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Anthropometric characteristics of rural Bengali adolescent girls from North Bengal, India

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KEYWORDS

Adolescence; Anthropometry; Physical growth; Bengali; India

ABSTRACT

Adolescence is the developmental period through which children grow into adults. Adolescents are the future generations of any country and their physical growth and nutritional needs are important for overall development of a society. The present cross-sectional investigation was undertaken to determine anthropometric characteristics of rural Bengali adolescent girls residing in North Bengal, India. The present investigation has observed that the adolescent girls exhibited low rates of physical growth when compared with the standard growth reference population but higher than those reported for other rural adolescent girls from India.

Introduction

Adolescence is the transitional phase between childhood and adulthood, and characterized by high growth acceleration, which is closely linked with nutritional status, and both are influenced by the process of sexual maturation. Nutrition plays a vital role during adolescence period because inadequate nutrition leads to malnutrition, growth retardation, reduced physical capacity, and poor mental and social development (Awasthi *et al*., 2000; Chhatwal *et al*., 2004; Sharma *et al*., 2007; Mondal *et al*., 2017; O' Brien *et al*., 2018). In South-east Asia a large number of children and adolescents suffer from chronic undernutrition, which adversely effects their health and development (Venkaiah *et al*., 2002; Olivieri *et al*., 2008; Patanwar and Sharma 2013; Konwar *et al*., 2019). The growth and nutritional status of adolescent girls, who are the future mothers bears special importance as they contribute to the overall nutritional status and health of the total population (Venkaiah *et al*., 2002; Deshmukh *et al*., 2006; Medhi *et al*., 2007; Mondal and Sen, 2010; Roy *et al*., 2016; Debnath *et al*., 2017; Pal and Bose, 2017; Nandi *et al*., 2018; O'Brien *et al*., 2018). Currently, it is estimated that there are about 69.7 million adolescents' girls constituting about 7% of the total population in India. The adolescents are potentially and nutritionally vulnerable in view of their rapid physical growth and maturation (Das and Bose 2011; Khatun et al., 2016; Debnath et al., 2019). Inadequate diet and unfavorable environmental, socio-economic conditions and demographic variables can adversely affect the physical growth and nutritional status. Better nutritional environment of adolescents in the higher socio-economic groups accelerates, while poor socio-economic status retards the physical growth pattern (Bose and Mukhopadhyay, 2004; Bose *et al*., 2005; Banik *et al*., 2007; Rengma *et al*., 2016; Joshi *et al*., 2019; Vaishnaw *et al*., 2020). Malnutrition is also one of the principal causes of premature mortality and morbidity among children and adolescents in India. World Health Organization (WHO) the ultimate

intention of the nutritional assessment is to improve human health and improvement nutritional status is also one of the goals of SDGs (Sustainable Development Goals). Several research investigations of both undernutrition and overnutrition have significant clinical and public health implication for developing health promotion strategies to prevent chronic diseases in adulthood. However, a handful studies have been reported on the assessment of nutritional status among adolescents' girls in India (Rao *et al*., 2000; Mitra *et al*., 2002; Mondal and Sen, 2010; Patanwar and Sharma, 2013; Mondal, 2014; Dhingra and Bhatt, 2017; Konwar *et al*., 2019).

Anthropometry has been widely used to assess physical growth and nutritional status (WHO 1995; Mondal and Sen 2010; Mondal *et al*., 2017; Debnath *et al*., 2018). It is well recognized worldwide that anthropometric measurements are indispensible in diagnosing of both undernutrition and overnutrition. Due to its simplicity, reliability and low cost, anthropometric measurements are widely used to evaluate physical growth and nutritional status (Venkaih *et al*., 2002; Bose and Mukhopadhyay, 2004; Hall *et al*., 2007; Bisai and Bose 2009; Das and Bose 2012; Mondal *et al*., 2017; O'Brien *et al*., 2018; Konwar *et al*., 2019; Bharali and Mondal 2019; Debnath *et al*., 2019). Anthropometric examination still remains a widely utilized tool in any research related with health and nutrition condition in childhood or adolescence stages (Bose and Mukhopadhyay, 2004; Medhi *et al*., 2007; Mondal and Sen, 2010a; Sen and Mondal, 2013; Mondal *et al*., 2017). Several studies have investigated physical growth status of children and adolescents belonging to various ethnic groups in India using this technique (Deshmukh *et al*., 2006; Medhi *et al*., 2007; Bisai and Bose, 2009; Basu *et al*., 2014; Sing and Mondal, 2014; Rengma *et al*., 2016; Debnath *et al*., 2017; Konwar *et al*., 2019; Vaishnaw *et al*., 2020). Several researchers have also assessed growth and nutritional status of school going children and adolescents from West Bengal (Bose *et al*., 2008; Chakraborty and Bose, 2009; Mondal and Sen, 2010; Das and Bose, 2011; Mondal and Bose, 2014; De, 2017; Debnath *et al*., 2017; Pal *et al*., 2017; Bhadra *et al*., 2018; Bharali and Mondal., 2019; Debnath *et al*., 2019). Moreover, it is attributed to poor socio-economic status can lead to poor nutrition and diseases which in turn can influence height of a growing child (e.g., de Onis 2001; Dasgupta *et al*., 2005). The proponents of strategic growth adjustment in human consider presence of adequate nutrition, health, and living condition as prerequisites and not true regulators of physical growth (e.g., Bogin *et al*. 2017; Hermanussen *et al*. 2018). Given the above, the present investigation tries to ascertain the growth patterns of rural adolescent girls aged 10 to 14 years belonging to the Bengali Hindu Caste Population (BHCP) of Darjeeling district of West Bengal.

Materials and Methods

Area and Subjects

The present cross-sectional investigation was carried out in the northern part of West Bengal, India, a region which is popularly known as North Bengal. This region comprises the districts of Darjeeling, Kalimpong, Jalpaiguri, Alipurduar, Coochbehar, North dinajpur, South Dinajpur and Malda. A large number of tribal (e.g., Oraon, Munda, Rabha, Lepcha, Toto, Santal) and non-tribal (Rajbanshi, Bengali speaking Hindu Caste and Bengali Muslim) populations inhabit in this region. Existing literature have shown that these populations remained very vulnerable to undernutrition (Banik *et al*., 2007; Mondal and Sen, 2010; Sen *et al*., 2011; Mondal, 2014; Roy *et al*., 2016; Debnath *et al*., 2017; Pal *et al*., 2017; Konwar *et al*., 2019). The girls selected to participate in the present investigation were the residents of a rural area of Naxalbari block (Upper Bagdogora) of Darjeeling district, which is situated around 14 km away from the sub-divisional town of Siliguri. This area is the homeland of diverse populations such as Nepali, Lepcha, Santali, Bengali Hindu Caste and Bengali Muslim. They speak different languages, having different ethnic origins and cultural traditions. All the girls belonged to the Bengali Hindu Caste Population (BHCP) and enrolled in the Bagdogora Balika Vidyalaya (BBV). Ethnically, the BHCP is a

Bengali-speaking endogamous caste group of West Bengal and faithful to Hinduism. They are probably a blend of Dravidian and Mongoloid ethnic groups with a strain of Indo-Aryan blood among the higher caste groups (Das Chaudhuri *et al*., 1993). The BBV school was primarily selected based on the twin factors of easy road accessibility and dominance of students belonging to the BHCP.

The girls were selected using a multistage stratified random sampling method. Initially 320 girls were approached to take part in this investigation. Forty-nine (49) of them were subsequently excluded from the study as either they did not belong to the age group selected or they did not belong to the BHCP. Age and ethnicity of the girls were subsequently verified from the school records. Hence the final sample size consisted of 271 girls in the age group 10-14 years. All the girls were observed to be free from any physical deformities, nutritional deficiency symptoms and did not suffer from any disease at the time of data collection. The data collection was conducted from March 2018 to April 2018. The work was conducted in accordance with the ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000 (Touitou *et al*., 2004). The objectives and protocol of the present investigation were informed to the Head Mistress of the school before commencement of the study.

Anthropometric measurements recorded

Altogether seven anthropometric measurements were recorded from each participant following standard techniques (Hall *et al*., 2007). These measurements were height, weight, sitting height, arm span, waist circumference, hip circumference and mid-upper-arm-circumference (MUAC). Height and sitting height of the girls were recorded using an anthropometer rod to the nearest 0.10 cm. Weight of the participants wearing minimum clothing and with bare feet was taken using a portable weighing machine to the nearest 0.10 kg. Arm span was measured by an anthropometer rod. The circumferences were recorded by using a non-stretchable plastic-coated measuring tape to the nearest 0.1mm.

The intra-observer and inter-observer technical errors of measurements (TEM) were calculated using a standard method (Ulijaszek and Kerr, 1999) and the coefficient of reliability (R) were calculated for testing the reliability of the measurements. For analysis of TEM, a total 50 girls were randomly selected from the BBV school. Their height, WC, HC and NC were measured by two of the authors (NRP and IS). The values of 'R' were subsequently determined from TEM. Very high values of 'R' (>0.975) were obtained for all four anthropometric measurements. As these values were appreciably higher than the cut-off value of 0.95 as suggested by Ulijaszek and Kerr (1999), the measurements recorded by the two authors were considered to be reliable, reproducible and free from any observer bias. All the measurements in the present study were subsequently recorded by NRP.

Body Mass Index (BMI) and Waist Hip Ratio (WHR) were derived using the following standard equations:

$BMI\ (kg/m^2) = Weight\ (kg)/\ Height^2\ (m^2)$
$WHR = WC\ (cm)/HC(cm)$

Statistical analysis

Descriptive statistics like mean and standard deviation of all anthropometric variables by age were computed. One-way analysis of ANOVA was performed to test the significant differences in mean anthropometric characteristics by age of the girls. The age- specific percentiles (5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th} and 95^{th}) values of height, weight and BMI have also derived using appropriate statistical procedure.

All statistical analysis was performed using the Statistical Packages for Social Sciences (SPSS; version 20.0). Statistical significance level was set at $p<0.05$.

Results

The age-specific descriptive statistics of anthropometric variables among the girls are depicted in Table 1. The mean height and weight increased with age from early adolescence to late adolescence. The age-specific mean height (149.46 cm) and weight (41.69 kg) were highest among 14 years aged girls. Girls belonging to the ages of 10 to 14 years have experienced greater acceleration in growth in height and weight. The age-specific highest positive attainment of growth spurt was observed in height (6.27 cm) and weight (5.99 cm) among girls aged 11 years. A similar increasing trend was observed in age specific mean values of MUAC, WC, HC, arm span and sitting height. Using ANOVA statistically significant ($p<0.05$) differences were observed in all anthropometric variables with respect to age (Table1). The BMI gradually increased from 11 to 14 years, with a slight decrease observed from 10 to 11 years and then values continued to rise reaching its highest peak in age of 14 years (18.76 kg/m^2). The age-specific mean values of WHR did not show any general increase with respect to age. The highest positive attainment of growth spurt was observed in BMI (1.83 kg/m^2) among girls aged 11 years. Using ANOVA statistically significant differences were observed in derived anthropometric and body composition variables with respect to age ($p<0.05$) (Table1). Age-specific selected percentile of 5th, 10th, 25th, 50th, 75th, 90th and 95th values for height, weight and BMI were derived separately among the girls are shown in Table 2. There appears to be an existing significant age-specific variation in anthropometric measurements of height, weight and BMI among adolescent girls as the girls approached in higher ages.

Comparison with the Reference Population

Age-specific mean values of height and BMI of adolescent's girls were compared with the WHO (2007) reference population. It was observed that the girls were generally below the 50th percentile of the reference values (Figures 1 and 2). The mean age-specific heights were well above the 5th and considerably below the 25th percentile of the reference values of girls aged 13 to 14 years. The age-specific mean values of BMI were observed to be below the 50th percentile, while age-specific mean BMI values were observed to be high in the 5thpercentile and to be same of 25th percentile in the ages of 12 and 14 years.

Discussion

Children and adolescents remain vulnerable due to their rapid physical growth rate and they require more attention for their physical and mental development which remains directly related to adequate level of nutrition (Bose *et al*., 2005; Deshmukh *et al*., 2006; Dhingra and Bhat 2017; Vaishnaw *et al*., 2020). Height and weight are the two basic measures that are mainly used to assess the physical growth of children and adolescence. The present investigation observed that age-specific mean value of anthropometric measures showed the growth spurt during the period of adolescence. The overall means and standard deviations of height and weight of the adolescence girls were 144.3 cm ($\pm$8.39) and 37.1 kg ($\pm$9.0), respectively. Mean height and weight increased progressively from 10 to 14 years (Table 1), which was observed to be similar to the results obtained from other Indian studies among rural and urban girls (Mondal and Sen, 2010; Roy *et al*., 2016; Pal and Bose, 2017; Nandi *et al*., 2018; Joshi *et al*., 2019; Khopkar *et al*., 2014). The nature of the percentile curves showed that the mean values of different anthropometric measurements represent more or less an increasing trend with the advancement of age. The age-specific increase was however not observed to be uniform for all the measurements because of the influence of genetic and environmental conditions (Medhi *et al*., 2007; Rengma *et al*., 2016;

Debnath *et al*., 2017; Nandi *et al*., 2018; Bharali *et al*., 2019; Konwar *et al*., 2019; Debnath *et al*., 2019).

In the present investigation, age at peak height was observed with the increase of age (e.g., 10-14 years) which was similar to the results of other studies reported on adolescent girls from India (Rao *et al*., 2000; Bisai and Bose, 2009; Sen *et al*., 2011; Khatun *et al*., 2016; Bharati *et al*., 2017; Nandi *et al*., 2018). A majority of the body measurements in the present investigation have shown a high rate of increase in the age group of 10-12 years that corresponded to the adolescent growth spurt, which was earlier than the average age of onset among adolescence for other Indian girls. The Figure 3 shows the comparison of the girls in the current investigation with other rural girls. It indicated that increase in height of the girls in the present investigation was significantly higher ($p<0.01$) than other that of Indian girls as reported by other studies (e.g., Das and Bose, 2011; Mondal and Terangpi, 2014; Roy *et al*., 2016; Bharathi *et al*., 2017; Bhadra *et al*., 2018) with their height increasing mostly in the age group of 10-14 years. Bengali adolescence girls of urban area of Kolkata (De, 2017) were observed to be significantly taller than girls in the present investigation. The results of the present investigation also showed that the girls under study had higher values for all anthropometric measurements when compared to other Indian studies. On the other hand, Figure 4 showed that the body weight of the rural girls were found to be significantly heavier than other Indian girls (e.g., Assamese, Rajbanshi and Santali) and significantly lighter than Bengali adolescence girls of urban area of Kolkata (De, 2017). With regard to BMI-for-age, a high proportion of population investigations showed high range of BMI when compared with other Indian adolescents girls (Figure-5) (Das and Bose, 2011; Mondal and Terangpi, 2014; Roy *et al*., 2016; Pal and Bose, 2017). The comparison of BMI of the girls with the reference population (WHO, 2007) showed that the mean BMI of the studied girls were found to be significantly lower than this population (Figure 2). However, the overall means of height, weight and other anthropometric measures in this present investigation showed higher values when compared with other Indian studies. One reasons for this could be better living conditions, improved nutrition and medical facilities and changes in socioeconomic and environmental conditions (Mascie-Taylor and Lasker, 2005; Olivieri *et al*., 2008; Roy *et al*.,2016; Mondal *et al*., 2017; Nandi *et al*., 2018; O'Brien *et al*., 2018; Joshi *et al*., 2019).

The present investigation observed that the girls showed higher levels of physical growth acceleration in comparison with other rural Indian girls (Das and Bose, 2011; Mondal and Terangpi, 2014; Roy *et al*., 2016; Pal and Bose, 2017) and lower levels of physical growth pattern when compared with the reference population (WHO, 2007). The poor attainment of physical growth among these girls can be primarily attributed to poor socio-economic conditions, large family size and lack of knowledge of mothers about adequate nutritional requirement (Rengma *et al*., 2015; Roy *et al*., 2016; Tigga *et al*., 2018; Debnath *et al*., 2018; Levin *et al*., 2019). The present investigation is similar to several other research investigations that indicated high prevalence of chronic undernutrition and anemia in adolescence girls in the country (Bisai and Bose, 2009; Maiti *et al*., 2012; Nandi *et al*., 2018; Konwar *et al*., 2019; Upadrasta *et al*., 2019; Reshmi *et al*., 2020). Those adolescents suffering from undernutrition or malnutrition are more likely to develop into thin or obese adult with low or high BMI that would have an impact on their physical work capacity, poor reproductive outcomes which leads to their greater morbidity and mortality in the population (Mondal and Sen 2010b; Rengma *et al*., 2015; Kunwar *et al*., 2018; Tigga *et al*., 2018; Debnath *et al*., 2019).

Conclusion

In the present investigation the authors have assessed the physical growth pattern of rural adolescents and compared the findings with other Indian studies. It may be concluded that these girls were heavier and taller than compared with other Indian studies. Age-specific variability in physical growth may

be attributed by several factors (e.g., socioeconomic, environmental, genetic and exposed to diseases) which may be directly or indirectly affect the overall development of a population. This study would also help to reveal the enhanced usefulness and effectiveness of the different intervention programs at targeted populations. One of the main limitations of this investigation was the small size. A longitudinal study using anthropometry, dietary intake and socio-economic and socio-demographic data would be helpful for planning of a proper nutritional intervention for rural populations to overcome the problem of undernutrition and/or malnutrition.

Recommendations

Nutrition related knowledge and awareness programmes are needed among parents and community level to reduce the future possibility of undernutrition. Further studies with interdisciplinary approach and comprehensive methods are required to examine nutrition intake, dietary pattern, disease prevalence and their association with nutritional status among adolescents.

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References

Awasthi, C. P., Kumar, S., Tiwari, P. P., Singh, A. B. (2000). "Nutritional status of preschool and school children in rural area of Sultanpur district". *Journal of Dairying Foods & Home Science* 19:16-21.

Banik, S. D., Bose, K., Bisai, S., Bhattacharya, M., Das , S., Jana, A., Purkait, P. (2007). "Undernutrition among adult Dhimals of Naxalbari, West Bengal: comparison with other tribes of eastern India". *Food Nutrition Bulletin* 28:348-352.

Basu, D., Islam, G., Gogoi, R., Dey, S., Deori, J. (2014). "Child's growth and nutritional status in two communities – Mishing tribe and Kaibarta caste of Assam, India". Inernational. *Journal of Sociology and Anthropology* 6:59-69.

Bhadra, M., Paul, P., Das, T. (2018). "Physical growth pattern and Nutritional status among adolescents Bhumij boys of Khatra block, Bankura District, West Bengal, India". *International Journal of Experimental Research Review* 16: 1-6.

Bharali, N., Mondal, N. (2019). "Double bourdan of malnutrition among SonowalKachari preschool children (<5 years) of North Lakhipur District of Assam, India". *Human Biology Review* 8: 233-240.

Bharthi, K., Ghritlahre, M., Das, S., Bose, K. (2017). "Nutritional status among children and adolescents aged 6–18 years of Kolam tribe of Andhra Pradesh, India". *Anthropology Review* 80: 13–23.

Bisai, S., Bose, K. (2009). "Leanness among early adolescents in two rural schools of two districts in West Bengal". *Indian Journal of Public Health* 53:235-236.

Bogin, B., Scheffler, C., Hermanussen, M. (2017). " Global effects of income and income 820 inequality on adult height and sexual dimorphism in 821 height". *American Journal of Human Biology* 29(2) <http://doi: 10.1002/ajhb.22980>.

Bose, K., Mukhopadhyay, A. (2004). "Nutritional status of adolescent Bengalee Boys". *Indian Pediatrics* 41:633.

Bose, K., Bhattacharya, S., Basu, K., Ghosh, K., Mukhopadhyay, A., Bhadra, M. (2005). "Age trends in anthropometric characteristics among 6-9 years old Bengalee Hindu school girls of Kolkata, India". *Anthropologischer Anzeiger* 63:439-448.

Bose, K., Bisai, S., Mukherjee, S. (2008). "Anthropometric characteristics and nutritional status of rural school children". *International Journal of Biological Anthropology* 2:1.

Chakraborty, R., Bose, K. (2009). "Very high prevalence of thinness using new international body mass index cut off points among 5-10 year old school children of Nandigram, West Bengal, India". *Journal of Research Medicine Science* 14:129-133.

Chhatwal, J., Verma, M., Riar, S. K. (2004). "Obesity among preadolescent and adolescents of a developing country(India)". *Asia Pacific Journal of Clinical Nutrition* 13: 231-235

Das, Chaudhuri, A. B., Basu, S., Chakraborty, S. (1993). "Twinning rate in the Muslim population of West Bengal". *Acta Geneticae Medicae Gemellologiae (Roma)* 42:35-39.

Das, G. M., Lokshin, M., Grangolati, M., Lvaschenko, O. (2005). "Improving child nutrition outcomes in India: Can the integrated child development services program be more effective?". *World bank policy research working paper* 3647 doi: 10.1596/1813-9450-3647.

Das, S., Bose, K. (2011). "Prevalence of thinness using new international cut-off points among Santal tribal children and adolescents of Purulia District, West Bengal, India". *Sri Lanka Journal of Child Health* 40:105-110.

Das, S., Boe, K. (2012). "Nutritional assessment by mid-upper arm circumference of Santal adults of Purulia, West Bengal,". *Collegium Antropologicum* 36:581-584.

de Onis, M. (2001). "Child Growth and Development. In: Semba R.D., Bloem M.W. (eds) Nutrition and Health in Developing Countries. Nutrition and Health". *Humana Press*, Totowa, NJ. <https://doi.org/10.1007/978-1-59259-225-8_4>

De, K. (2017). "Anthropometric status of adolescent girls of rural India". *Journal of Traditional Medicine Clinical Naturopathy* 6: 205

Debnath ,S., Mondal, N., Sen, J. (2017). "Use of upper arm anthropometry, upper arm muscle area-by-height (UAMAH) and midupper-arm-circumference (MUAC)-for-height as indicators of body composition and nutritional status among children". *Anthropology Review* 80:85–102.

Debnath, S., Mondal, N., Sen, J. (2019). "Double burden of malnutrition among adolescents in India". *Human Biology Review* 8: 155-178.

Deshmukh, P. R., Gupta, S. S., Bharambe, M. S., Dongre, A. R., Maliye, C., Kaur, S., Garg, B. S. (2006). "Nutritional status of adolescents in rural Wardha". *Indian Journal of Pediatrics* 73:139-141.

Dhingra, R., Bhat, A. (2017). "Association of body mass index and lifestyle variables among adolescent in urban Jammu". *International Journal of Health Science Research* 7:276-284.

Hall, J. G., Allanson, J. E., Gripp, K. W., Slavotinek, A. M. (2007). "Handbook of Physical Measurements". *New York: Oxford University Press*.

Joshi, N., Kumar, M., Chatterjee, K. (2019). "Study of sociodemographic factors and their relationship with the morbidity among adolescent girls of Pune slum area". *International Journal of Research Medicine Science* 7:1399-1405.

Khatun, A., Mukhopadhyay, A., Bose, K. (2016). "Age and sex variations in anthropometric characteristics of Muslim adolescents of North 24 Parganas, West Bengal". *Human Biology Review* 5:456-464.

Khopkar, S. A., Virtanen, S. M., Kulathinal, S. (2014)."Anthropometric characteristics of underprivileged adolescents: A study from urban slums of India". *Journal of Anthropology* < Article ID 197048. https://doi.org/10.1155/2014/197048>

Konwar, P., Vyas, N., Hossain, S. S., Gore, M. N., Choudhury, M. (2019). "Nutritional status of adolescent girls belonging to the tea garden estates of Sivasagar district, Assam, India". *Indian Journal of Community Medicine* 44:238-242.

Levin, C., Hale, J., Hutchison B. (2019). "Economic effects of the double burden of malnutrition." *Lancet* 395(10218):156-164.

Mascie-Taylor, C. G. N., Lasker, G. W. (2005). " Biosocial correlates ofstature in a British National cohort". *Journal of Biosocial Science* 37:245-251.

Medhi, G. K., Hazarika, N. C., Mahanta, J. (2007)."Nutritional status of adolescents among tea garden workers". *Indian Journal of Pediatrics* 74:343-347.

Mitra, M., Kumar, P. V., Ghosh, R. (2002). "Growth pattern of the Kamars - A primitive tribe of Chhattisgarh, India". *Collegium Anthropolicum* 26: 485-499.

Mondal, N., Sen, J. (2010). "A Prevalence of stunting and thinness among rural adolescents of Darjeeling district, West Bengal, India". *Italian Journal of Public Health* 7: 54-61.

Mondal, N., Sen, J. (2010b). "Prevalence of undernutrition among children (5-12 years) belonging to three communities residing in a similar habitat in North Bengal, India". *Annals of Human Biology* 37:198-216.

Mondal, N. (2014). "Thinness as Major Underlying Problem among Adolescents of Northeast India". *Journal of Nepal Paediatric Society* 34:39-47.

Mondal, N., Terangpi, M. (2014). "Prevalence of undernutrition among tribal adolescents of Karbi Anglong district of Assam, Northeast India". *Sri Lanka Journal of Child Health* 43:154-157.

Mondal, N., Ghosh, P., Sen, J. (2017). "Physical growth patterns and body composition of Rajbanshi adolescent boys of Eastern India". *Human Biology Review* 6: 263-283.

Nandi, A., Behrman, J. R., Kinra, S., Laxminarayan, R. (2018). "Early-life nutrition is associated positively with schooling and labor market outcomes and negatively with marriage rates at age 20–25 years: Evidence from the Andhra Pradesh Children and Parents Study (APCAPS) in India". *The Journal of Nutrition* 148: 140–146.

O'Brien, E. C., Alberdi, G., McAuliffe, F. M. (2018). "The influence of socioeconomic status on gestational weight gain: a systematic review". *Journal of Public Health* 40:41–55.

Olivieri, F., Semproli, S., Pettener, D., Toselli, S. (2008). " Growth and malnutrition of rural Zimbabwean children (6-17 years of age)". *American Journal of Physical Anthropology* 136:214-222.

Pal, A., Pari, A. K., Sinha, A., Dhara, P. C. (2017). "Prevalence of undernutrition and associated factors: A cross-sectional study among rural adolescents in West Bengal, India". *International Journal of Pediatrics Adolesccence Medicine* 4:9-18.

Pal, S., Bose, K. (2017). " Anthropometric characteristics of rural primary school children of Hooghly District, West Bengal, India". *Human Biololy Review* 6: 30-46.

Patanwar, P., Sharma, K. K. N. (2013). "Nutritional Status of Kurmi Adolescent Girls of Raipur City Chhattisgarh, India". *International Journal of Scientific Research Publication* 3:1-6.

Rao, S., Joshi, S., Kanade, A. (2000). "Growth in some physical dimensions in relation to adolescent growth spurt among rural Indian children". *Annals of Human Biology* 27:127-138.

Rengma, M. S., Bose, K., Mondal, N. (2016). "Socio-economic and demographic correlates of stunting among adolescents of Assam, North-east India". *Anthropology Review* 79:409–425.

Reshmi, P.S., Takalkar, A. A. (2020). "Prevalence of anemia in adolescent girls and its association with certain demographic variables: our experience from rural Telangana". *International Journal of Community Medicine Public Health* 7:1007-1011.

Roy, S., Barman, S., Mondal, N., Sen, J. (2016). "Prevalence of Stunting and Thinness AmongAdolescent Girls Belonging to the Rajbanshi Population of West Bengal, India". *Journal of Nepal Paediatric Society* 36:147-155.

Sharma, A., Sharma, K., Mathur, K. P. (2007). "Growth pattern and prevalence of obesity in affluent schoolchildren of Delhi". *Public Health Nutrition* 10: 485-491.

Sen, J., Mondal, N., Dey, S. (2011). "Assessment of the nutritional status of children aged 5-12 years using upper arm composition". *Annals of Human Biology* 38:752-759.

Sen, J., Mondal, N. (2013). "Fat mass and fat-free mass as indicators of body composition among Bengalee Muslim children". *Annals of Human Biology* 40:286-293.

Singh, J., Mondal, N. (2014) "Use of upper-arm anthropometry as measure of body-composition and nutritional assessment in children and adolescents (6-20 years) of Assam, Northeast India". *Ethiopian Journal of Health Science* 24:243-52.

Tigga, P. L., Debnath, S., Das, M., Mondal, N., Sen, J. (2018). "Prevalence of undernutrition and overweight or obesity among the Bengali Muslim population of West Bengal, India,". *Anthropology Open Journal* 3(1): 1-10.

Touitou, Y., Portaluppi, F., Smolensky, M. H., Rensing, L. (2004). "Ethical principles and standards for the conduct of human and animal biological rhythm research". *Chronobiology International* 21:161-70.

Ulijaszek, S. J., Kerr, D. A. (1999). "Anthropometric measurement error and the assessment of nutritional status". *British Journal of Nutrition* 82:165-177.

Upadrasta, V. P., Ponna, S. N., Bathina, H., Bharathi, S., Kapu, A. K. R., Sadasivuni, R. (2019) "Knowledge, attitudes and practices of adolescent school girls regarding prevention of iron deficiency anaemia". *International Journal of Community Medicine Public Health* 6:2694-2699

Vaishnaw, T., Das, M. C., Kumar, V. P. (2020). "Nutritional status of school age children in urban slum area in Vijayawada and Guntur". *Journal of Clinical Diagnostic Research* 14: OC01-OC04

Venkaiah, K., Damayanti, K., Nayak, M. U., Vijayaraghavan, K. (2002). "Diet and nutritional status of rural adolescents in India". *European Journal of Clinical Nutrition* 56:1119-1125.

World Health Organization (WHO). (1995). "Physical Status: The Use and Interpretation of Anthropometry". Technical Report Series No. 854. Geneva.

World Health Organization (WHO). (2007). Child growth standards: head circumference for-age, arm circumferenceforage, triceps skinfold-for-age and subscapular skinfold-for-age: methods and development. Geneva.

Tables and Figures

Table1: Age wise mean±standard deviation (SD) of the anthropometric variables and within age differences among the girls

Variable (N=271)	10 Year (N=52)	11 Year (N=56)	12 Year (N=56)	13 Year (N=57)	14 Year (N=50)	F-Value
Height(cm)	135.70±8.07	140.97±7.63	146.73±6.77	148.50±5.72	149.46±4.57	58.11**
Weight(kg)	29.55±6.75	35.54±8.53	37.21±7.54	41.30±8.70	41.69±7.91	26.81**
Arm span(cm)	127.46±24.52	132.78±24.96	146.91±7.58	146.28±13.57	149.29±6.33	18.03**
Sitting Height(cm)	70.68±4.38	73.39±4.54	75.50±10.43	76.96±5.76	78.52±2.95	18.45**
WC(cm)	59.75±7.32	65.32±9.19	66.40±9.09	70.76±7.79	71.44±7.11	19.36**
HC(cm)	68.43±7.83	71.91±8.83	79.21±7.17	79.78±7.30	81.61±7.32	37.64**
MUAC(cm)	18.44±2.14	19.98±2.88	19.46±2.85	21.11±2.74	21.58±2.98	11.52**
BMI(kg/m²)	15.88±2.41	17.71±3.22	17.19±2.81	18.70±3.78	18.66±3.51	7.07**
WHR	0.87±0.09	0.91±0.12	0.84±0.12	0.89±0.11	0.88±0.10	2.82*

*Significance at the level of *p<0.05; **p<0.01*

Table2: Age wise percentile values for height(HT), weight(WT) and body mass index (BMI) among the girls

Age (Year)	5th			10th			25th			50th		
	HT	**WT**	**BMI**	**HT**	**WT**	**BMI**	**HT**	**WT**	**BMI**	**HT**	**WT**	**BMI**
10	124.99	20.97	12.55	126.78	22.00	13.33	129.05	24.00	14.12	134.05	29.75	15.71
11	125.21	24.00	12.96	129.70	24.85	14.22	137.02	28.75	15.03	141.85	34.25	16.95
12	132.89	25.00	13.68	136.64	28.95	14.03	142.85	32.12	15.32	147.15	36.50	16.52
13	138.77	28.80	14.17	140.46	32.40	14.91	145.50	37.00	16.24	148.50	40.00	18.06
14	141.94	31.27	14.71	143.58	33.15	15.18	146.92	35.80	16.04	149.05	40.75	18.21

Age (Year)	75th			90th			95th		
	HT	**WT**	**BMI**	**HT**	**WT**	**BMI**	**HT**	**WT**	**BMI**
10	141.15	3.75	16.63	147.58	39.60	19.82	150.00	43.33	21.87
11	146.15	40.75	20.60	150.19	49.00	22.36	153.15	50.15	23.92
12	150.57	40.00	18.53	154.60	48.60	21.01	158.86	51.15	22.97
13	153.00	45.00	20.22	155.00	50.40	22.83	156.63	55.05	25.80
14	152.12	46.00	20.33	154.00	53.90	23.50	159.34	58.42	24.02

Figure 1: Age-specific comparison of mean height of the girls with the WHO (2007) reference population

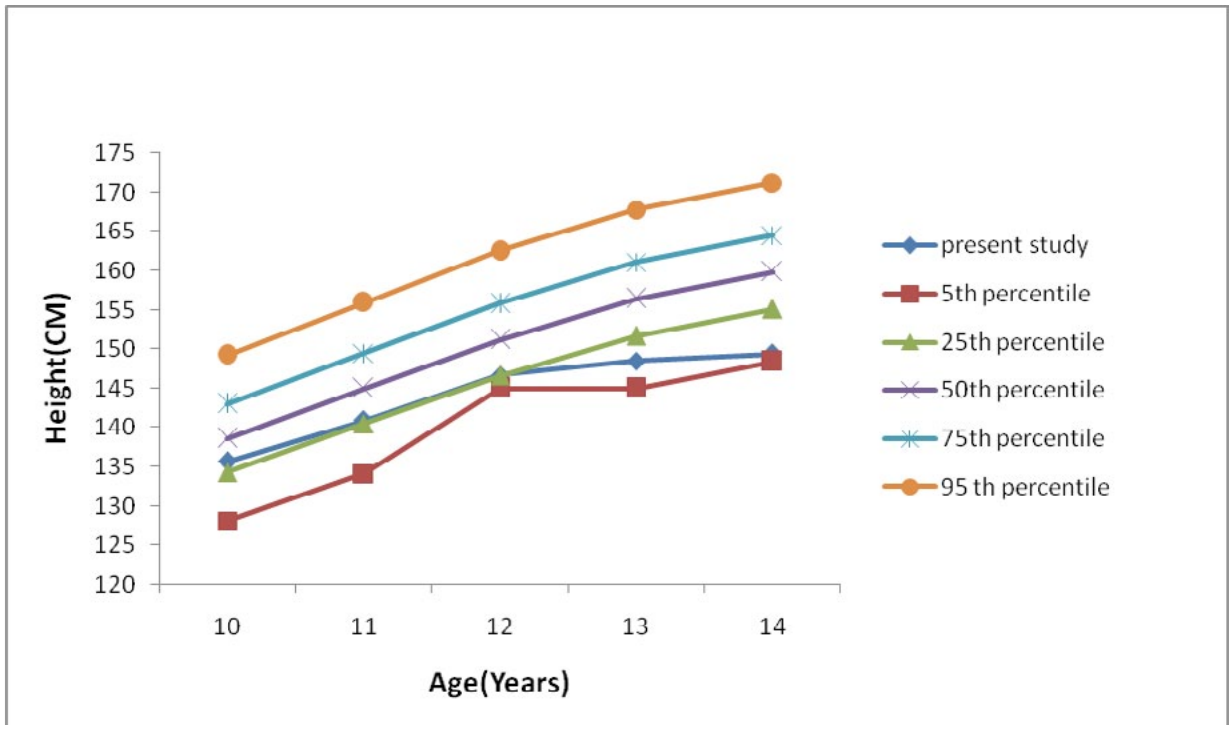

Figure 2: Age-specific comparison of mean BMI of the girls with the WHO (2007) reference population

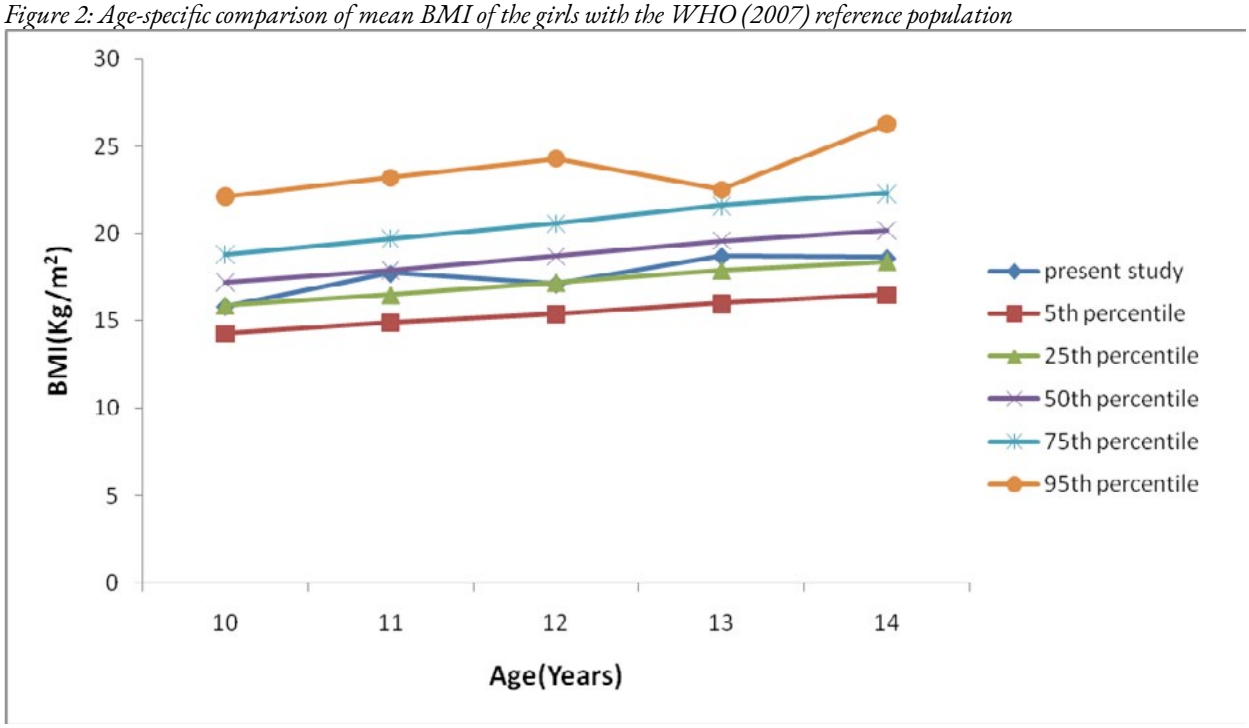

Figure 3: Age-specific comparison of mean height of the girls with other Indian studies (Das and Bose 2011;Mondal and Terangpi 2014; Roy et al., 2016; De 2017)

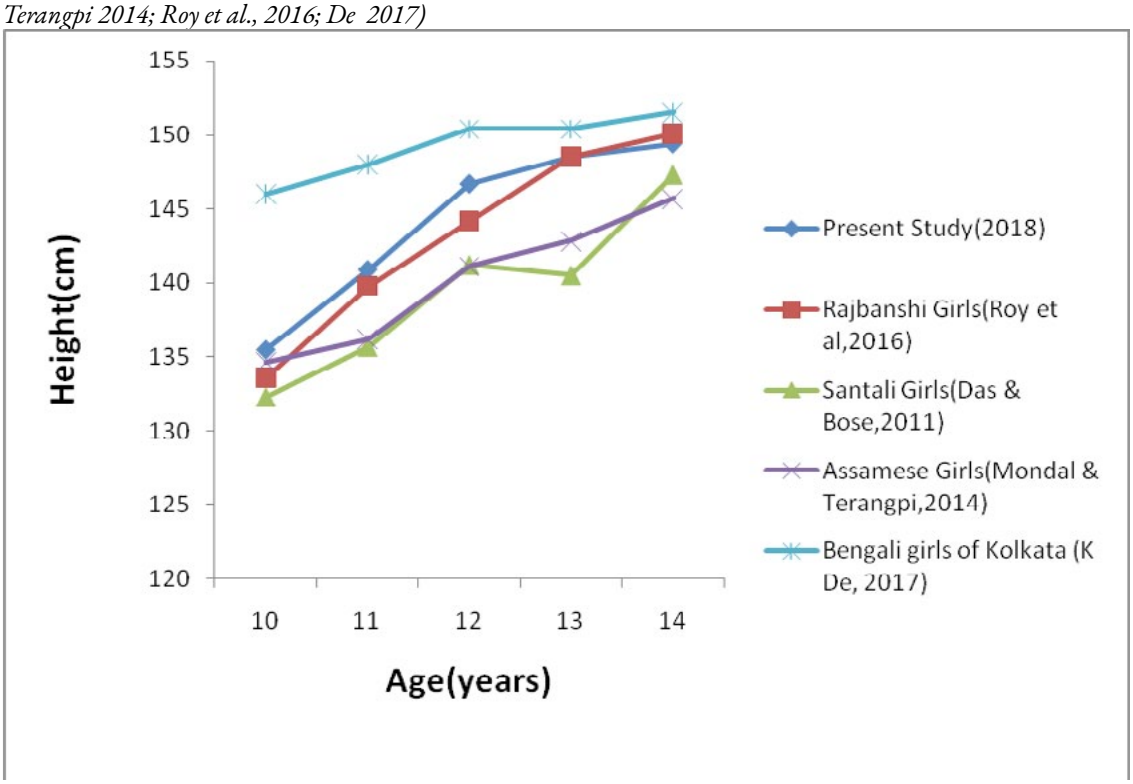

Figure 4: Age-specific comparison of mean weight of the girls with other Indian studies (Das and Bose 2011;Mondal and Terangpi 2014; Roy et al., 2016; De, 2017)

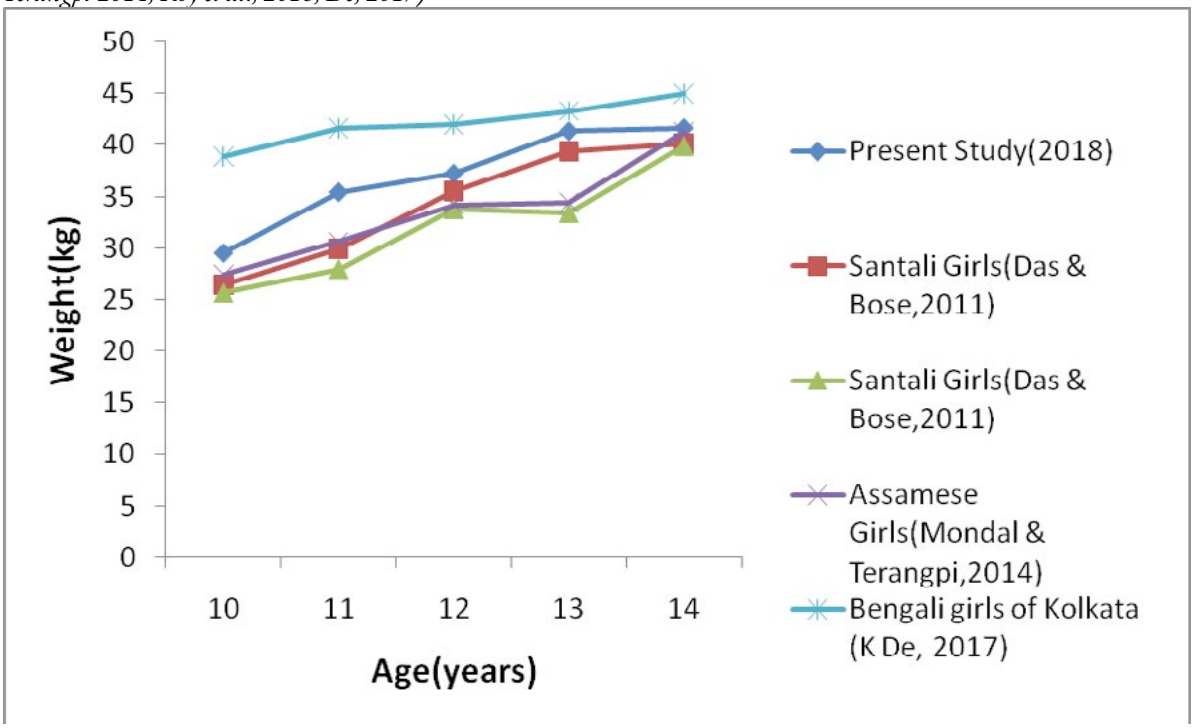

Figure 5: Age-specific comparison of mean BMI of the girls with other Indian studies ((Das and Bose 2011;Mondal and Terangpi 2014; Roy et al., 2016; De 2017)