

Original Research

Body Composition Comparison of Purulia District, West Bengal, India's Pre-Menarche and Post-Menarche Sabar Girls

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Article information

Accepted: March 18th, 2025; Published: March 30th, 2025

Cite this article

Mahata LL, Biswas S, Bisai S. Body Composition Comparison of Purulia District, West Bengal, India's Pre-Menarche and Post-Menarche Sabar Girls. *Anthropol Open J.* 2025; 8(1): 7-13.

ABSTRACT

Background

It was known that menarche plays a significant role to change body composition during adolescence. And there is a paucity of information on body composition in relation to pre- and post-menarcheal status on comparative manner among the tribal adolescence girls of West Bengal, India.

Objectives

To assess the body composition and compare the relative distribution of fat between the pre- and post-menarcheal girls and to explore the impact of body composition on menarcheal status among the Sabar tribal adolescence girls of the Purulia district, West Bengal, India.

Methods

The present cross-sectional study was conducted from three different blocks of Purulia district during June 2019 to December 2019. A total of 65 adolescence girls were randomly selected from the aged between 10 to 18-years. Among them, 34 girls were post-menarche stage and 31 girls were pre-menarche stage. Anthropometric measurements (height, weight, triceps and sub-scapular skinfolds) were measured. Spearman's rho correlation coefficient and Mann-Whitney U-test, Binary logistic regression were performed through SPSS version 25.

Results

It was depicted that significant differences were found in all anthropometric and body composition characteristics between the pre and post menarche state. The mean values of percent body fat (PBF), fat mass (FM), fat free mass (FFM), fat mass index (FMI) and fat free mass index (FFMI) in pre-menarche girls were 14.61%, 4.45 kg, 24.35 kg, 2.33 kg/m² and 13.08 kg/m², respectively. Similarly, the mean values of PBF, FM, FFM, FMI and FFMI in post-menarche girls were 20.37%, 8.07 kg, 31.00 kg, 3.70 kg/m² and 14.29 kg/m², respectively. The results of Spearman correlation coefficients (r) showed that the body composition measures were significantly correlated with the anthropometric variables except FFM and FFMI among the post-menarche girls. Menarcheal status of the Sabar tribal adolescent girls of Purulia district was pretentious of PBF and FFM.

Conclusion

The body composition characteristics were significantly different between pre- and post-menarche-state. So, further study in larger augmentation is required to validate the present findings.

Keywords

India; Tribes; Sabar girls; Menarche; Body composition.

INTRODUCTION

Menarche is a state that is started after the first occurrence of menstruation. It's major role on the development of both physical and sexual health.^{1,2} In general, menarche is started after significant skeletal maturity,³ and occurs during 6-months to 1-year after reaching the maximum growth spurt or peak height velocity.⁴ The onset of menstruation impacts to physiological and psychological³ changes in a woman's reproductive life.⁵ Many studies reported age at menarche is influenced by nutrition, body composition, socio-economic and physical factors.^{6,7} Earlier studies mentioned that onset of menarche tended to occur later in girls who consumed vegetarian diet.⁸⁻¹⁰ In contrast, another study found socio-economic factor such as occupation, education, and household income of the parents were not related to the age at menarche.¹¹ More importantly, menarche is influenced by genetic, environmental and socio-economic factors, which produce significant variation between population.^{4,12,13} There was a vast variation of affecting factors on age at menarche. Menarcheal age was associated with nutritional factors, which influence the age at menarche mainly through their effects on accumulation of adipose tissue.¹⁴ It is recognized that body size and body composition are strong predictors of the initiation of menarche.¹⁵ It was documented that mean age at menarche has been decreasing 4-months per decade and menarcheal age stabilized at 12.8-years by the mid 20th Century.¹⁶ Age at menarche is lower in developed countries than the developing countries. This difference is generally happened due to differences of socio-economic condition, particularly nutrition.¹⁷ While adolescent girls decrease their physical activity during puberty, their weight is increases and its impact on fatness and menarche occurs due to leptin secretion.¹⁸ The process of biological maturation influences the anthropometric characteristics.^{19,20} The adolescent period, including puberty is a unique period of hormonal, psychological, cognitive and physical changes and these changes have to face with emotional, social and behavioral dimensions.^{21,22} Puberty become faster and reach menarche at an earlier age among overweight girls.^{23,24} Among the thin girls, if menarche is started earlier then there is a trend to gain weight rapidly.²⁵ Earlier age at menarche had also related with higher body mass index (BMI), waist circumference, blood pressure, glycated hemoglobin and a worse lipid profile during adulthood.²⁶

According to census 2011, the tribal population was 8.6% of the total population of India. The Sabar is one of the primitive Mundari speaking tribe widely spread over hill regions of Orissa, Madhya Pradesh, Andhra Pradesh, Jharkhand, and West Bengal. A total of 40 tribal groups are found in West Bengal and Sabar is one of the major tribe in this state. They are mainly concentrated in Purulia, Bankura and Midnapur district and adjoining areas.²⁷ According to the census 2011, the total population of Sabar in West Bengal and Purulia district were 40374 and 6914, respectively.²⁷

Different studies had been shown that the significant difference in body composition between pre- and post-menarcheal girls and these differences vary from racial to racial group.²⁸⁻³⁰ It is evident that the amount of body fat in post menarcheal Bengali girls had greater than their counterpart.^{31,32} It is well established that anthropometric measurement like skinfold thickness is an use-

ful indicator to assess body composition in all age groups.³³ An earlier study reported that the anthropometric and body composition characteristics had significantly higher mean values in menarcheal group than pre-menarcheal group.³² In view the above facts, the present study was undertaken to compare the body composition characteristics between pre-menarcheal and post-menarcheal girls and to find out the impact of body composition on menarcheal status of the adolescence girls of the Sabar tribe of Purulia district, West Bengal, India.

MATERIALS AND METHODS

The Setting

This cross-sectional study was carried out during June 2019 to December 2019 on the Sabars community at three different blocks (Barabazar, Banwan and Manbazar-II) under the Purulia district of West Bengal, India. These blocks are highly Sabar concentrated area of the district. The study area is situated at the border of area of Jharkhand and West Bengal. All three blocks are situated approximately 225-255 km away from Kolkata, the provincial capital of West Bengal.

Samples

The data were collected from three different blocks of Purulia district, West Bengal. The participants were selected from all girls above the age of 10-years-old for the present study. Mean age at menarche was almost 13-years age (12.87-year). During analyzing the data, we eliminated the data from above 15-years age and before 11-years age and also there were another reason that we were selected before and after two years from mean age at menarche. This short age range was designed to minimize the effect of age on anthropometric traits. The final sample size included in the analysis is 65 individuals. The estimated sample size (26 from each group) was computed by standard formula: $n_1 = 2 \left(\frac{z_{\alpha/2}}{E} \right)^2$ Where, n_1 is the sample size required in each group, value of z at 97% confidence interval is 2.17. Standard deviation (σ) is 5 of PBF, and E is the margin of error (3). Age of the girls were ascertained from the birth certificate. The study protocol was approved by the Institutional ethical committee of SKB University prior to conduct the survey.

Anthropometric Measurement

All are anthropometric measurements were taken by a trained girl. Height was taken using Martins anthropometric rod to the nearest 0.1 cm. Weight was taken using spring balance weighing machine to the nearest 0.5 kg. Skinfold measurement such as Triceps (TRISKF), Biceps (BISKF) and sub-scapular skinfold (SUBSSKF) thickness were measured to the nearest 0.2 mm using Holtain skinfold calliper.

Assessment of body composition: Percent body fat (PDF) were calculated with two skinfold thickness i.e. Triceps skinfold (TRISKF), sub-scapular skinfold (SUBSSKF). PBF derive using standard Formulae developed by Slaughter et al.³⁴ These equations were:

Girls: $PBF = 1.33 (TRISKF + SUBSSKF) - 0.013 (TRISKF + SUBSS-$

KF)-2-2.5

The fat mass (FM) was calculated following the standard equation:

$$FM=(PBF/100)\times\text{body weight (kg)}.^{35}$$

$$FFM=\text{Body weight (kg)}-FM \text{ (kg)}.^{35}$$

The FM and fat free mass (FFM) were then divided by height-squared in meter to assess the fat mass index (FMI) and fat-free mass index (FFMI), respectively.

Statistically analysis: Mean age at menarche was calculated through descriptive study. Due to small sample size and non-normal distribution non-parametric test were employed. Independent sample Mann-Whitney U-test was performed to test significance difference between pre- and post-menarche state. Spearman's rho correlation coefficients were used to evaluate the relationship between anthropometric and body composition variables and binary logistic regression were used to identify the variables which were impacts on menarcheal status. All statistical analyses were performed using the statistical package for social sciences (IBM® SPSS, version-25).

RESULTS

The mean (SD) age at menarche was 12.87 (±0.92) years among the Sabar adolescence girls of Purulia districts. Out of 65 girls, 34 girls were pre-menarche stage and 31 girls were post-menarche stage. The mean values of anthropometric and body composition measurers were higher among post menarche girls compare to pre-menarche girls. The mean difference between pre-menarche and post-menarche girls of the height, weight, BMI, TRISKF, SUBSSKF were 10.26 kg, 11.22 cm, 2.56 kg/m², 3.19 mm and 3.60 mm respectively (Table 1).

Table 2 indicates body composition characteristics i.e. PBF, FM, FFM, FMI and FFMI among the studied girls. It was noticed that the post menarche girls had significantly higher mean values of body composition measurers than pre-menarche girls. The mean difference between pre- and post-menarcheal girls of PBF, FM, FFM, FMI and FFMI were 5.75%, 3.62 kg, 6.65 kg, 1.37 kg/m² and 1.21 kg/m² respectively. All body composition measurers showed significant differences between pre-menarche and post-menarche girls (p value<0.001).

Table 3 represents the Spearman's rho correlation coef-

Table 1. Anthropometric Characteristics Among the Pre Menarcheal and Post-Menarcheal Sabar Girls

Anthropometric Variable	Pre-Menarche (n=34)	Post-Menarche (n=31)	Difference (+)	Mann-Whitney U
Weight (kg)	28.30 (6.34)	39.07 (4.96)	10.26	117.0***
Height (cm)	135.90 (7.70)	147.13 (4.97)	11.22	124.0***
BMI (kg/m ²)	15.43 (1.96)	17.99 (1.56)	2.56	164.0***
TRISKF (mm)	7.65 (3.03)	10.84 (2.91)	3.19	192.0***
SUBSSKF (mm)	7.92 (3.10)	11.53 (4.10)	3.60	243.0***

Level of significance ***=p<0.001

Table 2. Descriptive Statistics on Body Composition Measurer Among Pre and Post-Menarcheal Sabar Girls

Body Composition Parameter	Pre-Menarche (n=34)	Post-Menarche (n=34)	Difference (+)	Mann-Whitney U
PBF (%)	14.61 (4.86)	20.37 (4.04)	5.75	182.0***
FM (kg)	4.45 (2.52)	8.07 (2.30)	3.62	138.0***
FFM (kg)	24.35 (4.10)	31.00 (3.33)	6.65	117.0***
FMI (kg/m ²)	2.33 (1.76)	3.70 (1.53)	1.37	166.5***
FFMI (kg/m ²)	13.08 (1.07)	14.29 (1.09)	1.21	234.5***

Level of significance ***=p<0.001

Table 3. Spearman's Rho Correlation Coefficient between Anthropometric Measurements and Body Composition Variables of the Pre-Menarche and Post-Menarche Girls

Anthropometric Parameter	Pre-Menarche					Post-Menarche				
	PBF	FM	FFM	FMI	FFMI	PBF	FM	FFM	FMI	FFMI
Weight	0.688**	0.889**	0.983**	0.796**	0.832**	0.458**	0.750**	0.885**	0.690**	0.667**
Height	0.602**	0.793**	0.900**	0.639**	0.594**	0.425*	0.589**	0.522**	0.465**	0.051
BMI	0.644**	0.800**	0.875**	0.808**	0.945**	0.396*	0.643**	0.809**	0.658**	0.855**
TRISKF	0.918**	0.814**	0.476**	0.843**	0.333	0.665**	0.627**	0.211	0.605**	-0.001
SUBSSKF	0.931**	0.913**	0.623**	0.943**	0.565**	0.891**	0.839**	0.066	0.865**	-0.048

Statistically significant level=*p<0.05, **p<0.001.

ficients between anthropometric measurements and body composition characteristics. Among the pre-menarche girls, all body composition measurers were significantly correlated with anthropometric characteristics except TRISKF with FFMI. But among post menarche girls, FFM and FFMI were not significantly correlated with TRISKF and SUBSSKF. On the other hand, height was also not correlated with FFMI.

Binary logistic regression has been performed to assess the impact of body composition measurers on their menarcheal status. The model is contained four body composition variable (PBF, FM, FFM and FMI). We have excluded FFMI by step forward. Though sample size is small. The model as a whole explained between 47.5% (Cox and Snell R square) and 63.3 % (Nagelkerke R squared) of the variance in menarcheal status, and overall correctly classified 83.1% of cases (Table 4). In the Table 5, only two variables made a statistically significant contribution to the model (PBF and FFM) (p value<0.001) and most predictors variable was PBF (OR 3.677) followed by FFM (2.018).

DISCUSSION

In the present study it was found that the all body composition measurers and anthropometric characteristics were significantly different between pre- and post-menarche girls. Similar results reported by earlier studies.^{32,36} Majority of anthropometric characteristics were positively correlated with body composition characteristics among pre-menarcheal girls. In post menarcheal girls, height with FFMI and TRISKF and SUBSKF were not correlated. BMI has a high correlation with total body fat and percentage of body fat in children and adults.³⁷ Increase in fat mass and body weight was the main fact behind these differences.³⁶ Moreover, FFM had greater impact on menarcheal status other than all body composition characteristics as found in the present study. Silimilarly,

PBF also had an impacts on menarcheal status but early menarche, longer reproductive years, and menopause were significantly associated with increased body fatness, which was assessed by BMI, waist circumference, PBF and abdominal fat.³⁸ More importantly, weight, height, abdominal and suprailiac skinfolds were associated with the onset of menstruation. But after controlling for age and body weight, timing of menarche were not associated with total dietary energy, protein, lipid, and carbohydrate intakes.⁸ FFM and fat mass were significantly greater mean value in the pubertal group than pre-pubertal group.³⁹

In the present study, the mean age at menarche was 12.87-years which is similar with other studies^{15,40} but greater than a another report.⁴¹ It was well documented that there is significant difference in body composition and onset of menarcheal age between low and high socio-economic class. In high economic class, both values are higher in compared to low socio-economic class.⁴² The initiation of puberty with menarche is directly related with BMI, fat mass, and leptin and only as a partial modifier of menarche in terms of a discrete acceleration of menarche in overweight and obese girls.⁴⁰ Many studies were reported the association of body size menarcheal age and of body fat as measured by BMI.^{11,14,17} There is tend to occur first menstruation is related to the fat deposition in both lower and upper body region. While changes in lower body part (hips circumference and pelvis breadth) tended to peak preceding first menstruation and changes in upper body part (triceps and subscapular skinfold thickness) is reached peaked in the year following first menstruation.⁴³ Leptin works as a regulator of body weight and serum level which are strongly associated with both BMI and fat mass. Higher BMI and PBF in girls were more advanced in their maturation status compared to girls with low BMI and PBF.⁴⁴ Peak mass or BMI of pre-menarche girls are increased during onset of menarche which are not affected as much compared to the post-menarche groups' BMI.⁴⁵ Body

Table 4. Classification Table of the Cases

Observed	Predicted			Percentage Correct
	Menarche Status			
	Pre-Menarche	Post-Menarche		
Pre-menarche	28	6	82.4	
Post-menarche	5	26	83.9	
Overall percentage			83.1	

The cut value is 0.500

Table 5. Results of Logistic Regression Analysis Between Dependent and Independent Variables

Body Composition	B	SE	Wald	DF	Sig.	OR	95% CI for OR	
							Lower	Upper
PBF	1.302	0.632	4.252	1	0.039	3.677	1.067	12.679
FM	-0.611	1.269	0.232	1	0.630	0.543	0.045	6.525
FFM	0.702	0.278	6.373	1	0.012	2.018	1.170	3.481
FMI	-4.503	2.875	2.452	1	0.117	0.011	0.000	3.105
Constant	-25.383	9.870	6.614	1	0.010	0.000		

*Dependent variable-menarcheal status; Predictor variable: PBF, FM, FFM, FMI
B: Regression coefficient, SE: Standard error of B, DF: Degree of freedom, OR: Odds ratio

fat was not related with menarche independently. Whenever body weight was taken into account, the relationship between skinfold and menarche disappears but body weight and menarche is associated with each other¹⁷ but in the present study PBF was related with menarche independently. Although, BMI and body composition parameter (PBF, FM, and FMI) are related each other, as assessment of body fat from skinfolds thickness gives a more direct result of body fat mass.⁴⁶ All body composition characteristics were significantly higher in post menarcheal girls compared to premenarcheal girls in both Japanese and Caucasian groups.³⁰

CONCLUSION

In conclusion, body composition characteristics were significantly different between pre- and post-menarcheal status among the Sabars tribal girls. Present study found that BMI was highly correlated with PBF and FM. More importantly, FFM and PBF of the body composition characteristics had a significant impact to menarcheal status of the Sabar tribe. Therefore, similar study should be conducted among the girls of the other population in varied setting to understand the pattern of body composition characteristics on pre- and post-menarcheal state.

ACKNOWLEDGEMENTS

All subjects who participated in the study are gratefully acknowledged. Authors also thankful to Shiule Gope for data collection. We also grateful to the SKB University and local administrative authorities for their kind help and support.

FUNDING

None.

INSTITUTIONAL BOARD PERMISSION

Yes.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

REFERENCES

- Rubina C, Maisoneta M, Kieszaka S, et al. Timing of maturation and predictors of menarche in girls enrolled in a contemporary British cohort. *Paediatr Perinatal Epidemiol.* 2009; 23: 492-504. doi: [10.1111/j.1365-3016.2009.01055.x](https://doi.org/10.1111/j.1365-3016.2009.01055.x)
- Hozoori M, Moradi F, Hosseini-Zade Z, Kazemian M, Arsang-Jang S. Age at menarche and its relationship to anthropometric indices in adolescent girls. *Int J Pediatr.* 2017; 5(7): 5255-5262. doi: [10.22038/ijp.2017.22352.1872](https://doi.org/10.22038/ijp.2017.22352.1872)
- Elizondo S. Age at menarche: Its relation to linear and ponderal growth. *Ann Hum Bio.* 1992; 19: 197-199. doi: [10.1080/03014469200002072](https://doi.org/10.1080/03014469200002072)
- Karapanou O, Papadimitriou A. Determinants of menarche. *Reprod Biol Endocrinol.* 2010; 8: 115. doi: [10.1186/1477-7827-8-115](https://doi.org/10.1186/1477-7827-8-115)
- Swenson I and Havens B. Menarche and menstruation: A review of the literature. *J Community Health Nursing.* 1987; 4(4): 199-210. doi: [10.1207/s15327655jchn0404_3](https://doi.org/10.1207/s15327655jchn0404_3)
- Murata K, Araki S. Menarche and sleep among Japanese school-girls: An epidemiological approach to onset of menarche. *Tohoku J Exp Med.* 1993; 141: 21-27. doi: [10.1620/tjem.171.21](https://doi.org/10.1620/tjem.171.21)
- Gokhale, D. Factors influencing age at menarche: An Indian scenario. *India J Youth Adol Health.* 2015; 2(3).
- Moisan J, Meyer F, Gingras S. Diet and age at menarche. *Cancer Causes Control.* 1990; 1: 149-154. doi: [10.1007/BF00053166](https://doi.org/10.1007/BF00053166)
- Sanchez A, Kissinger DG, Philipps RI. A hypothesis on the etiological role of diet on the age of menarche. *Med Hypothesis.* 1981; 7: 1339-1345. doi: [10.1016/0306-9877\(81\)90124-9](https://doi.org/10.1016/0306-9877(81)90124-9)
- Kissinger DG, Sanchez A. The association of dietary factors with the age of menarche. *Nutr Res.* 1987; 7: 471-479. doi: [10.1016/S0271-5317\(87\)80003-9](https://doi.org/10.1016/S0271-5317(87)80003-9)
- Merzenich H, Boeing H, Wahrendorf J. Dietary fat and sports activity as determinants for age at menarche. *Am J Epidemiol.* 1993; 138: 217-224. doi: [10.1093/oxfordjournals.aje.a116850](https://doi.org/10.1093/oxfordjournals.aje.a116850)
- Danubio ME and Sanna E. Secular changes in human biological variables in Western Countries: An updated review and synthesis. *J Anthropol Sci.* 2008; 86: 91-112.
- Wronka I. Association between BMI and age at menarche in girls from different socio-economic groups. *Anthro Anz.* 2010; 68(1): 43-52. doi: [10.1127/0003-5548/2010/0066](https://doi.org/10.1127/0003-5548/2010/0066)
- Maclure M, Travis LB, Willett WC, MacMahon B. A prospective cohort study of nutrient intake and age at menarche. *Am J C Nutr.* 1991; 54: 649-656. doi: [10.1093/ajcn/54.4.649](https://doi.org/10.1093/ajcn/54.4.649)
- Berkey CS, Gardner JD, Frazier AL, Colditz GA. Relation of childhood diet and body size to menarche and adolescent growth in girls. *Am J Epidemiol.* 2000; 152: 446-452. doi: [10.1093/aje/152.5.446](https://doi.org/10.1093/aje/152.5.446)
- Loomba-Albrecht LA, Styne DM. Effect of puberty on body composition. *Curr Opin Endocrinol Diabetes Obes.* 2009; 16: 10-15. doi: [10.1097/med.0b013e328320d54c](https://doi.org/10.1097/med.0b013e328320d54c)
- Meyer F, Moisan J, Marcoux D, Bouchard C. Dietary and physical determinants of menarche. *Epidemiol.* 1990; 1: 377-381. doi:

10.1097/00001648-199009000-00007

18. Kasa-Vubu JZ, Ye W, Borer KT, Rosenthal A, Meckmongkol T. Twenty-four hour growth hormone and leptin secretion in active postpubertal adolescent girls: Impact of fitness, fatness, and age at menarche. *J Clin Endocrinol Metab.* 2006; 91(10): 3935-3940. doi: [10.1210/jc.2005-2841](https://doi.org/10.1210/jc.2005-2841)

19. Do Bonfim BMA, Bonuzzi GMG, Domingues VL, Reiser FC. The influence of maturational and morphological status pre and post-menarche on the 100-m freestyle swimming performance of competitive teenagers. *Motriz Rio Claro.* 2020; 26: 1-6.

20. Erlandson MC, Sherar LB, Mirwald RL, Maffulli N, Baxter-Jones ADG. Growth and maturation of adolescent female gymnasts, swimmers, and tennis players. *Med Sci Sport Exercise.* 2008; 40: 34-42. doi: [10.1249/mss.0b013e3181596678](https://doi.org/10.1249/mss.0b013e3181596678)

21. Gaudineau A, Ehlinger V, Vayssiere C, Jouret B, Arnaud C, Godeau E. Factors associated with early menarche: Results from the French health behavior in school-aged children (HBSC) study. *BMC Public Health.* 2010; 10: 175. doi: [10.1186/1471-2458-10-175](https://doi.org/10.1186/1471-2458-10-175)

22. Sawyer SM, Azzopardi PP, Wickremarathne D, Patton G. The age of adolescence. *Lancet Adol Health.* 2018; 2(3): 223-228. doi: [10.1016/S2352-4642\(18\)30022-1](https://doi.org/10.1016/S2352-4642(18)30022-1)

23. Buyken Ae, Karaolis-Dunckert N, Remer T. Association of prepubertal body composition in healthy girls and boys with the timing of early and late pubertal markers. *Am J Clin Nutr.* 2009; 89: 221-30. doi: [10.3945/ajcn.2008.2673](https://doi.org/10.3945/ajcn.2008.2673)

24. Bralic I, Tahirovic H, Matanic D, et al. Association of early menarche age and overweight/obesity. *J Pediatr Endocrinol Metab.* 2012; 25(1-2): 57-62. doi: [10.1515/jpem-2011-0277](https://doi.org/10.1515/jpem-2011-0277)

25. Anderson Se, Dallal Ge, Must A. Relative weight and race influence average age at menarche: Results from two nationally representative surveys of US girls studied 25 years apart. *Pediatr.* 2003; 111 (4): 844-850. doi: [10.1542/peds.111.4.844](https://doi.org/10.1542/peds.111.4.844)

26. Lakshman R, Forouhi NG, Sharp SJ, Luben R, Bingham SA, Khaw KT. Early age at menarche associated with cardiovascular disease and mortality. *J Clin Endocrinol Metab.* 2009; 94: 4953-4960. doi: [10.1210/jc.2009-1789](https://doi.org/10.1210/jc.2009-1789)

27. Census of India 2011 (India, States & Union territories) Basic Population Data. T00-005: Total Population, Population of Scheduled Castes and Scheduled Tribes and their proportion to the total population. Web site. https://censusindia.gov.in/tables_published/a-series/a-series_links/t_00_005.aspx. Accessed December 16, 2021.

28. Kimm SY, Barton BA, Obarzanek E, McMahon RP, Kronsberg SS, Waclawiw MA. Obesity development during adolescence in a biracial cohort: The NHLBI Growth and Health Study. *Pediatr.* 2002; 110: e54. doi: [10.1542/peds.110.5.e54](https://doi.org/10.1542/peds.110.5.e54)

29. Freedman DS, Khan LK, Serdula MK, Dietz WH, Srinivasan SR, Berenson GS. The relation of menarcheal age to obesity in childhood and adulthood: The Bogalusa Heart Study. *BMC Pediatr.* 2003; 3: 3. doi: [10.1186/1471-2431-3-3](https://doi.org/10.1186/1471-2431-3-3)

30. Sampei MA, Novo NF, Juliano Y, Colugnati FA, Sigulem DM. Anthropometry and body composition in ethnic Japanese and Caucasian adolescent girls: Considerations on ethnicity and menarche. *Int J Obes Relat Metab Disor.* 2003; 27: 1114-1120. doi: [10.1038/sj.ijo.0802374](https://doi.org/10.1038/sj.ijo.0802374)

31. Bhadra M, Mukhopadhyay A, Bose K. Body mass index, regional adiposity and central fat distribution among Bengalee Hindu girls: A comparative study of pre menarcheal and menarcheal subjects. *Acta Medica Auxologica.* 2001; 33: 39-45.

32. Bhadra M, Mukhopadhyay A, Bose K. Differences in body composition between pre menarcheal and menarcheal Bengalee Hindu girls of Madhyamgram, West Bengal. *Anthropol Sci.* 2005; 113: 141-145. doi: [10.1537/ase.040505](https://doi.org/10.1537/ase.040505)

33. World Health Organization (WHO). Physical status: The use and interpretation of anthropometry. *World Health Organ Tech Rep Ser.* 1995; 854: 1-452.

34. Slaughter MH, Lohman TG, Boileau RA, et al. Skinfold equation for estimation of body fatness in children and youth. *Hum Biol.* 1988; 60(5): 709-723.

35. VanItallie TB, Yang MU, Heymsfield SB, Funk RC, Boileau RA. Height normalized indices of the body's fat-free mass and fat mass: Potentially useful indicators of nutritional status. *Am J Clin Nutr.* 1990; 52: 953-959. doi: [10.1093/ajcn/52.6.953](https://doi.org/10.1093/ajcn/52.6.953)

36. Sil P. Body composition and somatotype profile of pre and post menarche stage of Bengali school girls. *Int J Physical Educ Sports Health.* 2021; 8(1): 210-212.

37. Guo SS, Wu W, Chumlea WC, Roche AF. Predicting overweight and obesity in adulthood from body mass index values in childhood and adolescence. *Am J Clin Nutr.* 2002; 76: 653-658. doi: [10.1093/ajcn/76.3.653](https://doi.org/10.1093/ajcn/76.3.653)

38. Feng Y, Hong X, Wilker E, et al. Effects of age at menarche, reproductive years, and menopause on metabolic risk factors for cardiovascular disease. *Atherosclerosis.* 2008; 196: 590-597. doi: [10.1016/j.atherosclerosis.2007.06.016](https://doi.org/10.1016/j.atherosclerosis.2007.06.016)

39. Bandini LG, Must A, Spadano JL, Dietz WH. Relation of body composition, parental overweight, pubertal stage, and race-ethnicity to energy expenditure among premenarcheal girls. *Am J Clin Nutr.* 2002; 76: 1040-1047. doi: [10.1093/ajcn/76.5.1040](https://doi.org/10.1093/ajcn/76.5.1040)
40. Bau Am, Ernert A, Schenk L, et al. Is there a further acceleration in the age at onset of menarche? A cross-sectional study in 1840 school children focusing on age and bodyweight at the onset of menarche. *Eur J Endocrinol.* 2009; 160: 107-113. doi: [10.1530/EJE-08-0594](https://doi.org/10.1530/EJE-08-0594)
41. Chatterjee D, Chanda S, Bandhapadhyay R. A comparative study on anthropometry and central body fat distribution of pre-menarcheal and post-menarcheal santal girls of Jharkhand. *Stud Tribes Tribals.* 2005; 3(2): 133-136. doi: [10.1080/0972639X.2005.11886530](https://doi.org/10.1080/0972639X.2005.11886530)
42. Rao S, Joshi S, Kanade A. Height velocity, body fat and menarcheal age of Indian girls. *Indian Pediat.* 1998; 35: 619-628.
43. Ziomkiewicz A, Koziel S. Grow first, gain fat in the meantime. Longitudinal study of anthropometric changes around menarche. *Anthropol Rev.* 2015; 78(2): 169-181. doi: [10.1515/anre-2015-0012](https://doi.org/10.1515/anre-2015-0012)
44. Kaplowitz PB, Slora EJ, Wasserman RC, Pedlow SE, Herman-Giddens ME. Earlier onset of puberty in girls: Relation to increased body mass index and race. *Paediatr.* 2001; 108: 347-353. doi: [10.1542/peds.108.2.347](https://doi.org/10.1542/peds.108.2.347)
45. Gerber B, Pienaar AE, Kruger A. Influences of differing menarche status on motor capabilities of girls, 13 to 16 years: A two-year follow-up study. *Int J Environ Res Public Health.* 2021; 18: 5539. doi: [10.3390/ijerph18115539](https://doi.org/10.3390/ijerph18115539)
46. Heitmann BL. Evaluation of body fat estimated from body mass index, skinfolds and impedance. A comparative study. *Eur J Clin Nut.* 1990; 44: 831-837.