	6.26	8.09	47.68	12.25	3.43	2.90	23.59	3.87	0.02	0.06	77.32	11.53	1.66	1.42	
13	172	159.38	8.07	6.97	7.89	53.16	12.49	5.48	4.20	24.29	3.65	0.70	1.75	79.65	10.88	2.33	1.97	
14	189	164.63	7.45	5.25	6.42	55.42	13.50	2.26	1.64	24.06	3.86	-0.23	0.57	79.24	11.71	-0.41	0.34	
15	151	167.46	6.26	2.83	3.72	62.82	15.68	7.40	4.67	26.15	4.22	2.09	4.75	84.15	12.58	4.91	3.71	
16	40	168.95	5.82	1.49	1.35	63.16	17.43	0.34	0.18	25.94	4.22	-0.21	0.21	81.91	13.44	-2.24	0.98	
	Girls																	
10	98	141.27	7.22	-	-	37.16	9.04	-	-	21.68	3.37	-	-	70.95	9.68	-	-	
11	118	146.48	6.74	5.21	5.47	40.17	9.04	3.01	2.42	21.51	3.46	-0.17	0.37	71.30	9.04	0.35	0.27	
12	118	150.16	6.57	3.68	4.24	44.41	10.15	4.24	3.39	22.49	3.35	0.98	2.20	73.48	10.04	2.18	1.74	
13	152	152.79	5.86	2.63	3.46	49.65	10.58	5.24	4.09	23.94	3.62	1.45	3.38	77.79	9.84	4.31	3.53	
14	133	154.51	6.09	1.72	2.43	51.69	10.49	2.04	1.21	24.29	3.35	0.35	0.83	78.69	10.31	0.90	0.75	
15	107	154.93	6.16	0.42	0.52	52.64	11.11	0.95	1.08	24.45	3.28	0.16	0.36	80.06	10.65	1.37	1.00	
16	37	152.47	4.93	-2.46	2.09	48.71	9.81	-3.93	1.90	23.66	3.50	-0.79	1.24	77.01	9.86	-3.05	1.53	

*: Independent t test is done between the current age-group with the previous age-group.

Table 4: Results of t-test of Differences between (10-16)-year Old Boys and Girls of different anthropometric variables

Age-groups	Anthropometric Variables	t-test for Equality of Means between Boys and Girls		
		t	df	p-value (2-tailed)
10	Height	0.279	702	0.781
	Weight	2.565	702	0.011*
	MUAC	2.430	702	0.015*
	Waist circumference	2.678	702	0.008*
11	Height	-0.156	1073	0.876
	Weight	2.434	1073	0.015*
	MUAC	4.773	1073	0.000*
	Waist circumference	4.071	1073	0.000*
12	Height	4.277	1181	0.000*
	Weight	2.789	1181	0.005*
	MUAC	2.192	1181	0.029*
	Waist circumference	3.437	1181	0.001*
13	Height	14.432	1051	0.000*
	Weight	5.042	1051	0.000*
	MUAC	1.853	1051	0.064
	Waist circumference	3.460	1051	0.001*
14	Height	23.183	918	0.000*
	Weight	5.567	918	0.000*

	MUAC	0.174	918	0.862
	Waist circumference	0.592	918	0.554
15	Height	23.677	568	0.000*
	Weight	7.571	568	0.000*
	MUAC	3.669	568	0.000*
	Waist circumference	2.427	568	0.016*
16	Height	14.474	124	0.000*
	Weight	4.164	124	0.000*
	MUAC	1.733	124	0.086
	Waist circumference	1.350	124	0.179

*: significant at 5% level.

Table 5: Results of t-test of Differences between (10-16)-year old Boys and Girls of Different Anthropometric Variables of Bengali Medium Schools

Age-groups	Anthropometric Variables	t-test for Equality of Means between Boys and Girls		
		T	df	p-value (2-tailed)
10	Height	1.585	406	0.140
	Weight	0.688	406	0.492
	MUAC	0.969	406	0.333
	Waist circumference	1.500	406	0.134
11	Height	1.317	737	0.188
	Weight	0.139	737	0.889
	MUAC	2.105	737	0.036*
	Waist circumference	2.011	737	0.045*
12	Height	2.606	873	0.009
	Weight	1.428	873	0.154
	MUAC	0.873	873	0.383
	Waist circumference	1.835	873	0.067
13	Height	11.105	727	0.000*
	Weight	3.875	727	0.000*
	MUAC	1.423	727	0.383
	Waist circumference	2.495	727	0.067
14	Height	17.810	596	0.000*
	Weight	4.436	596	0.000*
	MUAC	0.908	596	0.364
	Waist circumference	0.128	596	0.898
15	Height	15.600	310	0.000*
	Weight	4.043	310	0.000*
	MUAC	1.518	310	0.130
	Waist circumference	0.159	310	0.874
16	Height	6.750	47	0.000*
	Weight	1.128	47	0.265
	MUAC	0.163	47	0.871
	Waist circumference	0.058	47	0.954

*: significant at 5% level.

Table 6: Results of t-test of Differences between (10-16)-Year Boys and Girls of
Different Anthropometric Variables of English Medium Schools

Age-groups	Anthropometric Variables	t-test for Equality of Means between Boys and Girls		
		t	df	p-value (2-tailed)
10	Height	1.232	294	0.219
	Weight	2.631	294	0.009*
	MUAC	2.346	294	0.020*
	Waist circumference	1.793	294	0.074
11	Height	0.417	334	0.677
	Weight	3.319	334	0.001*
	MUAC	4.723	334	0.000*
	Waist circumference	3.475	334	0.001*
12	Height	2.420	306	0.016*
	Weight	2.426	306	0.016*
	MUAC	2.560	306	0.011*
	Waist circumference	2.981	306	0.003*
13	Height	8.314	322	0.000*
	Weight	2.710	322	0.007*
	MUAC	0.846	322	0.398
	Waist circumference	1.606	322	0.109
14	Height	12.911	326	0.000*
	Weight	3.041	326	0.003*
	MUAC	0.561	326	0.575
	Waist circumference	0.434	326	0.665
15	Height	15.922	256	0.000*
	Weight	5.764	256	0.000*
	MUAC	3.481	256	0.001*
	Waist circumference	2.734	256	0.007*
16	Height	13.329	75	0.000*
	Weight	4.432	75	0.000*
	MUAC	2.562	75	0.012*
	Waist circumference	1.812	75	0.074

*: significant at 5% level.

Table 7: Results of t-test of Differences Between (10-16)-Year Boys of English and Bengali Medium Schools of Different Anthropometric Variables

Age-groups	Anthropometric Variables	t-test for Equality of Means between English and Bengali Medium Schools		
		t	df	p-value (2-tailed)
10	Height	5.222	409	0.000
	Weight	2.823	409	0.005
	MUAC	1.827	409	0.068
	Waist circumference	2.131	409	0.034
11	Height	4.235	532	0.000
	Weight	2.907	532	0.000
	MUAC	2.491	532	0.004
	Waist circumference	3.916	532	0.013
12	Height	3.916	571	0.000
	Weight	2.281	571	0.023
	MUAC	1.782	571	0.078
	Waist circumference	2.490	571	0.013
13	Height	3.175	457	0.002
	Weight	1.360	457	0.174
	MUAC	0.879	457	0.380
	Waist circumference	2.270	457	0.024
14	Height	3.700	412	0.000
	Weight	0.146	412	0.884
	MUAC	1.434	412	0.152
	Waist circumference	1.679	412	0.094
15	Height	3.910	257	0.000
	Weight	2.164	257	0.031
	MUAC	1.365	257	0.173
	Waist circumference	3.189	257	0.002
16	Height	3.209	57	0.002
	Weight	0.863	57	0.392
	MUAC	0.262	57	0.795
	Waist circumference	0.563	57	0.576

Table 8: Results of t-test of Differences between (10-16)-Year Girls of English and Bengali Medium Schools of Different Anthropometric Variables

Age-groups	Anthropometric Variables	t-test for Equality of Means between English and Bengali Medium Schools		
		t	df	p-value (2-tailed)
10	Height	1.328	291	0.185
	Weight	0.109	291	0.913
	MUAC	0.007	291	0.994
	Waist circumference	1.218	291	0.224
11	Height	3.417	539	0.001
	Weight	0.021	539	0.983
	MUAC	1.335	539	0.182
	Waist circumference	0.214	539	0.831
12	Height	2.764	608	0.006
	Weight	0.269	608	0.788
	MUAC	0.707	608	0.480
	Waist circumference	0.150	608	0.881
13	Height	3.108	592	0.002
	Weight	1.815	592	0.070
	MUAC	1.164	592	0.245
	Waist circumference	3.184	592	0.002
14	Height	3.318	504	0.001
	Weight	0.401	504	0.689
	MUAC	0.086	504	0.931
	Waist circumference	1.258	504	0.209
15	Height	3.286	309	0.001
	Weight	0.475	309	0.689
	MUAC	0.365	309	0.931
	Waist circumference	0.657	309	0.209
16	Height	0.096	65	0.924
	Weight	2.216	65	0.030
	MUAC	2.437	65	0.018
	Waist circumference	1.157	65	0.252

Table 9: Quadratic Regression of Height, Weight, MUAC and Waist Circumference on Age among Adolescent Children in Kolkata

	Boys			Girls		
	Intercept	Coeff. of Age	Coeff. of Age_Sq	Intercept	Coeff. of Age	Coeff. of Age_Sq
Height	53.275	10.721	-.211	31.582	16.289	-.544
Weight	4.519	2.717	.066	-49.083	12.065	-.354
MUAC	24.246	-.704	.052	9.951	1.458	-.032
WC	52.935	2.062	-.014	42.263	3.281	-.055

Table 10: Results of Linear Regression of Height, Weight, MUAC and WC on Household Size, Medium of Instruction, Type of School and Age among Adolescent Children in Kolkata

	Height	Weight	MUAC	WC
(Constant)	103.200 (.000)	2.153 (.087)	15.966 (.000)	54.168 (.000)
Household Size	-.621 (.004)	-1.021 (.002)	-.304 (.004)	-.881 (.004)
Medium of Instruction	3.566 (.000)	2.849 (.000)	.500 (.000)	2.857 (.000)
Type of School	-1.260 (.000)	-1.590 (.000)	-.377 (.003)	-1.412 (.000)
Age of the Student	3.815 (.000)	3.639 (.000)	.614 (.000)	1.734 (.000)
R^2 values p-value	R^2=0.405 (.000)	R^2=0.204 (.000)	R^2=0.068 (.000)	R^2=0.072 (.000)

Table 11: Results of Linear Regression of Height, Weight, MUAC and WC on Household Size, Medium of Instruction, Type of School and Age among Adolescent Children in Kolkata Separately for Boys and Girls

	Height		Weight		MUAC		WC	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
(Constant)	85.63 (.000)	119.59 (.000)	-6.10 (.001)	9.82 (.000)	16.08 (.000)	15.76 (.000)	54.70 (.000)	52.90 (.000)
Household Size	-.059 (.846)	-.705 (.005)	-.220 (.666)	-1.468 (.000)	-.064 (.687)	-.479 (.001)	-.365 (.450)	-1.229 (.002)
Medium of Instruction	2.227 (.000)	2.093 (.000)	2.396 (.000)	1.039 (.032)	.425 (.033)	.065 (.688)	3.044 (.000)	1.503 (.001)
Type of School	.791 (.047)	-1.898 (.000)	.358 (.593)	-2.527 (.000)	.143 (.491)	-.612 (.000)	-.622 (.325)	-1.540 (.001)
Age of the Student	5.328 (.000)	2.433 (.000)	4.314 (.000)	3.034 (.000)	.594 (.000)	.640 (.000)	1.686 (.000)	1.829 (.000)
R^2 values p − value	0.589 (.000)	0.274 (.000)	0.251 (.000)	0.176 (.000)	0.065 (.000)	0.081 (.000)	0.064 (.000)	0.084 (.000)

Table 12: Results of Linear Regression of Height, Weight, MUAC and WC on Household Size, Medium of Instruction, Type of School and Age along with Interaction Terms Separately for Boys and Girls

	Height		Weight		MUAC		WC	
	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
(Constant)	85.63	119.56	-5.76	9.83	16.17	15.79	54.98	53.09
	(.000)	(.000)	(.002)	(.000)	(.000)	(.000)	(.000)	(.000)
Household Size	-.091	-.437	-1.177	-1.093	-.297	-.476	-1.182	-1.393
	(.859)	(.420)	(.174)	(.218)	(.267)	(.110)	(.148)	(.098)
Medium of Instruction	2.341	2.719	2.930	2.387	.534	.433	3.679	3.010
	(.000)	(.000)	(.000)	(.000)	(.029)	(.038)	(.000)	(.000)
Type of School	.700	-1.974	-.476	-2.782	-.047	-.727	-1.449	-2.093
	(.144)	(.000)	(.556)	(.000)	(.852)	(.001)	(.057)	(.001)
Age of the Student	5.328	2.428	4.312	3.023	.593	.638	1.685	1.819
	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)	(.000)
HHSize × Medium	-.345	-1.576	-1.681	-3.397	-.347	-.930	-1.969	-3.821
	(.670)	(.009)	(.217)	(.001)	(.411)	(.005)	(.125)	(.000)
HHSize × Type	.285	.205	2.620	.699	.596	.318	2.60	1.536
	(.735)	(.752)	(.065)	(.509)	(.175)	(.371)	(.052)	(.126)

Appendix 1

Table A1: Quadratic regression of Height, Weight, MUAC and WC on Age

		Coeffs.	t	Sig.	VIF
Height Boys	(Constant)	53.275	6.375	.000	
	Age	10.721	7.969	.000	228.044
	AgeSq	-.211	-3.956	.000	228.044
	R-square = 0.578. p value = 0.000				
Height Girls	(Constant)	31.582	4.302	.000	
	Age	16.289	13.932	.000	231.486
	AgeSq	-.544	-11.825	.000	231.486
	R-square = 0.290. p value = 0.000				
Weight Boys	(Constant)	4.519	.324	.746	
	Age	2.717	1.209	.227	228.044
	AgeSq	.066	.743	.458	228.044
	R-square = 0.243. p value = 0.000				
Weight Girls	(Constant)	-49.083	-4.025	.000	
	Age	12.065	6.214	.000	231.486
	AgeSq	-.354	-4.635	.000	231.486
	R-square = 0.172. p value = 0.000				
MUAC Boys	(Constant)	24.246	5.630	.000	
	Age	-.704	-1.016	.310	228.044
	AgeSq	.052	1.899	.058	228.044
	R-square = 0.062. p value = 0.000				
MUAC Girls	(Constant)	9.951	2.430	.015	
	Age	1.458	2.237	.025	231.486
	AgeSq	-.032	-1.242	.214	231.486

	R-square = 0.074. p value = 0.000			
WC Boys	(Constant)	13.182	4.016	.000	
	Age	2.122	.972	.331	228.044
	AgeSq	.084	-.160	.873	228.044
	R-square = 0.053. p value = 0.000			
WC Girls	(Constant)	11.592	3.646	.000	
	Age	1.846	1.778	.076	231.486
	AgeSq	.073	-.761	.446	231.486
	R-square = 0.076. p value = 0.000			

Appendix 2

Table A2: Height on Socio-Demographic Variables

	Coeff	t	Sig.	VIF
(Constant)	103.253	129.370	.000	
Sex	-1.782	-4.388	.000	4.223
HHSize	-.274	-.639	.523	4.345
Type	1.625	3.803	.000	3.842
Age	3.865	62.163	.000	1.025
Sex×HHSize	-.491	-1.128	.259	3.034
Sex×Medium	-.244	-.486	.627	3.042
Sex×Type	-3.381	-6.436	.000	6.815
HHSize×Medium	-.794	-1.566	.117	3.040
HHSize×Type	.514	.958	.338	5.707
Medium×Type	2.201	5.301	.000	3.976

R-square = 0.454, p value = 0.000.

Medium of Instruction was automatically removed from the regression because of multicollinearity problem

Table A3: Weight on Socio-Demographic Variables

	Coeff	t	Sig.	VIF
(Constant)	1.779	1.405	.160	
Sex	.317	.493	.622	4.223
HHSize	-.534	-.784	.433	4.345
Type	.194	.286	.775	3.842
Age	3.666	37.180	.000	1.025
Sex×HHSize	-1.739	-2.518	.012	3.034
Sex×Medium	-1.295	-1.623	.105	3.042
Sex×Type	-3.258	-3.910	.000	6.815
HHSize×Medium	-2.313	-2.876	.004	3.040
HHSize×Type	1.905	2.238	.025	5.707
Medium×Type	3.035	4.609	.000	3.976

R-square = 0.222, p value = 0.000.

Medium of Instruction was automatically removed from the regression because of multicollinearity problem

Table A4: MUAC on Socio-Demographic Variables

	Coeffs	t	Sig.	VIF
(Constant)	15.824	39.035	.000	
Sex	.314	1.522	.128	4.223
HHSize	-.120	-.550	.582	4.345
Type	-.040	-.183	.855	3.842
Age	.617	19.534	.000	1.025
Sex×HHSize	-.600	-2.710	.007	3.034
Sex×Medium	-.322	-1.258	.208	3.042
Sex×Type	-.766	-2.869	.004	6.815
HHSize×Medium	-.632	-2.453	.014	3.040
HHSize×Type	.524	1.924	.054	5.707
Medium×Type	.639	3.032	.002	3.976

R-square = 0.078, p value = 0.000.

Medium of Instruction was automatically removed from the regression because of multicollinearity problem.

Table A5: Waist Circumference on Socio-Demographic Variables

	Coeffs	t	Sig.	VIF
(Constant)	53.914	45.211	.000	
Sex	.261	.430	.667	4.223
HHSize	-.566	-.883	.377	4.345
Type	-1.394	-2.184	.029	3.842
Age	1.757	18.918	.000	1.025
Sex×HHSize	-1.677	-2.577	.010	3.034
Sex×Medium	-1.372	-1.826	.068	3.042
Sex×Type	-.978	-1.246	.213	6.815
HHSize×Medium	-2.855	-3.768	.000	3.040
HHSize×Type	2.281	2.845	.004	5.707
Medium×Type	4.009	6.461	.000	3.976

R-square = 0.080, p value = 0.000.

Medium of Instruction was automatically removed from the regression because of multicollinearity problem