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Height, weight and BMI of the teenagers: A Comparative Study of Jharkhand, Bihar, West Bengal and Orissa

S. Shome[1], P. Srimani[2], A. De (Bose)[2] and P. Bharati[3]

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[1]Suparna Shome, Sociological Research Unit, Indian Statistical Institute, 203 B.T. Road, Kolkata 700108. Email: Suparna Shome <sddshome@gmail.com>

[2] Phalguni Srimani, Department of Anatomy, R. G. Kar Medical College and Hospital, Kolkata. Email: Phalguni Sreemani- falgunisreemani@yahoo.co.in

[2] Alpana De (Bose), Department of Anatomy, R. G. Kar Medical College and Hospital, Kolkata. Email: alpana.debasu@gmail.com

[3]Premananda Bharati, Professor and Head, Biological Anthropology Unit, Indian Statistical Institute, 203 B.T. Road, Kolkata 700108, India. Email: pbharati@gmail.com

Corresponding author: Premananda Bharati, Biological Anthropology Unit, Indian Statistical Institute, 203 B.T. Road, Kolkata 700108, India. Email: pbharati@gmail.com

ABSTRACT

This paper compares the height, weight and BMI of the 15-19 groups of male and female of four eastern region states of India namely Jharkhand, Bihar, West Bengal and Orissa using Third National Family Health Survey (NFHS-3) data. The sample sizes of Jharkhand, Bihar, West Bengal and Orissa are 176, 236, 375 and 229 for male and 631, 893, 1052 and 829 for female respectively. Data on socio-demographic background of the households like place of residence, social group, education of males and females, and wealth index of the family are taken to see the differential effects of these variables on the teen ager's height and weight.

It is well recognized that height and weight are interrelated. These are also related with socio-economic variables. But, does the relation remain same over all teen ager's (15-19 years) height and weight groups in different eastern region states? The objective of this paper is to find the effect of the socio-economic variables on heights and weights for different groups of persons formed according to the different levels of heights and weights and to see whether there are gender differences in the variation of heights and weights in the four eastern region states. Descriptive studies show a clear positive relation of height and weight with the economic level. In case of BMI, it is the age group which seems to be the most influential factor. The notable feature is that percentages of short height in all the four eastern region states are higher in comparison to India (29.5%) in case of male. For underweight, the percentage of West Bengal only is lower than national average. The result is similar in case of short height for the females also and for underweight all eastern region state's female shows higher percentage than national average.

Key words: Height; Weight; Teen agers; NFHS-3 data; Eastern region states: India.

INTRODUCTION:

Variation of height and weight is different among the males and females in India. It is mainly due to difference in nutritional status. A significant difference is observed in heights and weights of children belonging to upper and lower income families across all age groups. Adolescents are not exceptional from this. Actually adolescence is a transitional phase between childhood and adulthood (time) when the body prepares itself for the nutritional demands of work load for both boys and girls and additionally for girls during demands of pregnancy, lactation and heavy work load. During this teen period boys and girls gain their height and weight rapidly. But it is found that a variation is observed among the teen agers of 15-19 years of age groups. A number of factors may be responsible for this difference.

Both height and weight is the reflection of an individual's nutritional status. The only difference between this two is that short height reflects chronic malnutrition (is considered as a long term condition), whereas underweight (measure through BMI) is considered as temporary malnutrition and can be regained through dietary intake. Therefore, height is thought to be a retrospective measure of an individual's health and biological standard of living and almost determined before the person reaches the age of twenty (Komlos and Baton 1998). Thus, height is the combination of genetic and environmental factors. Heights, between populations may differ due to genetic factor but within population differences are mainly due to several socio-economic, nutritional and health oriented factors. On the other hand, weight, is the reflection of short-term measure of nutritional status. Changes in a short time may occur due to inadequate or excess amount of food intake.

In Indian situation, in view of endogamy, the variation of height is perhaps more influenced by population structure and less by climate and geography. This is because nearly eighty percent of stature (Bharati et al 2010) is genetically regulated and non-genetic factors such as climate, nutrition and socio-economic factors together account for remaining twenty percent. In India very little work has been done relating to height and weight data on the age group of 15-19 years. It can not be overlooked that rural children exhibit a wide spectrum of undernutrition in the pre- school and pre-pubertal period. Thus children entering adolescence with differing nutritional status are likely to differ greatly in their adolescent growth performance, resulting in the large between individual variations.

Adolescence is a vulnerable period in human life cycle when nutritional requirements increase due to the adolescent growth spurt. This period is characterized by rapid increase in height, weight and hormonal changes resulting in sexual maturation (Gupta 1990) Variations in adolescent growth parameters are shown by Kanade et.al. (1999). It shows that nutritional deprivation seems to affect almost all growth parameters and final adult size too. The phenomenon of early biological maturation has been studied along with other socio-economical influences to indicate the trend of growth among adolescent girls (Chugh & Puri, 2001; Ramachandran et al. 2002; Khanna & Kapoor 2004). Adolescence, one of the nutritional stress periods of life with profound growth comes with increased demands of energy, protein, minerals and vitamins (Gopalan et al 2001). Recently, growth and nutritional status of Bengali adolescent girls has been assessed by using 15 standard anthropometric parameters compared with similar groups within India and abroad (Banerjee et al. 2009).

In Bihar, more than 50 % people are below poverty line, illiteracy among women was above 50 % (Census, 2001) and because of poor access to health and nutrition services, there is high under nutrition among children. In Jharkhand, poverty head count ratio percentage is 39.1 in comparison to India 29.8 in 2009-2010 (Jharkhand economic and human development indicators) and female literacy is 56.21 in comparison to India 65.46 (2011 census). In West Bengal poverty ratios declined half during 2000 but in Bihar it remained the same. Whereas in Orissa, malnutrition among women aged 15-49 years is 41.4% and female literacy is 64.36 compared to 35.6% and 65.46 respectively in India (2011 census). One of the reasons is that a substantial portion of the people is still engaged in manual work for their livelihood and require higher energy intake than is actually consumed. In this context, it is necessary to investigate the socio-economic condition such as education of parents, place of residence or economic conditions in order to understand the retardation of growth and nutrition.

Here the main objective of the paper are (i) to see the variation of growth and nutrition status of 15-19 years of males and females in four states of India like Jharkhand, Bihar, West Bengal and Orissa and to see their comparative account with that of all India results and (ii) to explain the responsible socio-economic factors leading to height and weight and BMI variation.

MATERIALS AND METHODS:

The present data were taken from National Family Health Survey-3 (NFHS-3) during the year 2005-06. The survey was coordinated by International Institute for Population Sciences (IIPS) in collaboration with

the Ministry of Health and Family Welfare. Boys and girls of 15-19 years of age are taken for this study. The sample sizes for the four eastern region states Jharkhand, Bihar, West Bengal and Orissa are 176, 236, 375 and 229 respectively and for India, it is 12,176 for males and for females it is 631, 893, 1052 and 829 respectively and 21813 for India. This survey collected data on weight and height on different ages. It was a nationwide cross section survey which gathered information on population's socio-economic, demographic, anthropometric and other characteristics along with other relevant information. Height is measured in centimeter and BMI is measured by weight (kg)/height (m^2). For male the heights are classified as Very short (<=149.99), Short (150.00-159.99), Below medium (160.00-163.99), Medium (164.00-166.99), Above medium (167.00-169.99), and Tall (>=170.00). For female the classification is Shortest (<145.00), Short (145.00-149.99), Medium (150.00-154.99), Tall (155.00-159.99) and Tallest (>=160.00). For simplification and/or to make parity both male and female heights are grouped in three categories: i) above medium (tall) ii) medium and iii) below medium (short). This classification was taken from Singh et al. (1977). Body Mass Index, which is defined as weight in Kg. divided by the square of height in meter (wt./$ht.^2$), is classified according to WHO classification (1998) as Underweight (<18.5), Normal (18.5-24.9), Overweight (25.0-29.9) and Obese (>=30.0). This classification is same for both boys and girls. Further it is classified as underweight, normal and overweight putting obese persons in the overweight group. Adolescent is signified by the onset of puberty, which is often defined as the physical transformation of a child into an adult. According to UNICEF, 15-19 years age group is defined as late adolescent group. A myriad of biological changes occur during puberty including sexual maturation, increases in height and weight, completion of skeletal growth accompanied by a marked increase in skeletal mass, and changes in body composition. In this ages growth is very close to adult value. Our present data also supports that the mean of height and BMI is quite close in this age. Moreover, it is also observed that the mean height of short stature and underweight is very close to each other in our study. All this condition helps us to classify short and underweight according to adult classification. The other covariates are place of residence according to rural and urban settings, age of the individual, social group like Scheduled caste, Scheduled Tribe, Other Backward classes and General category. To measure economic status, the data use Wealth Index, which is based on the 33 assets and housing characteristics like household electrification, type of windows, source of drinking water, type of toilet facility, type of flooring, material of exterior wall, type of roofing, cooking fuel, house ownership, number of household members per sleeping room, ownership of a bank or post office account, and ownership of mattress, pressure cooker, chair, cot/bed/, table, electric fan, radio/transistor, black and

white television, colour television, sewing machine, mobile phone, any other phone, computer, refrigerator, watch or clock, bicycle, motorcycle, or scooter, animal drawn cart, car, water pump, thresher and tractor. Each household asset has been given a weight, generated through principal component analysis and the resulting asset scores are standardized in relation to a normal distribution with a mean of zero and standard deviation of one (Gwatkin et al, 2000). Each household is then assigned a score for each asset, and the scores were summed for each household; individuals are ranked according to the score of the household in which they reside. The sample is then divided into quintiles i.e. five groups with an equal number of individuals in each and termed as poorest, poorer, middle, riche and richest. To measure educational status, it is classified among both boys and girls as illiterate, primary, secondary and higher secondary education groups.

The analysis is done through tables, figures and logistic regressions. For regression analyses, the nutritional status i.e. short height and Underweight has been considered as dependent variable and socio-economic variables are taken as independent variables. The statistical package for the social sciences (SPSS) has been used for all the analysis. Levels of significances of $p < .01$; and .01 to .05 are considered.

RESULTS:

Table 1, 2 and Figures 1a, 1b, 2a,2b, 3a and 3b describe the mean and SD of weight and height for each age of 15 to 19 years of male and females in four states of India such as Jharkhand, Bihar, West Bengal and Orissa as well as total India. It has been found that the distribution of height and weight around the mean is increasing over the ages in all the four states. The mean height in the starting age is lowest in Jharkhand followed by Orissa. A decreasing trend in mean height is noticed in the age of 18 years in all the eastern states except for Jharkhand, where this reducing trend is observed In the age of 19 years in case of male height. The similar trend is found also in case of mean weight. This picture is found for males only. For females, mean height is quite stable in West Bengal. Jharkhand and Bihar shows poor mean height in comparison to West Bengal and Orissa. It is also observed from the tables that mean height and weight of all the eastern region states are lower in comparison to national mean height and weight. In some ages, it is seen that the height and weight values are lower than their values at previous year, which should not be common for a growth study. This may be due to sampling error. For example, height measurements are by nature subject to statistical sampling errors even for a single individual in

more than one time. Therefore, a typical measurement error of plus or minus 0.5 cm sometimes may nullify the actual growth.

Table 3, 4 and figures 4a, 4b, 5a and 5b shows the percentage distribution of short height and underweight in the ages of 15-19 years for both males and females in the four states of India. For male, percentage of short height and underweight in the age of fifteen is highest in Jharkhand followed by Orissa, Bihar and West Bengal. It is also found that the percentage of short height and underweight is higher in the states (except West Bengal) than national percentage. The females show almost same trend in case of short height and underweight. The noting point is that the percentage of underweight in the age of 19 is lower in Orissa than other states. It is also observed that percentages of short height and underweight are higher in all the four states in comparison to national data for both males and females, except for West Bengal females in case of underweight.

Tables 5, 6, 7, 8, 9 and 10 describe the relationship of mean height, weight and BMI by socioeconomic variables. It is seen that mean height and weight are significantly different among the categories irrespective of different socioeconomic variables. For example, with few exceptions, positive highest mean height, weight and BMI are seen among the males and females of urban areas, higher education and economically better off group. Role of caste/ tribe is not so prominent. In most of the cases, the result is statistically significant at 1% to 5% level. Considering males and females, role of caste/ tribe shows a spurious result in the four states.

Tables 11 and 12 show the effect of socioeconomic variables on short height and underweight among the males and females of 15 to 19 years in the states of India. Results of logistic regression shows that males are significantly less short heighted in the urban areas in Jharkhand in comparison to rural areas. Table also shows that males with primary education are significantly six times higher affected in short height in comparison to illiterate one. Role of education on height is found in Orissa. It is observed that short height is significantly lower among higher education group. A positive significant trend is also found among the higher economic groups in the states both for short height and underweight. Regression analysis for females is shown in Table 12. Role of education in case of female is more pronounced case of short height. It is seen that in short height is significantly reduced in the higher education group in comparison to illiterate women. Rich wealth index also play a significant role in reducing short height and underweight in comparison to poor one.

DISCUSSION:

The paper makes a comparative study of height and weight of males and females of teen age of 15-19 year in four states of India and also compares the deviation in the perspective of total India. It is seen that means of height, weight and BMI of 15-19 years of males and females are lower than national mean except for male of West Bengal and Orissa, where mean BMI is higher or same with that of national mean figures. It leaves no scope for comparison that males will be taller than females. However, height of 15-19 ages often differ significantly between populations groups which may be due to genetic differences or childhood life style differences. It this observed that high percentage of short height and underweight starts from the age of 15 in all the four states which are similar to all India level both for males and females. The only exception is found in Bihar in case of underweight where the percentage is higher in the age of 16 in case of males. The percentage of short height males are highest in Jharkhand followed by West Bengal, Orissa and Jharkhand in the lowest rung of the ladder and for underweight the percentage is highest in Bihar followed by Jharkhand, Orissa and West Bengal. For females, the highest percentage of short height and underweight is similar like that of males followed by other states, only the difference is that percentage of underweight females in the age of 19 are higher than males. Magnitude of lower short height and low intensity of underweight in respect of socioeconomic variables are seen among the males and females of urban areas, women's higher education and rich wealth index categories. Another notable finding is that only in Orissa, reduction of short height is directly related with upward movement of literacy but in Jharkhand, Bihar and West Bengal, there is no impact of literacy on reducing short height in case of male. For underweight, no impact of education is observed in none of the four states. Impact of rich wealth is seen mainly in case of West Bengal in reducing underweight whereas a relation is observed in the other states in lowering the short height in case of males. Females show a mixed result where reducing tendency is found in the rich wealth index group. A significant increasing trend of short height is found in Bihar in relation to higher education, but reducing picture is noticed in West Bengal. The other important finding is that reduction of underweight is directly related to social groups in Orissa, whereas no impact is found in other states. It is also seen that wealth index is inversely related with short height and underweight for both males and females, implying that wealth index has a significant effect on reduction of both short height and underweight. In

Bihar and Jharkhand, under nutrition is very high which may be due to low per capita income and poor access to health that increase the morbidity. The reason for high underweight states may also be due to high illiteracy among women, causing low women status (Bihar Road map, 2007). The result thus lead to understand that India is far from being a homogenous country in terms of height and weight as there is a wide inter-state variation in socio-economic profile. Some of the states in India are also unique in gender disparity. The states like Jharkhand and Bihar shows the leading disparity in female education. It can also be said from the growth pattern of Bihar and Jharkhand, in poor economic state, economy is the sole factor for reducing under nutrition while in West Bengal which is better than Bihar and Jharkhand, mother's literacy has also role to reduce the under nutrition.

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Table 1 Mean height, weight and BMI of 15-19 years of Male of Jharkhand, Bihar, WB, Orissa and India

Age	Jharkhand							Bihar							West Bengal						
		Height		Weight		BMI			Height		Weight		BMI			Height		Weight		BMI	
	N	Mean	SD	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD
15	39	158.89	7.76	44.52	5.40	17.60	1.42	42	160.96	8.02	45.27	7.74	17.39	2.10	72	160.84	8.43	47.29	8.81	18.19	2.46
16	41	162.53	8.19	47.74	8.12	18.02	2.28	53	164.28	7.68	48.39	6.22	17.89	1.56	88	162.60	6.62	49.26	7.33	18.61	2.38
17	32	162.71	7.14	47.22	6.37	17.79	1.67	45	165.01	7.27	49.82	6.47	18.27	1.81	62	163.16	6.52	50.41	7.45	18.90	2.33
18	42	164.75	6.96	51.97	8.64	19.07	2.31	64	162.66	6.01	47.69	6.21	18.01	1.99	89	162.57	5.84	49.85	8.15	18.81	2.47
19	22	163.35	6.04	50.03	3.79	18.74	0.97	32	164.64	5.89	51.96	7.36	19.17	2.52	64	164.81	6.75	52.41	7.04	19.29	2.36
15-19	176	162.39	7.58	48.23	7.41	18.22	1.96	236	163.44	7.11	48.04	6.95	18.08	2.02	375	162.73	6.92	49.75	7.93	18.74	2.42

Table Continued

Age	Orissa							India						
		Height		Weight		BMI			Height		Weight		BMI	
	N	Mean	SD	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD
15	50	159.79	6.30	45.10	7.41	17.59	2.15	2204	160.70	8.11	46.28	8.79	17.92	3.57
16	51	161.70	7.39	48.16	8.89	18.35	2.61	2654	162.73	7.55	48.43	8.17	18.33	3.68
17	50	164.36	7.16	50.08	7.63	18.49	2.10	2384	164.46	7.30	50.65	8.35	18.69	2.53
18	38	163.73	5.36	51.78	7.36	19.28	2.28	2761	164.74	7.05	51.97	8.41	19.12	2.64
19	40	164.29	6.69	55.27	10.04	20.39	2.87	2173	165.22	7.24	53.31	8.29	19.51	2.63
15-19	229	162.65	6.87	49.76	8.89	18.73	2.56	12176	163.60	7.61	50.15	8.73	18.72	3.10

Table 2 Mean height, weight and BMI of 15-19 years of Female of Jharkhand, Bihar, WB, Orissa and India

Age	Jharkhand							Bihar							West Bengal						
		Height		Weight		BMI			Height		Weight		BMI			Height		Weight		BMI	
	N	Mean	SD	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD
15	115	149.22	5.89	41.63	6.46	18.65	2.32	203	149.56	5.20	41.18	5.81	18.39	2.23	194	150.25	4.85	41.96	6.19	18.57	2.50
16	131	149.88	5.62	42.53	5.96	18.90	2.20	178	150.74	6.16	41.68	5.67	18.33	2.13	219	150.62	5.26	43.18	6.21	19.03	2.48
17	130	149.32	5.93	41.87	5.44	18.75	1.92	147	149.91	5.18	42.48	5.48	18.89	2.17	198	150.82	5.62	43.87	7.16	19.25	2.71
18	144	149.42	5.79	43.16	6.00	19.31	2.33	233	150.17	5.57	43.10	5.83	19.10	2.31	242	150.53	5.52	44.45	7.39	19.59	2.91
19	111	150.18	5.67	42.91	5.55	19.03	2.23	132	149.52	5.48	43.07	6.24	19.24	2.45	199	150.97	5.86	45.09	8.24	19.73	3.10
15-19	631	149.59	5.77	42.44	5.90	18.94	2.21	893	150.01	5.54	42.28	5.84	18.77	2.28	1052	150.63	5.43	43.74	7.15	19.25	2.78

Continued

Age	Orissa							India						
		Height		Weight		BMI			Height		Weight		BMI	
	N	Mean	SD	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	Mean	SD
15	161	149.95	5.94	42.11	6.19	18.71	2.39	4155	151.40	5.94	43.08	6.75	18.80	2.89
16	165	150.94	5.14	43.95	6.21	19.26	2.26	4587	151.99	5.92	44.21	6.97	19.12	2.81
17	163	151.23	5.02	43.88	7.16	19.16	2.27	4183	152.10	5.97	44.76	6.97	19.36	3.01
18	190	150.76	5.85	43.39	7.39	19.08	2.25	4869	152.08	5.99	45.38	7.14	19.60	2.73
19	150	151.28	6.23	45.28	8.24	19.95	7.03	4019	152.44	6.01	45.91	7.71	19.78	3.57
15-19	829	150.82	5.60	43.69	7.15	19.22	3.65	21813	152.00	5.97	44.67	7.18	19.33	3.02

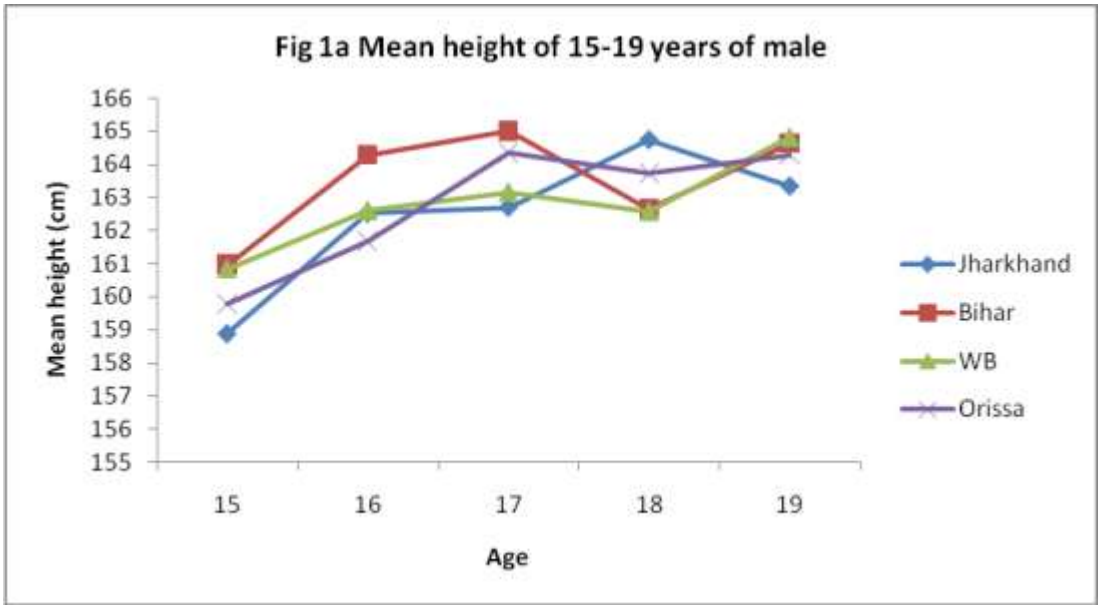
Fig 1a Mean height of 15-19 years of male
Mean height (cm)
166
165
164
163
162
161
160
159
158
157
156
155
15
16
17
18
19
Age
Jharkhand
Bihar
WB
Orissa

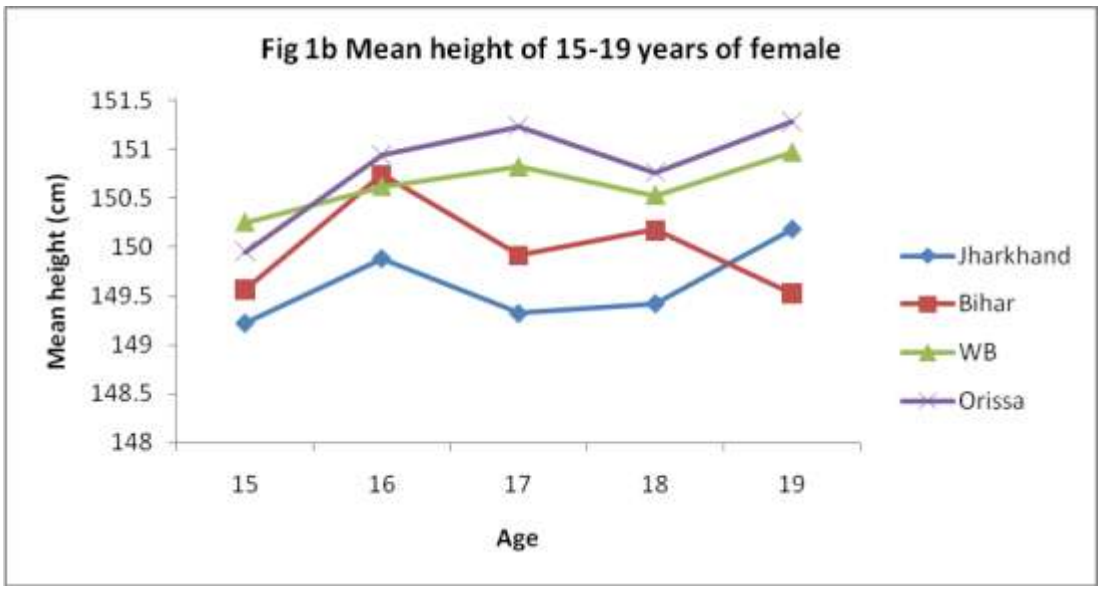
Fig 1b Mean height of 15-19 years of female
Mean height (cm)
151.5
151
150.5
150
149.5
149
148.5
148
15
16
17
18
19
Age
Jharkhand
Bihar
WB
Orissa

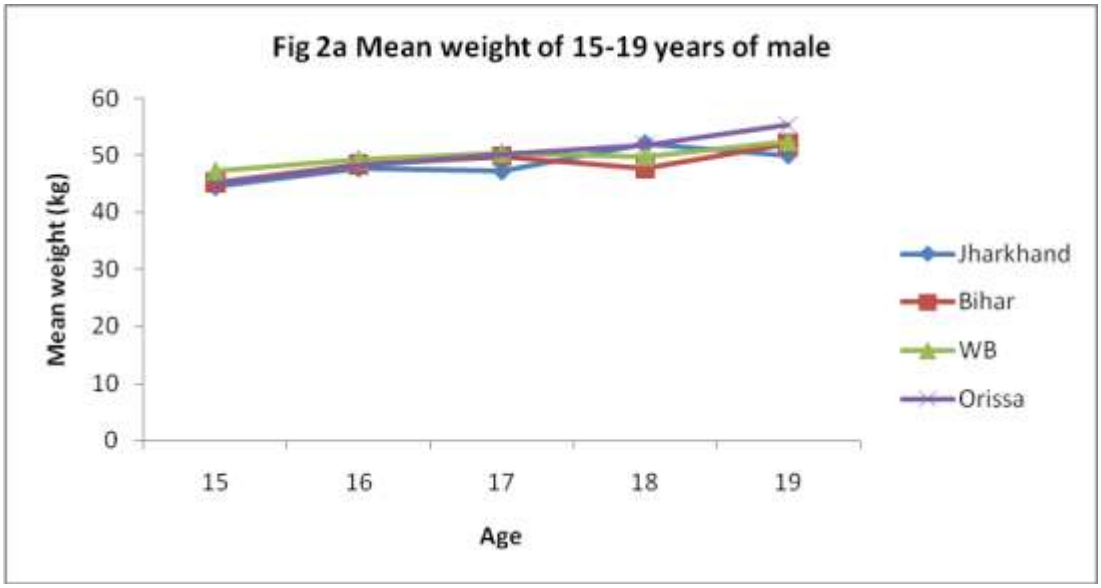
Fig 2a Mean weight of 15-19 years of male
Mean weight (kg)
60
50
40
30
20
10
0
15
16
17
18
19
Age
Jharkhand
Bihar
WB
Orissa

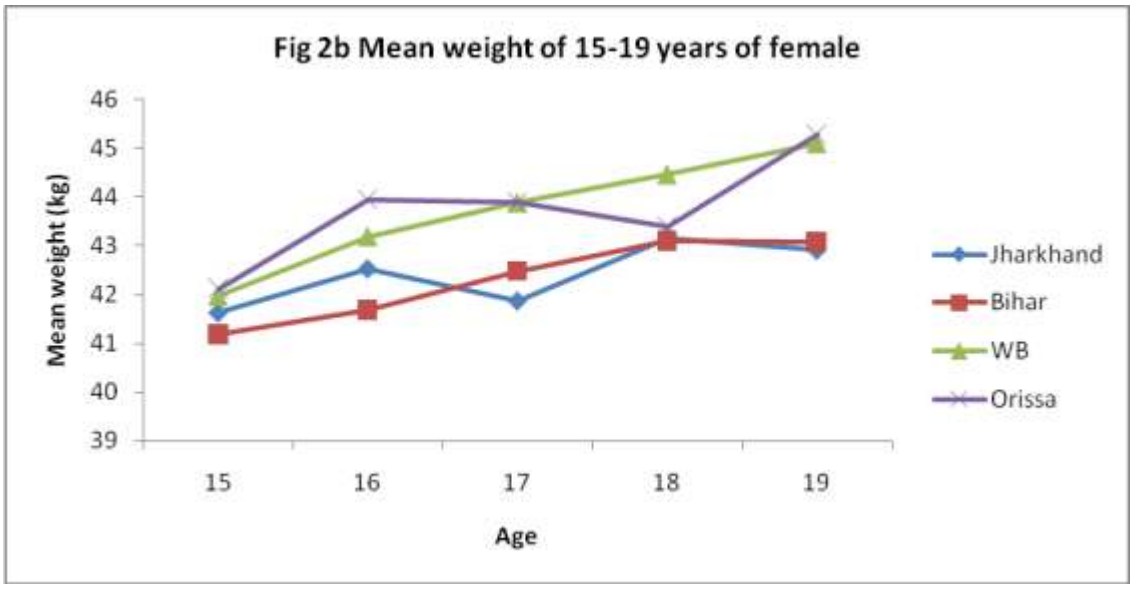
Fig 2b Mean weight of 15-19 years of female
Mean weight (kg)
46
45
44
43
42
41
40
39
15
16
17
18
19
Age
Jharkhand
Bihar
WB
Orissa

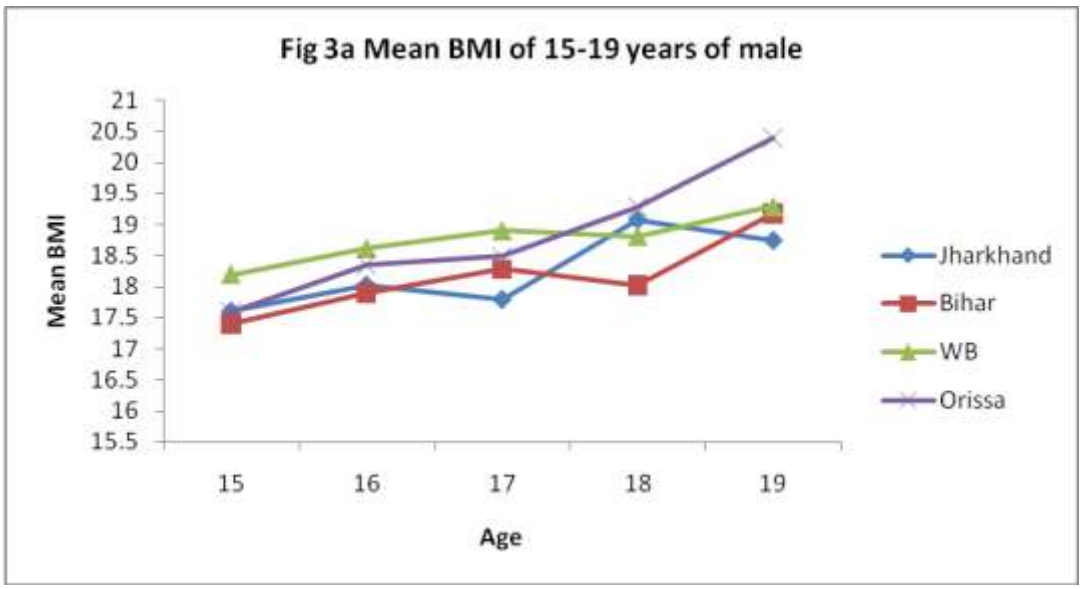
Fig 3a Mean BMI of 15-19 years of male
Mean BMI
21
20.5
20
19.5
19
18.5
18
17.5
17
16.5
16
15.5
15
16
17
18
19
Age
Jharkhand
Bihar
WB
Orissa

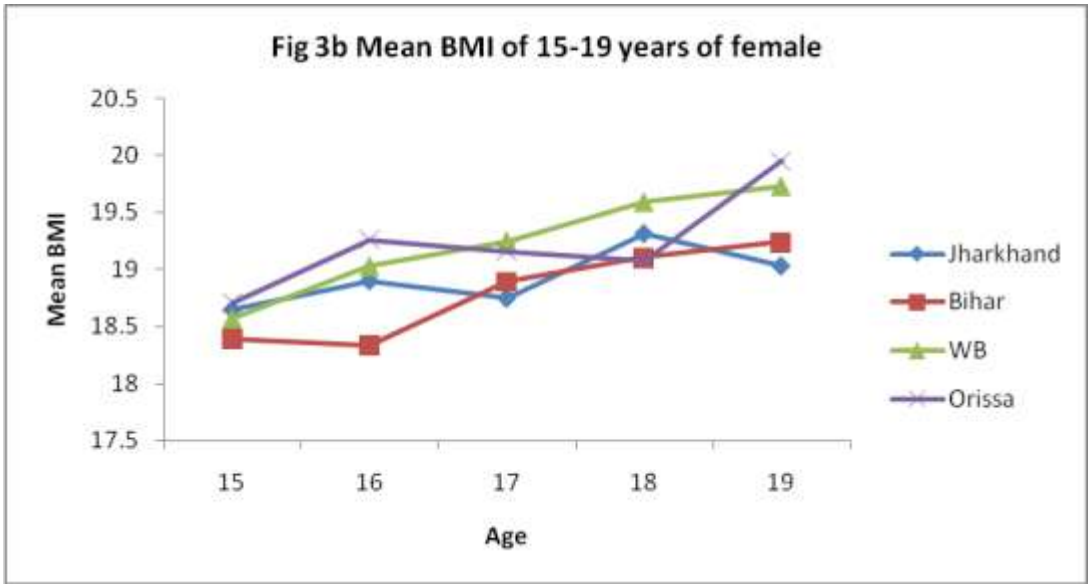
Fig 3b Mean BMI of 15-19 years of female
Mean BMI
20.5
20
19.5
19
18.5
18
17.5
15
16
17
18
19
Age
Jharkhand
Bihar
WB
Orissa

Table 3 Age-group wise percentage distribution of short height and under-weight male **of 15-19 years across 4 states and India**

Age	Jharkhand			Bihar			West Bengal			Orissa			India		
	N	Short height	Underweight	N	Short height	Underweight	N	Short height	Underweight	N	Short height	Underweight	N	Short height	Underweight
15	39	59.0	76.9	42	47.6	69.0	72	41.7	63.9	50	48.0	76.0	2204	43.2	67.1
16	41	36.6	68.3	53	26.4	77.4	88	39.8	54.5	51	35.3	60.8	2654	32.9	61.0
17	32	37.5	65.6	45	22.2	55.6	62	38.7	41.9	50	34.0	56.0	2384	25.7	52.0
18	42	28.6	45.2	64	29.7	54.7	89	36.0	50.6	38	26.3	47.4	2761	23.5	44.8
19	22	31.8	36.4	32	25.0	43.8	64	29.7	39.1	40	27.5	27.5	2173	23.3	37.4
15-19	176	39.2	60.2	236	30.1	61.0	375	37.3	50.7	229	34.9	55.0	12176	29.5	52.4

In case of male short height <160.00 cm and underweight <18.50

Table 4 Age-group wise percentage distribution of short height and under-weight Female **of 15-19 years across 4 states and India**

Age	Jharkhand			Bihar			West Bengal			Orissa			India		
	N	Short height	Underweight	N	Short height	Underweight	N	Short height	Underweight	N	Short height	Underweight	N	Short height	Underweight
15	115	56.5	53.9	203	51.2	57.1	194	45.9	53.1	161	50.9	57.1	4155	39.9	50.1
16	131	55.7	45.8	178	43.3	56.7	219	44.7	44.3	165	40.6	37.0	4587	36.5	44.6
17	130	50.8	46.2	147	50.3	42.9	198	41.9	46.5	163	41.1	41.7	4183	36.0	39..8
18	144	59.0	38.2	233	48.5	44.2	242	44.2	39.3	190	45.8	43.2	4869	36.1	36.8
19	111	49.5	47.7	132	52.3	47.7	199	41.2	39.7	150	41.3	38.7	4019	33.3	35.8
15-19	631	54.5	46.0	893	48.9	49.9	1052	43.6	44.3	829	44.0	43.5	21813	36.4	41.4

In case of female ,Short height <150.00cm and underweight <18.5

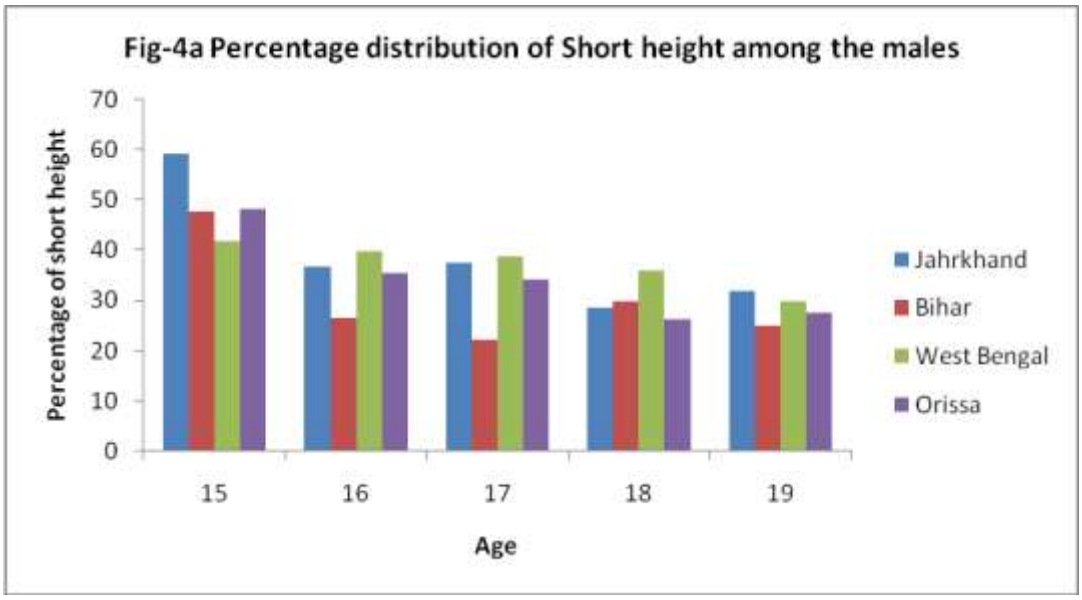
Fig-4a Percentage distribution of Short height among the males
Percentage of short height
70
60
50
40
30
20
10
0
15
16
17
18
19
Age
Jahrkhand
Bihar
West Bengal
Orissa

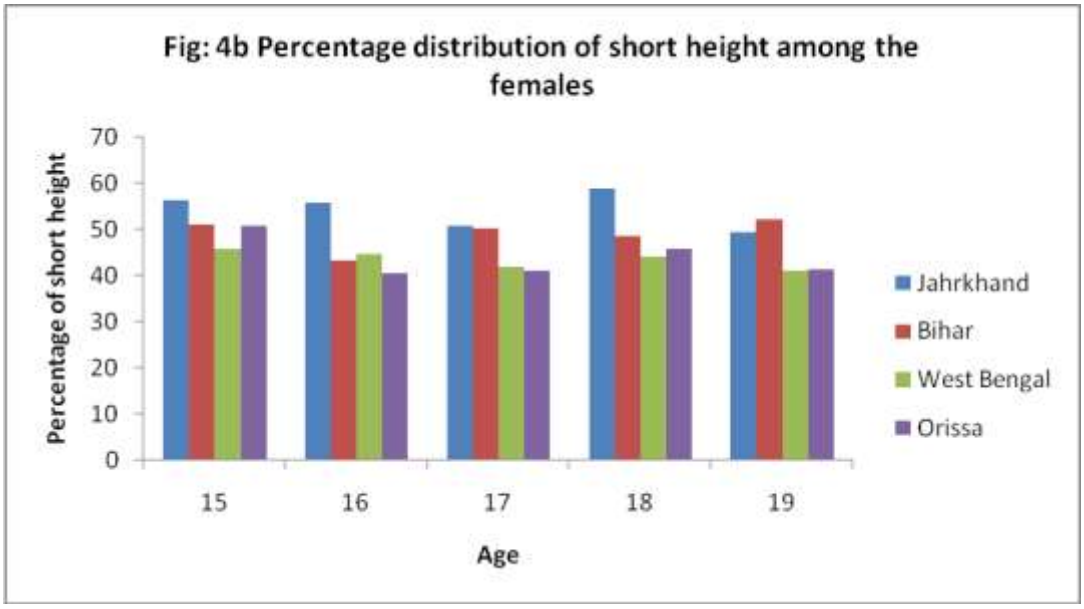
Fig: 4b Percentage distribution of short height among the females
Percentage of short height
70
60
50
40
30
20
10
0
15
16
17
18
19
Age
Jahrkhand
Bihar
West Bengal
Orissa

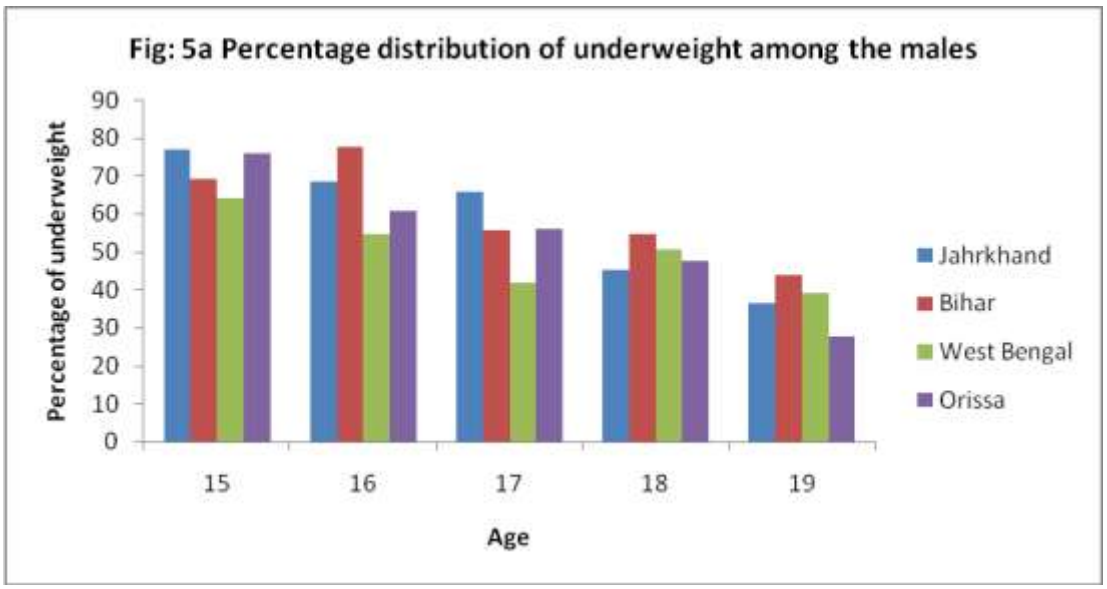
Fig: 5a Percentage distribution of underweight among the males
Percentage of underweight
90
80
70
60
50
40
30
20
10
0
15
16
17
18
19
Age
Jahrkhand
Bihar
West Bengal
Orissa

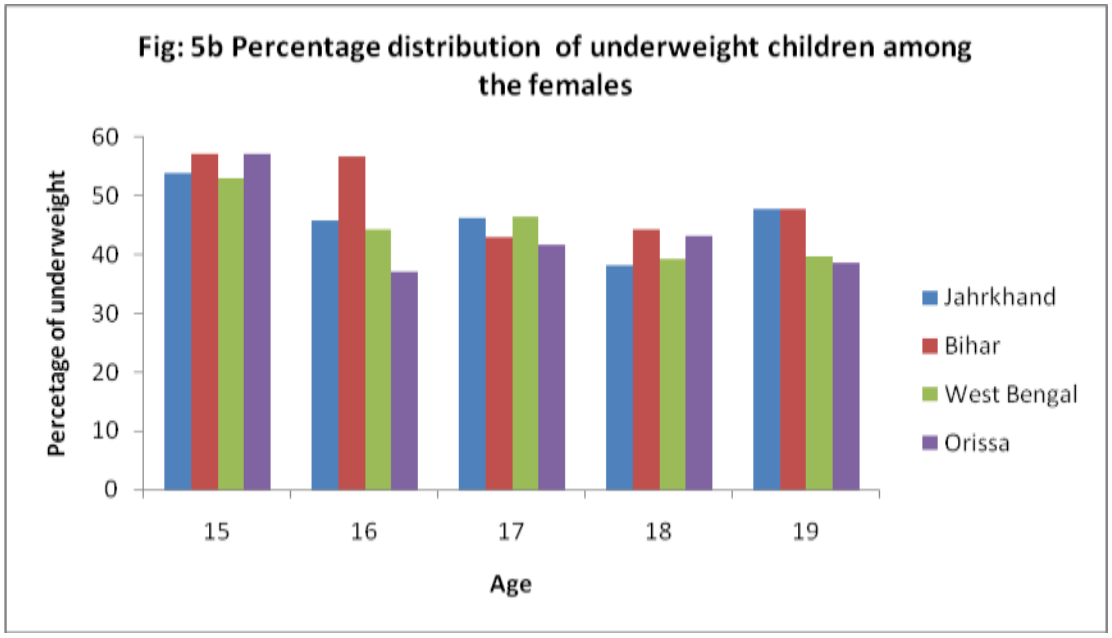
Fig: 5b Percentage distribution of underweight children among the females
Percetage of underweight
60
50
40
30
20
10
0
15
16
17
18
19
Age
Jahrkhand
Bihar
West Bengal
Orissa

Table 5 Relationship between 15-19 years male **mean height with different socio-economic variables in four states of India**

Socio-conomic variables	Jharkhand			Bihar			West Bengal			Orissa		
	N	**Height**	**Anova 'F' value**	**N**	**Height**	**Anova 'F' value**	**N**	**Height**	**Anova 'F' value**	**N**	**Height**	**Anova 'F' value**
Place Of Residence			28.710 .000 df 1			4.812 .029 df 1			1.954 .163 df 1			.033 .857 df 1
Rural	98	159.85		103	162.29		167	162.17		141	162.72	
Urban	78	165.58		133	164.32		208	163.17		88	162.55	
Caste/Tribe			6.088			7.403			1.897			7.754
SC	24	161.06	.001	35	161.56	.000	92	161.76	.111	40	159.85	.000
ST	29	157.70	df 3	2	165.45	df 3	12	164.28	df 3	49	160.33	df 3
OBC	93	163.56		146	162.47		21	165.88		63	163.67	
Others	29	164.70		53	167.25		196	163.30		75	164.86	
Male education			8.039			7.388			8.872			1.798
Illiterate	20	159.68	.000	28	160.67	.000	29	160.70	.000	14	158.46	.148
Primary	22	156.30	df 3	36	159.59	df 3	94	160.27	df 3	28	162.32	df 3
Secondary	131	163.75		163	164.62		248	163.77		178	162.99	
Higher	3	165.70		9	166.09		4	170.52		9	163.16	
MALE AGE			3.378			2.488			2.933			4.228
15	39	158.89	.011	42	160.96	.044	72	160.84	.021	50	159.79	.003
16	41	162.53	Df 4	53	164.28	Df4	88	162.60	Df4	51	161.70	Df 4
17	32	162.71		45	165.01		62	163.16		50	164.36	
18	42	164.75		64	162.66		89	162.57		38	163.73	
19	22	163.35		32	164.64		64	164.81		40	164.29	
WEALTH INDEX			11.100 .000			7.003 .000			5.306 .000			4.139 .003
Poorest	47	157.44	df 4	28	158.62	df 4	48	160.83	df 4	71	160.41	df 4
Poorer	33	161.57		52	161.98		64	161.93		44	162.04	
Middle	25	164.19		40	163.56		60	161.54		33	163.38	
Richer	34	163.63		48	163.81		126	162.61		45	164.14	
Richest	37	167.04		68	166.20		77	165.68		36	165.29	

SC Scheduled caste, ST=Scheduled Tribe, OBC= Other Backward classes, Others= Other General caste

Table 6 Relationship between 15-19 years Female **mean height with different socio-economic variables in four states of India**

Socio-conomic variables	Jharkhand			Bihar			West Bengal			Orissa		
	N	**Height**	**Anova 'F' value**	**N**	**Height**	**Anova 'F' value**	**N**	**Height**	**Anova 'F' value**	**N**	**Height**	**Anova 'F' value**
Place of residence			18.251 .000			8.941 .003			0.746 .388			7.618 .006
Rural	402	148.86	Df 1	566	149.59	Df 1	529	150.49	Df 1	594	150.49	Df 1
Urban	229	150.88		327	150.73		523	150.78		235	151.67	
Caste/Tribe			16.699			14.980			6.346			8.276
SC	90	148.21	.000	143	148.13	.000	298	149.62	.000	156	149.90	.000
ST	135	147.98	Df 3	4	147.08	Df 3	51	149.66	Df 3	195	149.64	Df 3
OBC	285	149.55		527	149.77		28	152.06		247	151.27	
Others	121	152.52		219	151.86		675	151.09		231	151.96	
FEMALE education			9.990 .000			11.069 .000			15.784 .000			6.725 .000
Illiterate	227	148.45	Df 3	360	148.95	Df 3	149	148.96	Df 3	187	149.57	Df 3
Primary	91	148.17		105	149.28		237	149.32		132	150.23	
Secondary	296	150.81		422	151.11		652	151.44		494	151.36	
Higher	16	151.12		6	148.13		14	153.26		16	153.77	
FEMALE AGE			.597			1.420			.520			1.474
15	115	149.22	.665	203	149.56	.225	194	150.25	.721	161	149.95	.208
16	131	149.88	Df 4	178	150.74	Df 4	219	150.62	Df 4	165	150.94	Df 4
17	130	149.32		147	149.91		198	150.82		163	151.23	
18	144	149.42		233	150.17		242	150.53		190	150.76	
19	111	150.18		132	149.52		199	150.97		150	151.28	
WEALTH INDEX			12.343 .000			16.969 .000			6.681 .000			16.160 .000
Poorest	256	148.57	Df 4	177	148.22	Df 4	170	150.12	Df 4	288	149.74	Df 4
Poorer	91	148.25		217	149.24		206	150.12		147	150.25	
Middle	82	149.85		170	150.15		183	149.79		158	150.06	
Richer	102	149.93		173	150.08		279	150.66		121	151.96	
Richest	100	152.89		156	152.84		214	152.22		115	154.13	

SC Scheduled caste, ST=Scheduled Tribe, OBC= Other Backward classes, Others= Other General caste

Table 7 Relationship between 15-19 years male **mean weight with different socio-economic variables in four states of India**

Socio-conomic variables	**Jharkhand**			**Bihar**			**West Bengal**			**Orissa**		
	N	**Weight**	**Anova 'F' value**	**N**	**Weight**	**Anova 'F' value**	**N**	**Weight**	**Anova 'F' value**	**N**	**Weight**	**Anova 'F' value**
Place of residence			21.684 .000			3.421 .066			18.759 .000			2.563 .111
Rural	98	46.04	Df 1	103	47.46	Df 1	167	47.82	Df 1	141	49.02	Df 1
Urban	78	50.99		133	49.14		208	51.30		88	50.94	
Caste/Tribe			3.038			7.607			3.613			4.182
SC	24	47.15	.031	35	45.14	.000	92	47.61	.007	40	47.28	.007
ST	29	45.41	Df 3	2	49.50	Df 3	12	50.58	Df 3	49	47.42	Df 3
OBC	93	48.58		146	47.93		21	53.85		63	50.36	
Others	29	50.95		53	51.81		196	50.52		75	52.13	
MALE education			5.725 .001			3.779 .011			4.229 .006			4.951 .002
Illiterate	20	46.97	Df 3	28	46.68	Df 3	29	48.40	Df 3	14	46.09	Df 3
Primary	22	42.67		36	46.35		94	47.77		28	50.04	
Secondary	131	49.33		163	48.85		248	50.59		178	49.49	
Higher	3	49.23		9	53.81		4	56.00		9	59.83	
MALE AGE			6.333			5.225			3.831			9.379
15	39	44.51	.000	42	45.26	.000	72	47.29	.005	50	45.10	.000
16	41	47.74	Df 4	53	48.39	Df 4	88	49.26	Df 4	51	48.16	Df 4
17	32	47.22		45	49.82		62	50.40		50	50.08	
18	42	51.97		64	47.69		89	49.85		38	51.77	
19	22	50.02		32	51.96		64	52.41		40	55.27	
WEALTH INDEX			10.308 .000			6.957 .000			15.522 .000			7.304 .000
Poorest	47	44.68	Df 4	28	44.15	Df 4	48	45.86	Df 4	71	47.17	Df 4
Poorer	33	46.88		52	47.80		64	47.85		44	48.14	
Middle	25	48.94		40	48.31		60	48.05		33	48.70	
Richer	34	47.73		48	47.27		126	49.70		45	51.28	
Richest	37	53.90		68	51.46		77	55.15		36	55.88	

SC Scheduled caste, ST=Scheduled Tribe, OBC= Other Backward classes, Others= Other General caste

Table 8 Relationship between 15-19 years Female **mean weight with different socio-economic variables in four states of India**

Socio-conomic variables	Jharkhand			Bihar			West Bengal			Orissa		
	N	**Weight**	**Anova 'F' value**	**N**	**Weight**	**Anova 'F' value**	**N**	**Weight**	**Anova 'F' value**	**N**	**Weight**	**Anova 'F' value**
Place of residence			16.256 .000			2.103 .147			39.823 .000			7.271 .007
Rural	402	41.73	Df 1	566	42.06	Df1	529	42.38	Df 1	594	43.26	Df 1
Urban	229	43.68		327	42.65		523	45.11		235	44.76	
Caste/Tribe			8.916			7.058			5.338			8.917
SC	90	41.14	.000	143	40.79	.000	298	42.87	.001	156	42.37	.000
ST	135	42.01	Df 3	4	43.92	Df 3	51	41.08	Df 3	195	42.34	Df 3
OBC	285	42.05		527	42.12		28	44.89		247	43.93	
Others	121	44.81		219	43.57		675	44.27		231	45.46	
FEMALE education			14.353 .000			7.277 .000			12.982 .000			7.298 .000
Illiterate	227	41.30	Df 3	360	41.35	Df 3	149	41.42	Df 3	187	41.75	Df 3
Primary	91	40.33		105	41.76		237	42.43		132	43.24	
Secondary	296	43.79		422	43.21		652	44.67		494	44.46	
Higher	16	45.75		6	40.36		14	47.06		16	46.18	
FEMALE AGE			1.584			4.153			5.850			3.935
15	115	41.63	.177	203	41.18	.002	194	41.95	.000	161	42.11	.004
16	131	42.53	Df 4	178	41.67	Df 4	219	43.18	Df 4	165	43.94	Df 4
17	130	41.86		147	42.48		198	43.86		163	43.87	
18	144	43.16		233	43.10		242	44.45		190	43.39	
19	111	42.91		132	42.27		199	45.09		150	45.28	
WEALTH INDEX			16.126 .000			10.947 .000			27.425 .000			17.220 .000
Poorest	256	41.41	Df 4	177	41.03	Df 4	170	41.57	Df 4	288	41.91	Df 4
Poorer	91	41.35		217	41.57		206	41.98		147	42.95	
Middle	82	42.27		170	42.12		183	42.04		158	43.40	
Richer	102	42.13		173	42.24		279	44.63		121	45.09	
Richest	100	46.52		156	44.86		214	47.43		115	47.99	

SC Scheduled caste, ST=Scheduled Tribe, OBC= Other Backward classes, Others= Other General caste

Table 9 Relationship between 15-19 years male **mean BMI with different socio-economic variables in four states of India**

Socio-conomic variables	**Jharkhand**			**Bihar**			**West Bengal**			**Orissa**		
	N	**BMI**	**Anova 'F' value**	**N**	**BMI**	**Anova 'F' value**	**N**	**BMI**	**Anova 'F' value**	**N**	**BMI**	**Anova 'F' value**
Place of residence			3.920 .049			.419 .518			19.612 .000			4.832 .029
Rural	98	17.97	Df 1	103	17.98	Df 1	167	18.13	Df 1	141	18.43	Df 1
Urban	78	18.55		133	18.15		208	19.22		88	19.19	
Caste/Tribe			.620 .603			2.631 .051			2.877 .023			1.113 .345
SC	24	18.09	Df 3	35	17.27	Df 3	92	18.17	Df 3	40	18.41	Df 3
ST	29	18.22		2	18.02		12	18.67		49	18.40	
OBC	93	18.12		146	18.12		21	19.01		63	18.68	
Others	29	18.67		53	18.48		196	18.89		75	19.14	
MALE education			1.484 .221			1.785 .151			.390 .760			7.015 .000
Illiterate	20	18.40	Df 3	28	18.07	Df 3	29	18.62	Df 3	14	18.31	Df 3
Primary	22	17.42		36	18.14		94	18.54		28	18.91	
Secondary	131	18.34		163	17.98		248	18.82		178	18.54	
Higher	3	17.94		9	19.57		4	19.30		9	22.35	
MALE AGE			4.146 .003			3.947 .004			1.938 .103			8.490 .000
15	39	17.60	Df 4	42	17.39	Df 4	72	18.18	Df 4	50	17.59	Df 4
16	41	18.02		53	17.89		88	18.61		51	18.34	
17	32	17.78		45	18.26		62	18.90		50	18.49	
18	42	19.07		64	18.01		89	18.80		38	19.28	
19	22	18.74		32	19.16		64	19.29		40	20.38	
WEALTH INDEX			3.455 .010			2.369 .053			10.230 .000			5.377 .000
Poorest	47	17.97	Df 4	28	17.55	Df 4	48	17.64	Df 4	71	18.27	Df 4
Poorer	33	17.94		52	18.20		64	18.24		44	18.28	
Middle	25	18.10		40	18.06		60	18.39		33	18.20	
Richer	34	17.83		48	17.56		126	18.76		45	18.93	
Richest	37	19.25		68	18.57		77	20.07		36	20.36	

SC= Scheduled caste, ST=Scheduled Tribe, OBC= Other Backward classes, Others= Other General caste

Table 10 Relationship between 15-19 years Female **mean BMI with different socio-economic variables in four states of India**

Socio-conomic variables	**Jharkhand**			**Bihar**			**West Bengal**			**Orissa**		
	N	**BMI**	**Anova 'F' value**	**N**	**BMI**	**Anova 'F' value**	**N**	**BMI**	**Anova 'F' value**	**N**	**BMI**	**Anova 'F' value**
Place of residence			3.726 .054			.048 .826			43.331 .000			.827 .363
Rural	402	18.81	Df 1	566	18.78	Df 1	529	18.69	Df 1	594	19.14	Df 1
Urban	229	19.16		327	18.75		523	19.80		235	19.40	
Caste/Tribe			1.810 .144			1.118 .341			2.560 .054			3.034 .029
SC	90	18.71	Df 3	143	18.58	Df 3	298	19.12	Df 3	156	18.84	Df 3
ST	135	19.14		4	20.31		51	18.32		195	18.89	
OBC	285	18.79		527	18.76		28	19.35		247	19.16	
Others	121	19.22		219	18.88		675	19.36		231	19.80	
FEMALE education			5.833 .001			1.127 .337			4.541 .004			2.302 .076
Illiterate	227	18.72	Df 3	360	18.62	Df 3	149	18.64	Df 3	187	18.63	Df 3
Primary	91	18.37		105	18.74		237	19.01		132	19.15	
Secondary	296	19.23		422	18.91		652	19.45		494	19.44	
Higher	16	20.01		6	18.32		14	20.04		16	19.47	
FEMALE AGE			1.814 .124			5.990 .000			5.725 .000			2.402 .048
15	115	18.65	Df 4	203	18.39	Df 4	194	18.57	Df4	161	18.70	Df 4
16	131	18.90		178	18.33		219	19.02		165	19.26	
17	130	18.75		147	18.89		198	19.25		163	19.16	
18	144	19.31		233	19.10		242	19.58		190	19.08	
19	111	19.02		132	19.24		199	19.73		150	19.95	
WEALTH INDEX			5.391 .000			1.684 .152			20.792 .000			4.101 .003
Poorest	256	18.74	Df 4	177	18.66	Df 4	170	18.43	Df 4	288	18.68	Df 4
Poorer	91	18.77		217	18.65		206	18.60		147	19.02	
Middle	82	18.82		170	18.67		183	18.73		158	19.46	
Richer	102	18.77		173	18.74		279	19.63		121	19.49	
Richest	100	19.86		156	19.19		214	20.44		115	20.18	

SC Scheduled caste, ST=Scheduled Tribe, OBC= Other Backward classes, Others= Other General caste

Table 11 Logistic Regression analysis of short height and underweight on different socio-economic variables in 15-19 years of males across four states of India

Socio-economic variables	Jharkhand		Bihar		West Bengal		Orissa	
	Short height	Under weight	Short height	Under weight	Short height	Under weight	Short height	Under weight
Place of residence								
Rural	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Urban	.378*	1.922	.730	.907	1.206	1.057	1.522	.764
Social group								
Muslim	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Hindu SC	1.951	1.648	.893	.908	.982	.897	5.708	1.522
Non Christian ST	1.723	.719	-	-	.242	.606	8.308	1.766
Christian ST	1.803	1.040	-	-	-	-	-	-
Hindu Other	--	--	-	-	1.011	1.320	-	-
Other religion	--	---	-	-	7.203	.236	2.118	1.909
MALE education								
Illiterate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Primary	6.498**	3.552	1.876	.748	1.041	1.055	.157*	1.086
Secondary	.968	2.607	.698	1.311	.474	1.424	.183*	1.665
Higher	.000	5.290	.394	.650	.000	2.772	.998	.374
WEALTH INDEX								
Poorest	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Poorer	.388	.642	.680	.673	.758	.442*	.458	1.089
Middle	.453	.777	.268*	.729	.789	.538	.518	1.185
Richer	.304*	.628	.441	1.346	.587	.336*	.588	.841
Richest	.339	.202*	.268*	.595	.304*	.143*	.183*	.896

<0.01 = 1% level ** , 0.01 – 0.05 = 5% level*

Table 12 Logistic Regression analysis of short height and underweight on different socio-economic variables in 15-19 years of females across four states of India

Socio-economic variables	Jharkhand		Bihar		West Bengal		Orissa	
	Short height	Under weight	Short height	Under weight	Short height	Under weight	Short height	Under weight
Place of residence								
Rural	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Urban	1.176	1.165	1.197	1.266	1.578*	.885	1.187	1.285
Social group								
Muslim	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Hindu SC	2.029*	.646	1.791*	1.084	1.263	.636*	1.620	.240*
Non Christian ST	2.877**	.497*	4.848	.000	.745	.703	1.943	.256*
Christian ST	1.804	.384	-	-	2.633	.610	1.593	.176*
Hindu Other	1.459	.735	1.286	.738	.854	.833	1.349	.249*
Other religion	1.183	.546	.000	.000	.979	1.777	.737	.165*
FEMALE education								
Illiterate	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Primary	1.288	1.190	.793	.943	.897	.829	.808	.589*
Secondary	.599*	.703	1.033	.914	.588*	.936	.790	.883
Higher	.881	.422	5.979*	2.305	.086*	1.201	.372	.648
WEALTH INDEX								
Poorest	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Poorer	1.444	1.080	.764	.902	1.096	.963	.880	.802
Middle	.846	1.319	.474**	1.019	1.143	.742	1.033	.707
Richer	.797	.994	.488*	.896	.847	.527*	.561*	.640
Richest	.359*	.525	.172**	.683	.540*	.327**	.433*	.461*

<0.01 = 1% level ** , 0.01 – 0.05 = 5% level*