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Effect of Socio-economic and Demographic Factors on Nutritional Status of Indian Post-adolescent Teenagers: A Set Theoretic Approach

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ABSTRACT The aim of the present study is to assess the effect of socio-economic and demographic factors on the nutritional status of teenagers and to look at the gender differentials in the variation of height, weight and BMI in different states as well as zones of India. For this study, the unit level data on 11734 boys and 21807 girls of 15-19 year of age are taken from National Family Health Survey-3 (NFHS-3), which has been conducted during the year 2005-06. Multiple linear regression is used in this study. In this paper, the researchers have devised a novel approach to find the individual contribution of the explanatory variables towards explaining the percentage variations of the response variables. The regression results show that the effect of almost all the selected socio-economic and demographic variables are significant on the nutritional status of Indian teenagers. Height, Weight and BMI are positively related with age. These results suggest that parents' education and family wealth index are most important predictors for teenagers' nutritional status of both genders.

INTRODUCTION

India is a subcontinent with diverse climatic zones and a variety of ethnic groups. Before British rule that is, in the pre-colonial period, there were many large, medium, and small kingdoms and provinces. However, the administrative features were similar. A rigid caste hierarchy is one of the empirical features of this country. Many of the 'Scheduled Castes' (SC) used to be regarded as untouchables. Although unsociability has been abolished by law (Singh 1999), it still exists and is practiced among Hindu upper caste like Brahmin, particularly in rural areas (Mohanty 2016; Adak et al. 2006). It is to be noted that there exist considerable differences among the Indian states in terms of socio-economic indicators like per capita income, population below poverty line in rural areas, literacy rates, percentage share of rural population and percentage share of tribal populations.

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 regulated by genetic factor 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 on height and weight data in the age group of 15-19 years.

Rural children exhibit a wide spectrum of undernutrition in the pre-school and pre-pubertal period. The nutritional scenario of the developing countries has been altering radically during

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the past two decades experiencing the double burden of malnutrition due to change in socio-economic and demographic factors, dietary habits, lifestyle modifications and increasing risk of non-communicable diseases (Mondal et al. 2015; Rengma et al. 2015). Thus children entering adolescence with differing nutritional status are likely to differ greatly in their adolescent growth performance, resulting in the large variations among individuals of post-adolescent teenagers.

Boys and girls gain height and weight rapidly during their teenage period. Since growth is not uniform over all teenagers, the variation is observed especially among the teenagers of 15-19 years of age groups. Variation of height and weight is different among male and female groups, which is mainly due to the differences in the nutritional status. Age-sex specific prevalence of stunting was found to be higher among boys than girls of age 14-18 years (Rengma et al. 2016). A significant difference is observed in heights and weights of the adolescent children belonging to the different income families (Haboubi and Shaikh 2009; De 2017). Period of adolescence is considered as a vulnerable period in human life cycle because nutritional requirements increase due to the adolescent growth spurt. The period of adolescence is considered to be a nutritionally vulnerable period of life for several reasons. First, it is the period of a high demand for nutrients because of the dramatic physical growth and development during this period. Second, it is the period of transition of lifestyle and food habits (Spear 2002). This period is characterized by rapid increase in height, weight and hormonal changes resulting in sexual maturation (Gupta 1990; Soliman et al. 2014). Kanade et al. (1999) have shown that adult size and variations in adolescent growth parameters are affected by nutritional deprivation. The phenomenon of early biological maturation has been studied along with other socio-economical influences to indicate the trend of growth among adolescent by Chugh and Puri (2001), Ramachandran et al. (2002), Khanna and Kapoor (2004) and Vaida (2012). Adolescence, being one of the nutritional stress periods of life with profound growth, comes with increased demands of energy, protein, minerals and vitamins (Swiny and Sinha 2016; Gopalan et al. 2001). Recently, growth and nutritional status of Bengali adolescent girls have been assessed by Banerjee et al. (2009) using 15 standard anthropometric parameters. They have also compared it with the studies made on the similar groups within India and abroad.

Both height and weight are the reflections of an individual's nutritional status. Short height reflects chronic malnutrition (that is, a long term phenomenon), whereas underweight, which is measured through BMI, is considered as temporary malnutrition and can be regained through dietary intake. 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 Baten 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.

From the above discussions it follows that environmental factors especially the socio-economic status (SES) of the households, apart from genetic factors, determine height, weight and BMI. The background variables, that is, the place of residence, education, wealth index and caste/religion are part of it. Thus it is interesting to find the individual contribution of these variables. An attempt towards finding these contributions has been made in this paper.

The present study is thus an attempt to see the variation of growth and nutrition status of males and females in the age group of 15-19 years in different states and zones of India and to see the overall and individual contributions of socio-economic factors on the variations in height, weight and BMI.

METHODOLOGY

A wealth of large data sets on health and related items are available with the International Institute for Population Sciences (IIPS), India for analysis. They, in collaboration with the Ministry of Health and Family Welfare, conduct National Family Health Surveys (NFHS) at regular intervals of time. The third NFHS (NFHS-3) was conducted during the year 2005-06. It was a nationwide cross section survey which gathered information on people's socio-economic, demo-

graphic, anthropometric and other characteristics along with other relevant information, including weight and height of people with different ages. In this study, the researchers have used the unit level data on height and weight of 15-19 year-old boys and girls. Sample size for their study is 33541 (boys: 11734; girls: 21807). Height was measured in centimeter and BMI was measured by the ratio of weight to the square of height (kg/m^2). The other covariates are 'place of residence' grouped as rural and urban and 'religion and ethnicity' like Muslim, Christian ST and non-ST, Hindu SC, ST, Hindu other and other religion category. To measure economic status, the data uses Wealth Index, which is based on the 33 assets and housing characteristics like electric fan, television, telephone, computer, car, sources of drinking water, types of toilet facility, etc.

To establish strong relationship between dependent and independent variables linear regression analysis is performed. Height, weight and BMI have been considered as dependent variable and socio-economic variables are taken as independent variables. For linear regression analysis, independent variables are taken as binary and dependent variable as continuous. For residence pattern, rural is taken as '0' and urban as '1'. For education, secondary and higher education is taken as '1' and other category that is, non-literate to primary education is considered as '0'. Similarly, for wealth index richest category is taken as'1' and other that is, poorest to richer as '0'. For caste and religion Hindu SC, ST and Muslim are considered as '0'and Hindu other, Christian ST and non-ST and other religion group are considered as '1'.

To see the contribution of the explanatory variables, that is, Place of Residence, Education, Wealth Index and Caste/Religion to height, weight and BMI, the researchers have devised a novel approach. It is well known that it is not possible to find the individual contribution of the explanatory variables unless the variables are independent. Since the variables are dependent, a portion common to both explain the variability of the responses. It is possible to find out how much these variables explain apart from these common portions. This can be explained by taking two explanatory variables, A and B, say. Let P(A) be the proportion of variability of y, the response variable, explained by the explanatory variable A. This can be found by regressing y on A and finding coefficient of determination of this regression. For a single explanatory variable, it is nothing but the square of the correlation coefficient between y and A. Let $P(A\cup B)$ be the proportion of variability of y explained by the explanatory variables A and B. This can be found by regressing y on A and B and finding coefficient of determination of this regression. It is nothing but the square of the corresponding multiple correlation coefficient. The common part of A and B which explains y is denoted by $P(A\cap B)$ or simply P(AB). This can be determined in a two-regressor set up from the following identity.

$$P(A\cup B) = P(A) + P(B) - P(AB)$$

In a three-regressor set up with explanatory variables A, B and C the researchers can similarly define $P(A\cup B\cup C)$, P(ABC) and so on. The identity used for the three-regressor case is

$$P(A\cup B\cup C) = P(A) + P(B) + P(C) - P(AB) - P(BC) - P(AC) + P(ABC).$$

In this case the researchers shall get the contributions $P(A\cup B\cup C)$, $P(A\cup B)$, $P(B\cup C)$, $P(A\cup C)$, P(A), P(B) and P(A) from regression results. Other contributions can be computed from the above identities. There is an equivalent way of expressing the contributions. The researchers can get, $P(A\bar{B}\bar{C})$, $P(\bar{A}B\bar{C})$, $P(\bar{A}\bar{B}C)$, $P(\bar{A}BC)$, $P(A\bar{B}C)$, $P(\bar{A}\bar{B}C)$ and $P(\bar{A}\bar{B}\bar{C})$ where P(ABC) is the proportion explained by the common portion of A and B but not common to C, and so on. The researchers can use the usual set theoretic identities to get these values. Example,

$$P(A) = P(A\bar{B}\bar{C}) + P(A\bar{B}C) + P(AB\bar{C}) + P(ABC)$$

$$P(AB) = P(ABC) + P(AB\bar{C}), \text{ and so on.}$$

Thus the proportion explained by only A is $P(A\bar{B}\bar{C})$, only B is $P(\bar{A}B\bar{C})$, and only C is $P(\bar{A}\bar{B}C)$. It may so happen that these quantities are negligible, because the proportion explained by common portions are more. $P(\bar{A}\bar{B}\bar{C})$ is the proportion which is not explained by any of these variables, A, B or C. Thus it is $1 - P(A\cup B\cup C)$.

This can be extended to any number of regressors. Thus it takes help of set theoretic results. In general by regressing the researchers can find P(A), $P(A\cup B)$, $P(B\cup C)$, $P(A\cup C)$, P(AUBUC), etc. by regression and hence find others. In a k-regressor set up with regressors $x_1, x_2, \ldots, x_k$, the researchers regress y on all the variables and get $R^2_{1,2,\ldots,k}$, the coefficient of determination, which is the proportion variability of y explained by $x_1, x_2, \ldots, x_k$. Then the researchers take k-1 regressors. The researchers regress y on the k-1 regressors for each subset and get corresponding R^2 values. The researchers then take subsets of k-2 regressors and so on.

With this background the researchers can now device a method of finding out the contributions of A, B and C. Either the researchers take the contributions of A, B and C using

$$C(A) = \frac{P(A)}{P(A) + P(B) + P(C)} \times P(A \cup B \cup C)$$

$$C(B) = \frac{P(B)}{P(A) + P(B) + P(C)} \times P(A \cup B \cup C) \text{ and}$$

$$C(C) = \frac{P(C)}{P(A) + P(B) + P(C)} \times P(A \cup B \cup C)$$

$$C^*(A) = \frac{P(\bar{A}\bar{B}C)}{P(\bar{A}\bar{B}C) + P(\bar{A}B\bar{C}) + P(A\bar{B}\bar{C})} \times P(A \cup B \cup C)$$

$$C^*(B) = \frac{P(\bar{A}\bar{B}C)}{P(\bar{A}\bar{B}C) + P(\bar{A}B\bar{C}) + P(A\bar{B}\bar{C})} \times P(A \cup B \cup C) \text{ and}$$

$$C^*(C) = \frac{P(\bar{A}\bar{B}C)}{P(\bar{A}\bar{B}C) + P(\bar{A}B\bar{C}) + P(A\bar{B}\bar{C})} \times P(A \cup B \cup C)$$

These definitions are consistent with the regression set up since the total variability explained by A, B and C is $P(A \cup B \cup C)$ which is the R^2 found by regressing y on A, B and C. The researchers recommend using the former definition, that is, C(A), C(B) and C(C), since it takes care of contribution of the explanatory variable A, say, singly and also with other explanatory variables B and C, say.

RESULTS

Mean and SD of height for teenagers (15-19 years) males and females is furnished in Table 1 for different states and zones of India. Among males the highest mean is seen in Punjab and the lowest is observed in Meghalaya. An increasing trend in height is perceptible in all the ages of teen male. However, in some cases it is seen that mean height is lower than the previous year. Mean height of the teen females is similar to but lower than those of males in the states of India. The results also show the same trend in the mean height that is, higher in Punjab and lower in Meghalaya, and also have an increasing pattern over ages during teenage period.

Mean weight of male and female teenagers is shown in Table 2. The mean weight has an upward trend over ages. The maximum mean weight is found to be in Punjab at the age of 19 years. The highest average weight, among females, is however captured by Mizoram at the age of 16 years. If the researchers take the highest weight for each age, Punjab takes the lion's share followed by Sikkim, Mizoram and Kerala. Low levels of mean weight in kg are found in Meghalaya (Male 43.26, Female 41.81), Chhattisgarh (Male 43.61, Female 41.57), Karnataka (Male 43.80, Female 41.80), Maharashtra (Male 43.91) and Gujarat (Female 41.63) at 15 years.

Table 3 shows the mean BMI of male and female in the states of India. This value is higher in teen females than in teen males. BMI is high in the North East states except for Tripura and Assam among the teenagers. Besides the North East states, BMI is also high in most of the North Indian states. It is also found from the Table that BMI is higher than national average only in North East zones. BMI is low among the teenaged males in Chhattisgarh, Rajasthan, Karnataka and Bihar states. Among females also northeast zone tops the list. Besides north- east zone, the high BMI is found among the teenaged females of Kerala and Delhi. BMI is low for the states Himachal Pradesh, Bihar, Jharkhand, Chhattisgarh, Gujarat, Maharashtra, Goa and Karnataka among the teenagers.

Table 4 shows the results of linear regression of height, weight and BMI on social, economic and demographic variables of the teen males and females in each of the zones separately. Regression analysis shows significant coefficients for almost all the socio-economic variables. Wealth index and Education have significant positive effect on the height, weight and BMI values among the teenagers both for males and females. As age increases, the height, weight and BMI also increase. The general Hindus, Christian and other religions have higher influence on these variables. The rural-urban differences show negative effect for some zones, that is, rural values are higher than the urban values.

To see how much the explanatory variables contribute to the explanation of the response variable only three important variables are taken as an illustration. Once the researchers take the three variables wealth index (x_1), age (x_2) and Religion-Caste (x_3), the effects of other variables become negligible. Respective contributions are given in the Table 5. From the table it is clear that contribution of the variables is more in male babies than in female babies. Wealth index contribute most of these variability, then comes age and religion-caste respectively.

Table 1: Zone and state-wise mean height of male and female teenagers in India

State	*15 years*		*16 years*		*17 years*		*18 years*		*19 years*		*15-19 years*	
	Male, mean (SD)	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, Mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*
North Zone	**163.38 (7.77)**	**153.5 (5.95)**	**164.6 (7.74)**	**153.89 (6.1)**	**166.15 (7.32)**	**154.16 (5.74)**	**166.54 (7.33)**	**154.03 (5.84)**	**166.75 (7.08)**	**154.52 (5.75)**	**165.45 (7.57)**	**154.01 (5.89)**
Jammu Kashmir	163.03 (8.13)	154.64 (6.25)	163.03 (8.37)	153.63 (5.41)	167.19 (7.75)	154.09 (5.86)	168.45 (6.82)	154.38 (6.45)	167.26 (6.65)	155.03 (5.54)	165.64 (7.89)	154.3 (5.85)
Himachal Pradesh	162.23 (7.94)	153.67 (5.62)	163.76 (6.6)	153.35 (5.47)	164.76 (7.81)	155.22 (5.77)	167.98 (7.53)	153.8 (5.51)	167.68 (6.78)	154.47 (5.8)	165.28 (7.6)	154.08 (5.64)
Punjab	166.3 (6.41)	154.33 (5.25)	165.38 (9.86)	155.08 (6.42)	168.5 (8.19)	154.5 (5.6)	168.33 (6.54)	155 (6.03)	168.2 (6.51)	155.3 (5.83)	167.33 (7.76)	154.86 (5.85)
Uttaranchal	162.12 (10.85)	151.97 (5.96)	163.37 (6.55)	152.83 (5.74)	164.73 (6.9)	153.42 (5.8)	164.53 (6.71)	152.88 (5.23)	164.12 (7.71)	152.83 (5.08)	163.73 (7.71)	152.83 (5.56)
Haryana	164.97 (7.47)	153.72 (5.94)	166.96 (6.32)	154.32 (5.57)	166.97 (6.5)	154.95 (5.35)	169.01 (6.92)	154.1 (4.99)	168.43 (7.12)	156.61 (5.1)	167.18 (6.88)	154.67 (5.46)
Delhi	161.75 (7.58)	151.41 (6.56)	163.38 (9.56)	152.94 (7.51)	165.3 (6.3)	153.17 (5.65)	162.26 (6.87)	153.06 (6.75)	165.31 (7.72)	151.84 (6.26)	163.53 (7.69)	152.53 (6.58)
Rajasthan	162.83 (6.42)	154.16 (5.9)	165 (6.56)	154.62 (6.23)	165.07 (6.9)	153.88 (5.96)	166.41 (7.45)	154.79 (5.96)	166.28 (6.82)	155 (5.48)	165 (6.91)	154.47 (5.92)
North-east Zone	**158.46 (7.73)**	**149.65 (5.87)**	**160 (7.35)**	**150.84 (5.74)**	**162.03 (7.03)**	**150.61 (6.02)**	**161.46 (6.44)**	**150.69 (5.49)**	**162.11 (6.69)**	**151.28 (5.42)**	**160.84 (7.16)**	**150.6 (5.73)**
Sikkim	155.48 (8.31)	149.07 (5.42)	159.61 (8.77)	150.53 (5.34)	160.14 (8.86)	150.29 (8.07)	160.2 (9.06)	150.26 (6.56)	158.7 (7.12)	150.95 (4.95)	158.85 (8.54)	150.19 **(6.07)**
Arunachal Pradesh	159.1 (7.85)	149.31 (5.69)	158.92 (7.18)	150.35 (6.12)	159.88 (7.63)	149.37 (5.37)	162.59 (6.46)	150.44 (5.35)	161.01 (5.35)	149.73 (4.86)	160.36 (6.95)	149.91 (5.56)
Nagaland	158.58 (7.76)	151.22 (5.04)	159.5 (6.89)	152.47 (5.02)	162.22 (6.64)	151.81 (4.79)	161.07 (6.28)	151.6 (5.05)	161.69 (6.17)	152.94 (5.72)	160.66 (6.83)	152 (5.14)
Manipur	160.22 (6.25)	151.49 (5.67)	161.85 (6.51)	151.86 (5.6)	163.07 (5.52)	151.63 (5.2)	162.75 (5.09)	151.99 (5.04)	163.88 (5.81)	152.29 (5)	162.41 (5.95)	151.88 (5.28)
Mizoram	158.51 (8.69)	149.84 (5.58)	159.66 (7.32)	152.28 (4.6)	163.29 (7.03)	150.87 (5.21)	159.48 (6.34)	152.32 (4.46)	162.23 (7.27)	151.35 (6.02)	160.42 (7.39)	151.32 (5.25)
Tripura	158.59 (5.5)	149.15 (5.69)	162.03 (7.19)	149.08 (5.7)	161.58 (5.02)	150.59 (6.1)	160.59 (5.55)	149.24 (5.12)	163.24 (6.58)	149.61 (5.41)	161.02 (6.2)	149.47 (5.61)
Meghalaya	150.6 (9.6)	145.35 (6.53)	155.07 (8.44)	146.84 (6.23)	154.66 (9.39)	147.94 (7.09)	157.78 (7.63)	147.41 (5.16)	156.82 (8.11)	148.73 (4.86)	155.21 (8.76)	147.27 (6.12)
Assam	161.68 (5.24)	149.68 **(6.03)**	160.98 (7.75)	150.94 (5.55)	164.9 (6.42)	151.26 (5.63)	164.3 (6.46)	151.32 (5.56)	166.94 (6.41)	151.54 (5.26)	163.66 (6.81)	150.95 (5.63)
East Zone	**160.28 (7.40)**	**149.79 (5.34)**	**162.97 (7.31)**	**150.58 (5.54)**	**163.9 (7.05)**	**150.41 (5.48)**	**163.27 (5.93)**	**150.28 (5.67)**	**164.49 (6.5)**	**150.58 (5.87)**	**162.92 (6.99)**	**150.32 (5.58)**
Bihar	160.96 (8.02)	149.56 **(5.2)**	164.28 (7.68)	150.74 (6.16)	165.01 (7.27)	149.91 (5.18)	162.66 (6.02)	150.17 (5.57)	164.64 (5.89)	149.53 (5.48)	163.44 (7.11)	150.01 (5.54)

Table 1: Contd....

State	*15 years*		*16 years*		*17 years*		*18 years*		*19 years*		*15-19 years*	
	Male, mean (SD)	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, Mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*
West Bengal	161.03 (7.54)	150.25 (4.85	163.03 (6.39)	150.62 (5.26)	163.29 (6.72)	150.83 (5.62)	162.79 (5.4)	150.53 (5.52)	165 (6.97)	150.97 (5.86)	162.99 (6.65)	150.63 (5.43)
Jharkhand	158.89 (7.76)	149.22 (5.89)	162.75 (8.17)	149.88 (5.62)	162.71 (7.14)	149.32 (5.94)	164.75 (6.97)	149.42 (5.8)	163.35 (6.05)	150.16 (5.69)	162.44 (7.57)	149.59 (5.78)
Orissa	159.89 (6.32)	149.95 **(5.64)**	161.7 (7.4)	150.94 (5.14)	164.36 (7.16)	151.23 (5.02)	163.63 (5.4)	150.76 (5.85)	164.29 (6.69)	151.28 (6.23)	162.67 (6.87)	150.82 (5.6)
Central Zone	**161.08 (8.15)**	**151.12 (5.67)**	**162.77 (6.99)**	**151.52 (5.54)**	**164.5 (7.46)**	**151.57 (5.77)**	**164.97 (6.79)**	**151.72 (5.86)**	**165.27 (6.85)**	**152.06 (5.8)**	**163.65 (7.41)**	**151.58 (5.73)**
Uttar Pradesh	161.09 (8.1)	150.93 **(5.71)**	162.88 (6.98)	150.97 (5.47)	164.46 (7.42)	151.04 (5.67)	165.01 (6.7)	151.53 (5.91)	165.41 (6.84)	151.25 (5.68)	163.69 (7.38)	151.13 (5.68)
Chhattisgarh	159.43 (8.43)	150.47 (5.84)	161.22 (6.9)	152.09 (5.54)	165.03 (7.33)	151.85 (5.99)	164.87 (6.78)	151 (6.06)	164.47 (7.26)	152.96 (5.71)	162.79 (7.61)	151.66 (5.88)
Madhya Pradesh	162.07 (8.2)	151.92 (5.43)	163.16 (7.03)	152.54 (5.53)	164.44 (7.77)	152.66 (5.7 2)	164.83 (7.23)	152.58 (5.54)	165.04 (6.73)	152.96 (5.9)	163.95 (7.44)	152.52 (5.62)
West Zone	**160.36 (8.34)**	**152.17 (5.98)**	**163.52 (7.35)**	**152.45 (5.79)**	**164.56 (7.01)**	**152.8 (6.05)**	**166.1 (6.71)**	**153.01 (6.1)**	**165.81 (7.94)**	**153.32 (6.28)**	**164.14 (7.73)**	**152.77 (6.06)**
Gujarat	160.52 (8.59)	152.19 (5.4)	163.91 (8.15)	152.77 (5.72)	163.84 (7.76)	154 (5.13)	164.94 (6.35)	153.42 (4.95)	167.74 (8.8)	153.1 (5.84)	164.16 (8.23)	153.11 (5.45)
Maharashtra	160.33 (8.38)	152.09 (6.28)	163.7 (7.21)	152.04 (5.86)	164.55 (6.91)	152.48 (6.26)	166.47 (6.7)	152.89 (6.52)	165.61 (7.78)	153.64 (6.49)	164.22 (7.66)	152.65 (6.32)
Goa	160.32 (7.81)	152.51 (5.6)	161.1 (7.27)	153.5 (5.55)	166.86 (6.9)	151.99 (6.4)	164.19 (7.18)	152.74 (6.2)	164.63 (7.88)	152.61 (6.23)	163.27 (7.6)	152.66 (6.02)
South Zone	**160.61 (8.14)**	**152.9 (5.84)**	**163.31 (7.9)**	**152.93 (6.17)**	**165.37 (6.81)**	**153.17 (5.85)**	**166.02 (7.2)**	**153.04 (6.16)**	**166.52 (7.05)**	**152.91 (6.18)**	**164.62 (7.66)**	**152.99 (6.06)**
Andhra Pradesh	162.16 (7.6)	152.21 (5.42)	164.21 (7.27)	152.25 (6.08)	165.81 (6.51)	153.05 (5.73)	166.9 (7.28)	152.95 (6.19)	167.22 (6.69)	152.82 (6.52)	165.52 (7.24)	152.67 (6.03)
Karnataka	159.71 (8.56)	152.51 (6)	161.87 (8.98)	152.4 (6.47)	164.13 (7.42)	153.15 (5.75)	165.23 (6.46)	153.11 (6.05)	165.14 (7.48)	152.5 (6.12)	163.37 (8.02)	152.77 (6.08)
Kerala	161.59 (8.28)	154.2 (6.63)	163.71 (7.6)	154.74 (5.78)	168.33 (5.89)	153.14 (6.27)	167.26 (6.68)	153.42 (5.91)	169.24 (6.89)	153.75 (5.58)	166.5 (7.35)	153.88 (6.01)
Tamil Nadu	159.53 (8.09)	153.79 (5.62)	163.28 (7.61)	153.46 (5.94)	165.29 (6.57)	153.39 (5.94)	165.35 (7.67)	152.93 (6.42)	166.46 (6.96)	153 (6.14)	164.22 (7.72)	153.26 (6.05)
All India	**160.67 (8.1)**	**151.4 (5.95)**	**162.77 (7.54)**	**151.99 (5.92)**	**164.46 (7.22)**	**152.1 (5.97)**	**164.77 (7.04)**	**152.08 (6)**	**165.22 (7.22)**	**152.44 (6.01)**	**163.61 (7.59)**	**152 (5.98)**

Table 2: Zone and state-wise mean weight of male and female teenagers in India

State	*15 years*		*16 years*		*17 years*		*18 years*		*19 years*		*15-19 years*	
	Male, mean (SD)	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, Mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*
North Zone	**48.36**	**43.65**	**49.62**	**45.05**	**51.59**	**45.74**	**53.27**	**46.67**	**54.57**	**47.38**	**51.37**	**45.69**
	(8.68)	**(6.79)**	(8.56)	**(7.16)**	**(8.23)**	**(6.68)**	(7.95)	**(7.49)**	(8.33)	**(7.39)**	(8.63)	**(7.23)**
Jammu Kashmir	47.26	44.71	47.71	45.28	52.18	47.2	53.99	46.9	53.76	46.63	50.77	46.14
	(8.16)	(7.01)	(8.25)	(8.28)	(8.75)	(7)	(7.84)	(7.01)	(7.18)	(7.87)	(8.5)	(7.54)
Himachal Pradesh	47.58	43.45	47.17	44	51.04	45.31	52.28	44.49	53.08	45.45	50.26	44.52
	(10.3)	(8.28)	(6.57)	(7.07)	(10.28)	(6.73)	(7.03)	(6.93)	(6.48)	(6.6)	(8.64)	(7.15)
Punjab	52.95	45.36	51.39	46.42	55.02	46.09	55.76	48.35	58.03	49.3	54.59	47.13
	(9.26)	(6.93)	(10.88)	(7.96)	(9)	(6.94)	(9.21)	(7.71)	(11.29)	(7.96)	(10.2)	(7.65)
Uttaranchal	46.78	42.35	47.25	43.76	50.89	45.41	52.26	47.14	52.79	46.52	49.63	45.15
	(8.75)	(6.58)	(6.25)	(5.79)	(5.25)	(7.52)	(6.33)	(8.65)	(6.35)	(6.63)	(7.03)	(7.35)
Haryana	50.07	43.59	52.01	45.24	51.17	45.26	53.84	46.61	56.66	48.86	52.3	45.85
	(8.81)	(6.12)	(10)	(6.49)	(8.69)	(6.31)	(7.58)	(7.43)	(10.19)	(8)	(9.11)	(7.07)
Delhi	49.37	43.43	53.05	46.45	52.34	46.82	52.93	46.68	54.96	47.19	52.65	46.15
	(8.52)	(6.64)	(8.77)	(7.4)	(5.95)	(6.5)	(9.05)	(8.2)	(7.1)	(7.21)	(8.17)	(7.35)
Rajasthan	45.59	43.23	48.77	44.67	48.43	45.09	51.95	46.52	52.36	47.01	49.21	45.22
	(6.07)	(6.18)	(6.47)	(7.1)	(6.06)	(5.77)	(7.29)	(6.21)	(6.74)	(6.87)	(6.98)	(6.52)
North-east Zone	**47.91**	**44.39**	**49.28**	**45.52**	**51.25**	**46**	**52.26**	**46.07**	**52.92**	**46.77**	**50.78**	**45.73**
	(8.08)	**(6.55)**	(7.12)	**(6.05)**	(6.53)	**(6.22)**	(6.54)	**(6.18)**	(6.32)	**(6.3)**	(7.16)	**(6.3)**
Sikkim	48.31	46.12	51.09	46.06	51.21	47.8	53.13	47.06	53.35	47.06	51.34	46.74
	(7.06)	(6.26)	(6.82)	(5.69)	(7.34)	(5.01)	(8.53)	(6.9)	(6.07)	(5.69)	(7.32)	(5.99)
Arunachal Pradesh	47.23	45.18	51.1	45.19	51.73	45.51	53.18	46.56	51.24	46.93	51.02	45.8
	(5.68)	(6.55)	(5.38)	(6.44)	(5.11)	(5.96)	(5.18)	(5.83)	(5.45)	(5.16)	(5.63)	(6.08)
Nagaland	48.25	44.99	48.61	46.27	50.84	46.37	52.58	46.99	52.89	46.86	50.79	46.3
	(8.07)	(5.62)	(6.66)	(5.11)	(6.03)	(5.68)	(6.12)	(5.45)	(6.04)	(5.61)	(6.82)	(5.5)
Manipur	48.63	45.46	50.31	46.89	52.3	46.89	53.01	46.98	53.76	48.4	51.68	47.01
	(9.07)	(5.74)	(8.31)	(6.18)	(5.96)	(5.34)	(6.14)	(6.28)	(5.6)	(6.16)	(7.31)	(6.02)
Mizoram	48.96	46.24	50.36	49.94	52.28	47.47	50.43	47.88	55.4	47.63	51.25	47.74
	(7.43)	(6.25)	(6.8)	(6.42)	(7.86)	(6.17)	(5.33)	(5.64)	(7.89)	(7.16)	(7.16)	(6.38)
Tripura	44.91	42.79	47.7	41.89	46.02	44.79	50.04	43.44	48.89	45.08	47.51	43.47
	(6.62)	(8.6)	(5.51)	(5.34)	(8.13)	(7.81)	(6.77)	(6.68)	(5.85)	(8.1)	(6.63)	(7.56)
Meghalaya	43.26	41.81	46.69	43.99	48.92	45.11	50.47	44.51	50.2	45.36	47.96	44.21
	(7.55)	(4.96)	(6.26)	(5.72)	(7.75)	(5.73)	(9.71)	(5.93)	(5.52)	**(5.13)**	(7.86)	(5.67)
Assam	50.4	42.33	48.54	44.04	52.01	44.08	51.3	44.51	54.66	45.08	51.17	44.01
	(8.03)	(6.12)	(7.65)	(5.79)	(7.14)	(7.51)	(6.31)	(5.93)	(9.75)	(6.69)	(7.74)	(6.42)
East Zone	**45.75**	**41.7**	**48.52**	**42.86**	**49.59**	**43.14**	**49.97**	**43.59**	**52.85**	**44.12**	**49.18**	**43.08**
	(7.67)	**(6.12)**	(7.42)	**(6.05)**	(7.15)	(6.24)	(7.79)	**(6.38)**	(7.9)	**(7.23)**	**(7.87)**	**(6.44)**
Bihar	45.27	41.18	48.39	41.68	49.82	42.48	47.7	43.11	51.97	43.07	48.4	42.28
	(7.74)	(5.81)	(6.23)	(5.68)	(6.47)	(5.48)	(6.21)	(5.83)	(7.36)	(6.24)	(6.95)	(5.84)

Table 2: Contd...

State	*15 years*		*16 years*		*17 years*		*18 years*		*19 years*		*15-19 years*	
	Male, mean (SD)	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, Mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*
West Bengal	47.35 (8.86)	41.96 (6.19)	49.26 (6.69)	43.18 (6.21)	50.32 (7.55)	43.87 (7.16)	49.94 (8.29)	44.45 (7.39)	52.75 (7.31)	45.09 (8.24)	49.86 (7.91)	43.74 (7.15)
Jharkhand	44.52 (5.4)	41.63 (6.46)	47.85 (8.19)	42.53 (5.96)	47.22 (6.37)	41.87 (5.44)	51.97 (8.64)	43.17 (6)	50.03 (3.79)	42.94 (5.57)	48.26 (7.42)	42.45 (5.91)
Orissa	45.18 (7.48)	42.11 (6.16)	48.16 (8.89)	43.95 (6.12)	50.09 (7.63)	43.88 (6.09)	51.69 (7.44)	43.39 (5.85)	55.27 (10.04)	44.62 (7.48)	49.77 (8.91)	43.57 (6.37)
Central Zone	**46.01** (7.8)	**42.5 (6.16)**	**48.2** (7.27)	**43.64 (6.16)**	**50.56** (8.15)	**44.01 (6.43)**	**51.76** (8.11)	**44.75 (6.67)**	**52.92** (8.13)	**45.28 (6.69)**	**49.77** (8.23)	**43.99 (6.48)**
Uttar Pradesh	46.29 (7.73)	42.72 (6.08)	48.56 (7.3)	43.66 (5.95)	50.71 (8.17)	44.17 (6.34)	52.09 (8.4)	45.16 (6.93)	53.48 (8.44)	45.09 (6.55)	50.07 (8.36)	44.1 (6.42)
Chhattisgarh	43.61 (7.84)	41.57 (5.86)	46.09 (6.47)	43.12 (6.05)	48.53 (5.15)	42.74 (5.23)	49.95 (6.64)	43.05 (5.89)	50.64 (7.1)	45.24 (6.01)	47.58 (7.17)	43.14 (5.93)
Madhya Pradesh	45.88 (8.01)	42.62 (6.47)	47.74 (7.38)	43.95 (6.75)	50.65 (8.99)	44.55 (7.27)	51.22 (7.38)	45.06 (6.46)	51.42 (6.61)	45.68 (7.37)	49.47 (7.97)	44.34 (6.92)
West Zone	**44.09** (8.67)	**42.72 (8.04)**	**48.13 (8.97)**	**42.85 (6.95)**	**49.52** (9.19)	**43.9 (7.41)**	**52.59** (9.71)	**44.98 (7.6)**	**52.07** (9.01)	**45.13 (7.79)**	**49.37** (9.61)	**43.97 (7.63)**
Gujarat	44.04 (9.77)	41.63 (7.12)	47.82 (7.37)	42.41 (6.46)	49.82 (8)	44.91 (7.61)	51.71 (8.53)	45.15 (7.01)	52.26 (8.39)	45.35 (7.6)	49.1 (8.93)	43.94 (7.3)
Maharashtra	43.91 (8.44)	43.03 (7.98)	48.27 (9.41)	42.72 (7.13)	49.03 (9.0 4)	43.35 (6.94)	52.84 (9.9)	44.92 (7.56)	51.95 (9.19)	45.36 (7.59)	49.31 (9.72)	43.91 (7.51)
Goa	46.03 (8.87)	43.22 (9.68)	47.07 (6.49)	44.47 (7.12)	54.51 -(11.32)	44.56 (8.84)	51.51 (9.78)	44.92 (8.95)	52.97 (8.38)	44.02 (8.7)	50.49 (9.53)	44.24 (8.67)
South Zone	**45.29** (9.51)	**43.48 (7.15)**	**47.46** (9.3)	**44.61 (8.07)**	**50.69** (8.41)	**45.34 (7.62)**	**51.52 (9.55)**	**46.02 (8.15)**	**54.04** (9.03)	**46.21 (8.47)**	**50.09** (9.61)	**45.24 (8)**
Andhra Pradesh	47.51 (9.62)	43.85 (6.94)	48.09 (8.16)	44.94 (8.69)	51.61 (8.92)	45.76 (7.6)	52.32 (9.22)	45.68 (8.31)	55.29 (9.29)	45.48 (7.95)	51.21 (9.4)	45.2 (8.02)
Karnataka	43.8 (9.75)	41.8 (5.58)	46.58 (10.14)	43.02 (6.66)	48.74 (7.31)	44.94 (7.39)	49.42 (7.65)	45.09 (6.82)	52.38 (8.84)	44.81 (7.48)	48.38 (9.15)	44.1 (6.98)
Kerala	44.64 (7.31)	44.81 (6.99)	48.23 (8.63)	47.23 (8.9)	52.19 (7.47)	45.41 (6.64)	52.99 (10.21)	48.14 (8.56)	58.04 (10.76)	48.59 (8.79)	51.59 (9.69)	46.92 (8.19)
Tamil Nadu	44.3 (9.09)	44.18 (8.92)	47.26 (10.15)	44.17 (7.46)	50.87 (8.62)	45.27 (8.49)	52.06 (11.08)	46.88 (9.03)	53.29 (8.22)	47.24 (9.43)	49.89 (10.07)	45.75 (8.8)
All India	**46.2** (8.52)	**43.08 (6.76)**	**48.44** (8.15)	**44.19 (6.8)**	**50.6** (8.09)	**44.74 (6.82)**	**51.94** (8.43)	**45.38 (7.15)**	**53.25** (8.26)	**45.86 (7.39)**	**50.11** (8.64)	**44.66 (7.05)**

Table 3: Zone and state-wise mean BMI of male and female teenagers in India

State	*15 years*		*16 years*		*17 years*		*18 years*		*19 years*		*15-19 years*	
	Male, mean (SD)	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, Mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*
North Zone	**18.05**	**18.5**	**18.26**	**18.99**	**18.65**	**19.24**	**19.2**	**19.67**	**19.58**	**19.83**	**18.72**	**19.25**
	(2.61)	**(2.51)**	**(2.51)**	**(2.57)**	**(2.48)**	**(2.55)**	**(2.56)**	**(2.96)**	**(2.4)**	**(2.85)**	**(2.57)**	**(2.74)**
Jammu Kashmir	17.77	18.67	17.87	19.11	18.62	19.87	18.98	19.7	19.15	19.38	18.44	19.35
	(2.85)	(2.5)	**(2.26)**	**(2.72)**	**(2.66)**	**(2.68)**	**(2.1)**	(2.84)	**(1.75)**	(2.97)	**(2.41)**	**(2.77)**
Himachal Pradesh	18.03	18.34	17.55	18.67	18.68	18.81	18.49	18.83	18.9	19.02	18.34	18.73
	(3.36)	(3.03)	**(1.84)**	(2.54)	**(2.77)**	(2.64)	**(2)**	(2.9)	**(2.25)**	(2.3)	**(2.52)**	**(2.7)**
Punjab	19.06	19.04	18.65	19.28	19.36	19.29	19.7	20.11	20.41	20.42	19.42	19.64
	(2.56)	(2.65)	**(2.84)**	(2.88)	**(2.87)**	(2.61)	**(3.3)**	(2.87)	**(3.14)**	**(3.02)**	**(3)**	**(2.86)**
Uttaranchal	17.67	18.3	17.67	18.71	18.78	19.26	19.32	20.13	19.61	19.92	18.48	19.3
	(1.92)	(2.39)	**(1.8)**	**(2.03)**	**(1.82)**	**(2.64)**	**(2.13)**	(3.23)	**(2.15)**	(2.75)	**(2.09)**	**(2.73)**
Haryana	18.28	18.44	18.59	18.98	18.34	18.84	18.87	19.62	19.85	19.89	18.66	19.15
	(2.23)	(2.35)	**(3.03)**	(2.36)	**(2.85)**	**(2.39)**	**(2.6)**	(3.07)	**(2.62)**	**(2.91)**	**(2.72)**	**(2.68)**
Delhi	18.86	18.95	19.91	19.84	19.15	19.97	20.05	19.92	20.09	20.47	19.67	19.83
	(3.06)	(2.65)	**(2.99)**	**(2.65)**	**(1.88)**	(2.58)	**(2.81)**	**(3.18)**	**(1.96)**	(2.97)	**(2.62)**	**(2.86)**
Rajasthan	17.18	18.16	17.91	18.67	17.74	19.05	18.73	19.44	18.91	19.58	18.04	18.95
	(2.02)	(2.16)	**(2.03)**	(2.69)	**(1.61)**	(2.28)	**(2.1)**	(2.57)	**(2.03)**	**(2.8)**	**(2.07)**	**(2.54)**
North-east Zone	**19.02**	**19.8**	**19.22**	**19.98**	**19.52**	**20.28**	**20.04**	**20.26**	**20.15**	**20.42**	**19.61**	**20.14**
	(2.49)	(2.52)	**(2.25)**	**(2.21)**	**(2.2)**	**(2.55)**	**(2.25)**	**(2.29)**	**(2.16)**	**(2.42)**	**(2.31)**	**(2.4)**
Sikkim	19.98	20.75	20.1	20.33	20.03	21.32	20.73	20.84	21.23	20.65	20.38	20.75
	(2.49)	**(2.55)**	(2.64)	**(2.26)**	(2.78)	(3.21)	**(3.11)**	**(2.74)**	**(2.35)**	(2.33)	**(2.69)**	**(2.62)**
Arunachal Pradesh	18.64	20.22	20.24	19.93	20.27	20.36	20.12	20.54	19.77	20.97	19.84	20.35
	(1.58)	**(2.3)**	**(1.77)**	**(2.12)**	**(1.84)**	**(2.11)**	(1.63)	(2.07)	**(1.98)**	**(2.5)**	**(1.83)**	**(2.22)**
Nagaland	19.12	19.66	19.06	19.91	19.31	20.11	20.25	20.42	20.26	20.04	19.65	20.03
	(2.34)	**(2.14)**	**(1.92)**	**(2.04)**	**(1.95)**	**(2.19)**	**(2.02)**	**(1.92)**	(2.28)	**(2.22)**	**(2.16)**	**(2.1)**
Manipur	18.92	19.81	19.18	20.31	19.65	20.4	19.99	20.31	20.02	20.84	19.57	20.36
	(3.09)	**(2.28)**	**(2.67)**	**(2.29)**	**(1.92)**	**(2.16)**	**(1.95)**	**(2.34)**	**(1.8)**	**(2.21)**	**(2.35)**	(2.27)
Mizoram	19.41	20.54	19.71	21.49	19.52	20.81	19.85	20.63	20.99	20.75	19.86	20.81
	(1.98)	**(2.05)**	**(1.93)**	**(2.11)**	**(1.94)**	**(2.05)**	(2.12)	(2.2)	**(2.06)**	**(2.46)**	**(2.04)**	**(2.19)**
Tripura	17.79	19.2	18.18	18.83	17.57	19.71	19.37	19.46	18.36	20.1	18.3	19.42
	(1.89)	**(3.45)**	**(1.97)**	**(2.03)**	**(2.41)**	(2.9)	**(2.16)**	**(2.48)**	**(1.97)**	**(3.11)**	**(2.11)**	**(2.91)**
Meghalaya	18.97	19.8	19.42	20.37	20.46	20.61	20.29	20.43	20.39	20.48	19.88	20.36
	(1.95)	**(2.01)**	**(2.2)**	**(1.92)**	**(2.88)**	**(2.17)**	**(3.83)**	**(2.05)**	**(1.53)**	**(1.87)**	**(2.66)**	**(2.03)**
Assam	19.23	18.88	18.66	19.32	19.15	19.26	19	19.43	19.58	19.61	19.08	19.3
	(2.49)	**(2.32)**	**(2.13)**	**(2.21)**	**(2.62)**	**(3.12)**	(2.12)	**(2.32)**	**(3.01)**	**(2.67)**	(2.43)	**(2.52)**
East Zone	**17.73**	**18.56**	**18.23**	**18.88**	**18.42**	**19.04**	**18.69**	**19.28**	**19.51**	**19.42**	**18.47**	**19.04**
	(2.14)	**(2.36)**	**(2.21)**	**(2.31)**	**(2.03)**	**(2.33)**	**(2.32)**	**(2.5)**	**(2.48)**	**(2.67)**	**(2.3)**	**(2.45)**
Bihar	17.39	18.39	17.89	18.33	18.27	18.89	18.01	19.11	19.17	19.25	18.08	18.78
	(2.1)	(2.23)	**(1.56)**	**(2.13)**	**(1.82)**	**(2.17)**	**(2)**	**(2.31)**	**(2.52)**	**(2.45)**	**(2.02)**	**(2.28)**

Table 3: Contd...

State	*15 years*		*16 years*		*17 years*		*18 years*		*19 years*		*15-19 years*	
	Male, mean (SD)	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, Mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*	*Male, mean (SD)*	*Female, mean (SD)*
West Bengal	18.17 **(2.49)**	18.57 **(2.5)**	18.52 **(2.26)**	19.03 (2.48)	18.84 **(2.25)**	19.25 **(2.71)**	18.78 **(2.49)**	19.59 **(2.91)**	19.37 (2.45)	19.73 **(3.1)**	18.72 **(2.41)**	19.25 (2.78)
Jharkhand	17.6 **(1.42)**	18.65 **(2.32)**	18.02 **(2.31)**	18.9 (2.2)	17.79 **(1.67)**	18.76 **(1.92)**	19.08 **(2.32)**	19.31 **(2.33)**	18.75 **(0.97)**	19.04 **(2.23)**	18.23 **(1.96)**	18.94 **(2.21)**
Orissa	17.59 **(2.17)**	18.71 **(2.39)**	18.35 **(2.62)**	19.26 (2.27)	18.49 **(2.1)**	19.16 **(2.27)**	19.27 **(2.32)**	19.08 **(2.25)**	20.39 **(2.87)**	19.42 **(2.5)**	18.73 **(2.57)**	19.12 (2.34)
Central Zone	**17.64** **(2.01)**	**18.59** **(2.34)**	**18.14** **(2.13)**	**18.99** **(2.34)**	**18.62** **(2.28)**	**19.14** **(2.45)**	**18.99** **(2.51)**	**19.42** **(2.53)**	**19.37** **(2.67)**	**19.57** **(2.57)**	**18.52** **(2.39)**	**19.13** **(2.46)**
Uttar Pradesh	17.74 **(1.95)**	18.73 **(2.23)**	18.24 **(2.08)**	19.13 **(2.19)**	18.68 **(2.23)**	19.34 **(2.43)**	19.09 **(2.57)**	19.65 (2.65)	19.53 **(2.73)**	19.69 (2.49)	18.61 **(2.39)**	19.29 **(2.42)**
Chhattisgarh	17.08 **(2.29)**	18.36 **(2.35)**	17.69 **(1.9)**	18.61 **(2.12)**	17.79 **(1.24)**	18.52 **(1.9)**	18.33 **(1.74)**	18.85 **(2.08)**	18.7 **(2.21)**	19.34 (2.38)	17.9 **(1.98)**	18.73 **(2.19)**
Madhya Pradesh	17.39 **(2.13)**	18.46 (2.54)	17.92 **(2.47)**	18.9 (2.79)	18.71 **(2.75)**	19.1 (2.77)	18.86 **(2.53)**	19.35 **(2.49)**	18.92 **(2.55)**	19.51 **(2.82)**	18.39 **(2.56)**	19.05 **(2.7)**
West Zone	**17.05** **(2.57)**	**18.43** **(3.16)**	**17.92** **(2.64)**	**18.42** **(2.67)**	**18.22** **(2.74)**	**18.8** **(2.98)**	**19.03** **(3.13)**	**19.18** **(2.82)**	**18.92** **(2.76)**	**19.18** **(2.94)**	**18.25** **(2.87)**	**18.82** **(2.93)**
Gujarat	16.95 **(2.8)**	17.93 (2.72)	17.76 **(2.14)**	18.15 **(2.5)**	18.51 **(2.33)**	18.93 **(3.12)**	19 **(2.81)**	19.18 **(2.86)**	18.55 **(2.41)**	19.34 (2.97)	18.15 **(2.61)**	18.73 **(2.88)**
Maharashtra	16.99 **(2.47)**	18.6 **(3.21)**	17.94 **(2.78)**	18.45 **(2.73)**	18.04 (2.64)	18.64 **(2.81)**	19.02 **(3.08)**	19.18 **(2.79)**	18.91 **(2.82)**	19.2 **(2.82)**	18.2 **(2.86)**	18.83 **(2.89)**
Goa	17.88 **(3.03)**	18.51 **(3.57)**	18.09 **(1.88)**	18.87 **(2.75)**	19.78 **(3.81)**	19.25 **(3.41)**	19.2 **(4.13)**	19.15 **(2.92)**	19.54 **(2.7)**	18.87 **(3.26)**	18.92 **(3.26)**	18.93 **(3.19)**
South zone	**17.44** **(2.79)**	**18.59** **(2.73)**	**17.71** **(2.69)**	**19.04** **(3.02)**	**18.5** **(2.63)**	**19.32** **(3.01)**	**18.62** **(2.77)**	**19.62** **(3.11)**	**19.46** **(2.87)**	**19.74** **(3.31)**	**18.4** **(2.83)**	**19.31** **(3.08)**
Andhra Pradesh	17.99 **(3.02)**	18.94 **(2.88)**	17.78 **(2.43)**	19.34 **(3.24)**	18.74 **(2.86)**	19.54 **(3.09)**	18.7 **(2.52)**	19.5 **(3.13)**	19.75 **(2.96)**	19.46 **(3.11)**	18.63 **(2.82)**	19.37 **(3.11)**
Karnataka	17.02 **(2.72)**	17.97 **(2.13)**	17.66 **(2.89)**	18.52 (2.65)	18.1 **(2.31)**	19.17 (2.99)	18.06 **(2.27)**	19.21 **(2.53)**	19.18 **(2.76)**	19.26 **(2.96)**	18.04 **(2.67)**	18.89 **(2.73)**
Kerala	17.06 **(2.19)**	18.81 **(2.4)**	17.89 **(2.19)**	19.68 (3.18)	18.38 **(2.13)**	19.37 (2.72)	18.93 **(3.24)**	20.43 (3.4)	20.26 **(3.51)**	20.52 **(3.29)**	18.54 **(2.83)**	19.79 (3.09)
Tamil Nadu	17.28 **(2.6)**	18.64 **(3.2)**	17.61 **(2.93)**	18.73 **(2.82)**	18.57 **(2.66)**	19.19 **(3.08)**	18.97 **(3.33)**	20.02 **(3.51)**	19.23 **(2.7)**	20.15 **(3.73)**	18.41 (2.98)	19.45 **(3.37)**
All India	**17.81** **(2.5)**	**18.78** **(2.61)**	**18.23** **(2.45)**	**19.1** **(2.55)**	**18.67** **(2.46)**	**19.33** **(2.67)**	**19.11** **(2.65)**	**19.6** **(2.73)**	**19.49** **(2.63)**	**19.72** **(2.82)**	**18.66** **(2.61)**	**19.31** **(2.7)**

Table 4: The effect of socio-economic and demographic factors on nutritional status of Indian teenagers

Variable	*North zone Coefficients*	*North East zone Coefficients*	*East zone Coefficients*	*Central zone Coefficients*	*West zone Coefficients*	*South zone Coefficients*	*All India Coefficients*
Height							
Male							
Intercept	145.65**	143.55**	145.07**	142.07**	137.08**	137.50**	141.05**
Residence	-1.62**	0.98**	0.20N	0.09N	0.46N	0.86**	0.22N
Education	2.45**	3.91**	2.81**	2.63**	2.02**	1.79**	3.05**
Wealth Index	3.25**	1.64	2.60**	3.12**	3.44**	3.69**	3.28**
Caste/religion	1.41**	-0.61N	1.34**	0.68*	0.60N	0.31N	0.10N
Age	0.95**	0.82**	0.85**	1.08**	1.35**	1.40**	1.11**
Female							
Intercept	149.43**	143.54**	146.71**	147.14**	146.86**	150.04**	146.780**
Residence	-1.10**	-0.08N	-0.42N	0.06N	0.10N	0.25N	-0.32**
Education	0.81**	2.30**	1.52**	0.98**	0.38	1.59**	1.59**
Wealth Index	1.86**	1.03**	2.53**	1.73**	2.44**	2.48**	2.22**
Caste/religion	0.91**	0.30N	0.48*	0.13N	0.22N	0.66**	0.27**
Age	0.18**	0.29**	0.13N	0.20**	0.26**	0.03N	0.20**
Weight							
Male							
Intercept	20.29**	25.68**	21.74**	16.97**	10.43**	10.95**	17.13**
Residence	0.58N	0.24N	0.37N	0.84*	0.57N	1.93**	0.65**
Education	0.80N	2.59**	1.36*	2.44**	1.30N	0.85N	1.54**
Wealth Index	3.94**	2.60**	5.04**	3.88**	5.14**	5.80**	4.43**
Caste/religion	1.40**	0.52N	1.50**	0.72*	0.52N	0.37N	0.78**
Age	1.63**	1.29**	1.44**	1.72**	2.05**	2.08**	1.74**
Female							
Intercept	29.54**	34.48**	31.75**	31.63**	31.84**	32.06**	31.65**
Residence	-0.07N	-0.25N	0.06N	0.64**	0.69*	0.89**	0.19N
Education	0.07N	1.69**	1.37**	0.54**	-0.76N	0.30N	0.83**
Wealth Index	2.70**	1.46**	3.55**	2.30**	3.29**	4.27**	2.88**
Caste/religion	0.81**	1.39**	0.67**	0.62**	0.29N	0.38N	0.82**
Age	0.86**	0.51**	0.56**	0.65**	0.64**	0.65**	0.65**
BMI							
Male							
Intercept	11.71**	13.85**	11.99**	10.79**	9.40**	9.69**	11.19**
Residence	0.60**	-0.15N	0.12N	0.30**	0.12N	0.53**	0.19**
Education	-0.27N	0.06N	-0.10N	0.35**	0.07N	-0.13N	-0.12N
Wealth Index	0.67**	0.59**	1.23**	0.70**	1.11**	1.29**	0.87**
Caste/religion	0.16N	0.32*	0.27N	0.09N	0.03N	0.03N	0.26**
Age	0.39**	0.32**	0.36**	0.42**	0.48**	0.48*	0.42**
Female							
Intercept	13.47**	17.04**	15.00**	14.85**	15.08**	14.44**	15.01**
Residence	0.24*	-0.10N	0.12N	0.27**	0.28*	0.30**	0.16**
Education	-0.18N	0.14N	0.23*	-0.01N	-0.41*	-0.28*	-0.04N
Wealth Index	0.67**	0.37**	0.90**	0.54**	0.80**	1.17**	0.67**
Caste/religion	0.11N	0.54**	0.17N	0.24**	0.06N	0.03N	0.28**
Age	0.32**	0.15**	0.21**	0.23**	0.21**	0.27**	0.23**

N.B.: *: 5% level of significance ($p<0.05$), **: 1% level of significance ($p<0.01$) and N: Insignificance ($p>0.05$)

Interpretation of the coefficients of the regression results is more or less straightforward. The intercept terms need to be properly addressed. In this context, the intercept terms give the true picture of the regional differences after eliminating the effect of the regressors, that is, education, wealth etc. Had there be no variation in educational levels; rural-urban, religion-caste and age proportions; and wealth distribution among the regions, the researchers would have got the differences of average heights, weights or BMIs same as the differences of the intercept terms of the respective regions. In other words, this accounts for all other variables not considered in the regression. The mean heights, weights and BMIs separately for males and females and also for each zone before and after eliminating the effect of the concerned variables are shown in Table 6.

Table 5: Percentage of variability of height, weight and BMI explained by wealth index, age and religion-caste

Response →	*Height*		*Weight*		*BMI*	
Explanatory↓	*C*	*C**	*C*	*C**	*C*	*C**
			Male			
Wealth Index	5.4	5.3	7.4	7.4	4.4	5.1
Age	3.1	4.6	7.1	7.8	2.8	2.5
Religion-Caste	3.3	1.9	1.0	0.3	1.7	1.3
Total	11.8	11.8	15.5	15.5	8.9	8.9
			Female			
Wealth Index	3.2	4.2	4.5	4.9	1.6	1.4
Age	2.1	1.0	1.6	1.8	1.3	1.6
Religion-Caste	0.1	0.2	1.5	0.9	1.3	1.2
Total	5.4	5.4	7.6	7.6	4.2	4.2

Table 6: Regional variation of height, weight and BMI before and after eliminating the effect of education; residential status, religion-caste and age proportions and levels of wealth separately for males and females

	North zone	*North-east zone*	*East zone*	*Central zone*	*West zone*	*South zone*
			After eliminating the effect of education; residential status, religion-caste and age proportions and levels of wealth			
Male height	145.65	143.55	145.07	142.07	137.08	137.50
Female height	149.43	143.54	146.71	147.14	146.86	150.04
Male weight	20.29	25.68	21.74	16.97	10.43	10.95
Female weight	29.54	34.48	31.75	31.63	31.84	32.06
Male BMI	11.71	13.85	11.99	10.79	9.40	9.69
Female BMI	13.47	17.04	15.00	14.85	15.08	14.44
			Before eliminating the effect of education; residential status, religion-caste and age proportions and levels of wealth			
Male height	165.45	160.84	162.92	163.65	164.14	164.62
Female height	154.01	150.60	150.32	151.58	152.77	152.99
Male weight	51.37	50.78	49.18	49.77	49.37	50.09
Female weight	45.69	45.73	43.08	43.99	43.97	45.24
Male BMI	18.72	19.61	18.47	18.52	18.25	18.40
Female BMI	19.25	20.14	19.04	19.13	18.82	19.31

Among males the mean height was the lowest in the North-east zone and the highest in the North zone. But after eliminating the effect of the important variables, the lowest mean height was found to be in the West zone. However, the North zone still maintained the status of being with the highest mean height. North zone more or less maintained high status also for female height, male weight and male BMI. Only for female weight and female BMI it dropped down to the lowest among the regions. It clearly indicates that there are other factors acting in the North zone, which go against females so far as weight and hence BMI is concerned. East zone improved from low position to reasonably high position. It clearly indicates that the low value of the height, weight and BMI is because of the unfavorable distribution of the variables considered in the researchers' analysis. Other zones remained more or less in the same position.

DISCUSSION

The physical growth is considered to be an important indicator of nutritional status and health of the population. This study examined

the nature and variation in height, weight and BMI of teenagers, especially of 15-19 years of Indian males and females based on National Family Health Survey (2005-06). The paper makes a comparative study of different states as well as zones in India and tries to find out the role of socio-demographic factors on height, weight and BMI.

Adolescence is a transitional period from childhood to adulthood. This period is marked by rapid physical growth and intellectual development mainly due to the influence of environmental factors. Physical surroundings such as sunshine, good housing, lighting and ventilation, occupation and economic status, lifestyle of parents, influence the growth and development of children. Education of parents also plays an important role in growth and development of children. It is to be noted that there is no difference in genetic potential of different populations of the world. The failure to achieve maximum genetic potential is affected by environmental stress particularly nutritional deficiencies and associated infections, which delay maturation and thereby resulting in growth retardation (Raviprasad 2012). This study suggests that mean heights are the lowest in North-east and East zones among both males and females whereas mean weights are low in the West, East and Central zones. When the researchers come to BMI, lowest means are again seen in West, East and Central zones. Thus the central belt of India is mostly affected. It can be mentioned that Central India has one of the fastest growing populations compared to other parts of the country. This part of India is also known for its poor demographic and health situation. Reasons behind this may be traced to high levels of mortality that had persisted over time along with low levels of social, economic and infrastructure development in the rural areas (Gautam et al. 2006).

The lifestyle and dietary pattern of the populations have an impact on their physique as well as BMI as shown by Abhilasha and Singh (2017). Today, different parts of the world are passing through different stages of demographic, health and socio-economic development transition. While, some of the countries are witnessing a population decline, country like India is facing the problem of exponential population growth, and all its developmental efforts are being dipped into uncontrolled population growth. The country is well established in its diversity. The demographic diversity is also equally striking. Such variation could be attributed to the large ethnic variation, socio-economic disparities and health care practices across the Indian population. India is the second most populous country in the world. Geographical regions in this country are characterized with different levels of health and nutritional status (Gautam and Adak 2007).

It is very clear from the analysis that household economic condition plays a significant role in controlling height, weight and BMI in all the zones of India. The result is similar with other studies (Abudayya et al. 2009; Mondal and Sen 2010; Leal et al. 2012; Sen and Mondal 2012; Keino et al. 2014; Shukla and Vaidya 2014). The researchers' result also shows that education is a key factor towards raising awareness to the causes of nutritional deficiencies and thus it has a positively significant effect on weight. Other studies have reported that parents' occupations and education have a significant inverse association with undernutrition (Sen and Mondal 2012; Keino et al. 2014; Tigga et al. 2015). Age certainly has a significant effect as teenage is also considered as growing age for both males and females especially for BMI. In India, people are divided in different castes with differences on their livelihood pattern. It is seen that caste/community categories have a significant effect in most of the zones irrespective of their gender. The present study observed that percentage of adolescent stunted females is higher (40.8%) compared to males (38.8%), whereas underweight males are higher in the age of 15-19 years compared to females. In this respect it can also be mentioned that quality of environment is usually regarded as a principal precursor for human health and particularly achieving the normal course of physical growth as expected. The geographical area, health and hygienic condition of the surroundings, psychological stability, and family setup all constitute the environmental setup where an individual grow to a mature adult. Since birth, an individual start maturing to keep pace with the standards of physical growth balancing his/her genetic makeup as well as environmental quality (Sikdar 2015). Height, weight and BMI of teenagers belong to different geographical and environmental setup of India may also be influenced by these factors.

The novel approach, described in the methodology section, has been demonstrated taking

three regressors, namely, wealth index, age and religion/caste to explain the variation of height, weight and BMI. The individual contributions found using the specific regressor variables are not large enough, because these are constrained by the total variation explained by the regression. However, this pioneer methodology will help other researchers in finding out the same in similar situations.

Lastly it should be pointed out, as it appears from the intercept terms of the regressions, that for the North zone there is some kind of gender discrimination and this discrimination is not due to the variables taken in the researchers' analysis.

CONCLUSION

In conclusion, the study reveals that, a nutritional gap is found in adolescent growth among the adolescent males and females. Also, parents' education and family wealth index are seen to be the most important predictors for teenagers' nutritional status for both the genders. Difference in adolescent growth is prominent in different zones, which is due to the variation in socio-economic, demographic and cultural practices.

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