Papers on Anthropology XXXIV/1–2, 2025, pp. 68–83

FACTORS ASSOCIATED WITH GENERAL AND CENTRAL OBESITY AMONG BENGALI ADOLESCENTS: A CROSS-SECTIONAL STUDY FROM NORTH BENGAL, INDIA

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ABSTRACT

Adolescent obesity is an emerging global health problem. The present study aims to assess the prevalence and factors associated with general and central obesity among adolescents. A community-based cross-sectional study was conducted among 390 Bengali adolescents (aged 11–17 years) in Darjeeling districts. Three anthropometric measurements (height, weight, and waist circumference) were taken. Both general and central obesity were determined. ANOVA, t-test, chi-square and binary logistic regression (BLR) were performed. Findings revealed that the overall prevalence of general obesity (BMI-based) was 22.1% (boys 21.8%, girls 22.3%), and central obesity (based on waist circumference and waist-to-height ratio) was 44.6% (boys 43.1%, girls 46.1%), and 26.1% (boys 28.9%, girls 24.4%) respectively. Chi square revealed no significant association between gender and obesity (both general and central). Our findings showed that the number of siblings was the most crucial factor associated with adolescent obesity. Father's and mother's education, and family income were also found to be associated with central obesity. Proper awareness along with dietary and lifestyle changes can alter the situation.

Keywords: *central obesity; BMI; waist circumference; waist-to-height ratio; Bengali adolescents; Darjeeling*

https://doi.org/10.12697/poa.2025.34.1-2.05

INTRODUCTION

Obesity is the excessive accumulation of body fat. In contrast, central or abdominal obesity is the excess fat accumulation in the abdominal area due to excess visceral mass. It has become a serious health problem not only in developed and developing countries [1–3], but it has also been rising in low-middle income countries [2]. Obesity has been found to be associated with significant co-morbidities and health problems such, as diabetes mellitus and hypertension among children or at a younger age [4]. India is predicted to have more than 27 million obese children, representing one out of ten children globally, by 2030 [5]. From a recent systematic review, the prevalence of overweight and obesity among Indian adolescents was found to range from 2.2–25.8% and 0.73–14.6%, respectively [6]. Though BMI is widely used to evaluate nutritional status among adolescents and adults, BMI does not relate to central obesity as it cannot differentiate muscle mass from bone and fat mass [7]. Its diagnostic accuracy is debatable as it often leads to an inaccurate assessment of adiposity; hence, it is essential to incorporate additional indicators, such as waist circumference along with BMI, to accurately assess the risk of obesity-related diseases [8]. WHtR is more accepted in cardiovascular risk factor assessment than BMI and percentage of body fat [9].

The frequency and severity of obesity in children and adolescents have also increased with a global increase in its prevalence in preschool children since 1990 in over 144 countries [10]. Central obesity can also be considered a leading cause of type 1 diabetes, higher levels of LDL-Cholesterol and low bone mass [11], and it has also been found to be associated with school absence, more visits to physicians, and lower health quality of life [12]. The prevalence of central obesity among children and adolescents in different developed countries, such as the US (from 10.5% to 18.0% between 1988–1994 and 1999–2004) or China (from 4.9% in 1993 to 11.7% in 2009), has increased [13]. A very recent systematic review found that the prevalence of central obesity among children and adolescents of Africa by WHtR ranged from 2.0–41% and by waist circumference from 9–35% [14]. Recent Indian studies found that the prevalence of central obesity among adolescents ranged from 5.66%–28.5% [15–18].

From the literature, we found that most of the studies on central obesity or abdominal obesity in West Bengal have been conducted by different researchers among adults [19–24]. We found one recent study on central obesity [25] that was conducted among school children (aged 8–16 years) in rural southern West Bengal. As data from North Bengal concerning central obesity and its associated factors among adolescents are less available, the present study will try to find the

associations of different socio-economic and demographic factors with obesity (both general and central) among school-going adolescents (aged 11–17 years) residing in the area of Matigara block of Darjeeling district, West Bengal, India.

MATERIALS AND METHODS

Study population and area

The present cross-sectional community-based study was conducted among adolescents aged 11–17 years belonging to the Bengali-speaking Hindu population. Three Bengali-medium higher secondary schools located in Matigara block of Darjeeling were selected. Before data collection, the study objective was clearly explained to the school authorities, and necessary consent was taken. Verbal consent was also obtained from the participants and their parents. The data were collected during July-September 2023. At first, 400 samples were collected, but after scrutinizing the data, ten schedules were found incomplete and were hence rejected. Thus, the final sample was 390 (197 girls and 193 boys). The study was in accordance with the ethical guidelines for human experiments as laid down in the Helsinki Declaration of 2000 [26]. The study protocol was approved by the Institutional Research Body of the University.

Anthropometric data collection

Using the standard procedures, anthropometric measurements were recorded by the first author in the above-said group [27]. Height was measured to the nearest 0.1 cm using an anthropometer rod, and weight was recorded using a weighing machine to the nearest 0.1 kg. Waist circumference was measured using a non-stretchable measuring tape to the nearest 0.1 cm. To check the reliability and reproducibility of the anthropometric measurements, technical error measurements (TEM) were calculated, and the errors were found to be within the reference values [28].

Cut-off values

The presence of general obesity was determined by WHO 2007 [29] age- and sex-specific BMI percentiles (< 5th percentile as underweight, 5th to < 85th percentile as normal, 85th to < 95th percentile as overweight, and ≥ 95th percentile as obese). For central obesity, waist circumference (WC percentile) and

waist-to-height ratio (WHtR) were considered. Central obesity based on WC was determined by the age- and sex-specific WC ≥ 90th percentile for Indian adolescents aged 5–19 years [30]. For WHtR-based central obesity, a WHtR ≥ 0.5 cut-off, used in different studies [18, 31–32] irrespective of age and sex, was used.

Socio-economic and demographic data

A pre-tested structured schedule was used to collect the socio-economic and demographic data, and each variable was coded into two types (except family income). The data were recorded on birth order (1–2 or ≥ 3), number of siblings (having no siblings or one and ≥ 2), family type (nuclear and joint or others), father's occupation (manual workers, professionals and others including business), mother's occupation (housewife and working), father's and mother's education (up to upper primary / secondary and above), family income (low, medium and high). The categorization of family income (in Indian rupees) as low, medium, and high was divided as < 10,000, 10,000–17,999, and 18,000 and above, respectively. Details are given in Table 3 (Results section).

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 26 was used for statistical analysis. Anthropometric variables were described by descriptive statistics (mean ± standard deviation). Independent t-test was performed to test the sex-specific variation in anthropometric measurements among the participants. A chi-square test was also done to find the significance of the difference between obesity and gender. Binary logistic regression (BLR) analysis was done to estimate the association of generalized and central obesity with socio-economic and demographic variables. As this analysis allows us to create dichotomous dependent variables, hence for generalized obesity, 'underweight and normal' was coded as 0, and 'overweight and obesity' called 'general obesity' was coded as 1. For central obesity (WC- and WHtR-based), 0 was coded as normal, and 1 as centrally obese. The predictor variables, such as gender, birth order, number of siblings, family type, parents' occupation, parents' education, and family income were entered as dummy variables and compared with the reference categories. A p-value set to < 0.05 was considered statistically significant.

RESULTS

Descriptive statistics (mean ± standard deviation) of height, weight, BMI, WC, and WHtR are represented in Table 1. The mean height of boys was 156.11 ± 11.07 cm and of girls 148.68 ± 6.45 cm. Boys were also found to be heavier than girls (47.66 ± 14.17 vs. 44.29 ± 11.83 kg). BMI was found to be greater in girls (19.90 ± 4.61 kg/m^2) compared to boys (19.24 ± 4.12 kg/m^2). The mean value of waist circumference (WC) was also higher among boys (71.21 ± 11.47 cm) than in girls (68.72 ± 9.73 cm). The mean waist-to-height ratio (WHtR) was higher among girls (0.462 ± 0.061). Independent t-test showed a significant sex difference in height, weight and WC.

Table1. Descriptive statistics (mean ± SD) of the anthropometric variables

Variables	Boys	Girls	t-value
	(mean ± SD)	(mean ± SD)	
Age (years)	13.99 ± 2.00	13.99 ± 2.03	
Height (cm)	156.11 ± 11.07	148.68 ± 6.45	–8.144***
Weight (kg)	47.66 ± 14.17	44.29 ± 11.83	–2.554*
BMI (kg/m^2)	19.24 ± 4.12	19.90 ± 4.61	1.489
WC (cm)	71.21 ± 11.47	68.72 ± 9.73	–2.309*
WHtR	0.455 ± 0.062	0.462 ± 0.061	1.009

SD = standard deviation; BMI = body mass index; WC = waist circumference; WHtR = waist-to-height ratio; */*** t-value represents significant sex-difference in the anthropometric variables (at $p < 0.05$, < 0.001).

The prevalence of general and central obesity is shown in Table 2. The overall prevalence of generalized obesity was 22.1%, and that of central obesity (WC and WHtR) was 44.6% and 23.7% respectively. Girls had higher prevalence of obesity (except WHtR-based central obesity) than boys. Chi-square exhibited no significant association between gender and obesity (both generalized and central) among the study participants.

Table 2. Prevalence of general obesity (based on BMI) and central obesity (based on WC and WHtR) among the adolescents

Anthropometric Assessment	Category	Boys (N = 193)	Girls (N = 197)	Total (N = 390)
BMI Percentile (WHO, 2007)	Underweight and normal	151 (78.2%)	153 (77.7%)	304 (77.9%)
	Overweight and obesity	42 (21.8%)	44 (22.3%)	86 (22.1%)
	χ^2		0.019 (NS)	
WC percentile (Sarna et al. 2021)	Normal	104 (53.9%)	112 (56.9%)	216 (55.4%)
	Central obesity	85 (43.1%)	89 (46.1%)	174 (44.6%)
	χ^2		0.347 (NS)	
WHtR (≥0.5)	Normal	146 (75.6%)	140 (71.1%)	286 (73.3%)
	Central obesity	57 (28.9%)	47 (24.4%)	104 (26.7%)
	χ^2		1.046 (NS)	

BMI percentile = body mass index percentile; WC percentile = waist circumference percentile; WHtR = waist-to-height ratio; N = number of individuals; NS = statistically not significant.

The results of binary logistic regression analysis fitted to estimate the crude odds of being obese or centrally obese with socio-economic and demographic parameters are represented in Table 3. The results showed that adolescents with more siblings (≥ 2) exhibited 0.382 times greater odds (95% CI: 0.176–0.829) of being obese (general) than their counterparts having no siblings or only one. Moreover, the association was significant. The odds of general obesity were 1.104 times higher among adolescents who belonged to a joint family and 1.168 times higher among those having fathers with a lower education level (up to upper primary). However, the associations were found to be insignificant.

For WC-based central obesity, boys showed insignificantly higher odds (OR-1.098, 95% CI: 0.719-1.678) of being centrally obese than girls. Significantly higher odds for being centrally obese were observed for adolescents with more siblings (OR-0.489, CI: 0.280-0.854), father's occupation (manual worker) (OR-0.553, CI: 0.356-0.859), mother's education with upper primary level (OR-0.5825, CI: 0.366-0.924) and belonging to middle-income family groups (OR-0.561, CI: 0.343-0.918). Father's education also showed a higher insignificant odds ratio of being affected by central obesity (OR-1.095, CI: 0.685-1.751) among the adolescents with father's lower educational level than those whose fathers had secondary and higher education.

Concerning the waist-to-height ratio, the BLR analysis showed that adolescents having ≥ 2 siblings exhibited 0.363 times higher significant odds ratio (CI: 0.181-0.728) of being centrally obese that those having no siblings or only

one. Adolescents whose fathers were manual workers were found to exhibit a significantly higher odds ratio (OR-0.613, CI: 0.377-0.997). Father's education (OR-1.383, CI: 0.817-2.341) and belonging to a joint family (OR- 1.201, CI: 0.677-2.129) showed a higher insignificant odds ratio.

Table 3. Binary logistic regression (BLR) analysis showing associations of socioeconomic and demographic variables with general and central obesity

Variables (frequency distribution)		Binary logistic regression					
		General obesity (based on BMI)		Central obesity (based on WC)		Central obesity (based on WHtR)	
		Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Gender	Girls (197)®	–	–	–	–	–	–
	Boys (193)	0.936	0.569–1.539	1.098	0.719–1.678	0.754	0.472–1.204
Birth order	1 or 2 (219)®	–	–	–	–	–	–
	≥ 3 (171)	0.730	0.427–1.251	0.828	0.525–1.306	0.874	0.530–1.441
Number of sibs	No sibs or one (303)®	–	–	–	–	–	–
	≥2 (87)	0.382*	0.176–0.829	0.489*	0.280–0.854	0.363**	0.181–0.728
Family type	Nuclear (285)®	–	–	–	–	–	–
	Joint (83)	1.104	0.600–2.032	0.912	0.534–1.555	1.201	0.677–2.129
	Others (22)	0.699	0.221–2.209	0.911	0.367–2.264	0.797	0.274–2.319
Father's occupation	Manual works (229)	0.709	0.423–1.191	0.553**	0.356–0.859	0.613*	0.377–0.997
	Professional ans others (161)®	–	–	–	–	–	–
Mother's occupation	Housewife (268)	0.878	0.508–1.517	0.838	0.524–1.339	0.952	0.569–1.593
	Working (122)®	–	–	–	–	–	–
Father's education	≤ Upper primary (225)	1.168	0.670–2.036	1.095	0.685–1.751	1.383	0.817–2.341
	Secondary and above (165)®	–	–	–	–	–	–
Mother's education	≤ Upper primary (206)	0.679	0.391–1.181	0.582*	0.366–0.924	0.787	0.469–1.324
	Secondary and above (184)®	–	–	–	–	–	–
Family income	Low (76)	0.939	0.467–1.887	0.813	0.448–1.475	0.900	0.465–1.744
	Middle (176)	0.723	0.406–1.288	0.561*	0.343–0.918	0.784	0.457–1.346
	High (138)®	–	–	–	–	–	–

95% CI = 95% confidence interval; ® = reference category; */** statistically significant odds ratio (at $p < 0.05$; < 0.01). The number in parenthesis represents the number of individuals in that category.

DISCUSSION

The present study reported a high prevalence of both general and central obesity, and the percentage of prevalence was higher in girls. Sitaula et al. had found a significantly higher prevalence of overweight/obesity among females than males belonging to the age group of 11–21 years [33]. The prevalence of total general (overweight and obesity) and central obesity among adolescents (10–18 years) in north India was found to be 14.2% and 5.4%, which is lower than in our findings [34]. Comparison of the present study with other studies (both Indian and international) is presented in Tables 4 and 5.

Table 4. Comparison of prevalence of general obesity (based on BMI percentile) among adolescents of different countries including India with the population of the present study

Criteria	Type of study	Authors (year)	Area (cut-offs used)	Sample size	Age group (years)	Prevalence of general obesity (overweight + obesity)		
						Boys	Girls	Total
BMI	International	Duan et al. (2020) [35]	China (BMI cut-off points specifically developed for the Chinese adolescent population)	1955	11–18	26.2%	13.2%	17.6%
		Abdullatif et al. (2021 [36]	Dubai (WHO (BMI growth charts for age and sex)	1683	12–18	43.2%	39.0%	41.0%
		Kadim et al. (2023) [37]	Iraq (International classification by Hockenberry and Wilson, 2015)	500	14–19	53.90%	28.89%	43.2%
		Sitaula et al. (2023) [33]	Nepal (AsiaPacific claasification of BMI)	267	11–21	12.6%	39.6%	29.2%
	Indian	Sinha (2019) [38]	Bihar (BMI percentile curves for Indian adolescents)	900	10–19	31.01%	16.67%	24.3%
		Goyal et al. (2020) [39]	Haryana (WHO BMI classification)	1600	10–19	25.12%	27.09%	26.0%
		Rathoria et al. (2021) [40]	Uttar Pradesh (CDC BMI-for-age)	415	10–19	12.44%	17.48%	14.94%
		Present Study	Darjeeling, West Bengal (BMI percentile, WHO 2007)	390	11–17	21.8%	22.3%	22.1%

Table 5. Comparison of prevalence of central obesity (based on waist circumference and WHtR) among adolescents of different countries including India with the population of the present study

Criteria	Type of study	Authors (year)	Area	Sample size	Age group (years)	Prevalence of central obesity		
						Boys	Girls	Total
Waist circumference	International	Castro et al. (2016) [41]	Brazil	930	14–19	10.5%	10.8%	10.6%
		Tebar et al. (2017) [42]	Brazil	1231	14–17	20.9%	15.0%	17.5%
		El-Kassas, Ziade (2017) [32]	Lebanon	311	11–16	50.7%	34.1%	41.8%
		Chew et al. (2018) [13]	Malaysia	832	15–17	35.1%	64.9%	11.3%
		Palacio-Agüero et al. (2020) [43]	Chile	491	10–17	11.5%	8.5%	10.0%
	Indian	Singh et al. (2013) [17]	Jammu	1160	10–18	–	–	5.66%
		Harish et al. (2014) [15]	Karnataka	4663	11–16	6.03%	8.85%	7.59%
		Suganthi et al. (2017) [18]	Tamil Nadu	859	11–15	10.0%	22.0%	18.0%
		Nawab et al. (2019) [16]	Aligarh	660	10–16	24.7%	33.6%	28.5%
		Present Study	Darjeeling, West Bengal	390	11–17	46.1%	43.1%	44.6%
Waist-to-height ratio (WHtR)	International	El-Kassas, Ziade (2017) [32]	Lebanon	311	11–16	47.9%	29.9%	38.3%
		Błaszczyk-Bębenek et al. (2019) [31]	Poland	309	16–18	12.8%	8.9%	10.7%
	Indian	Suganthi et al. (2017) [18]	Tamil Nadu	859	11–15	7.0%	17.0%	14.0%
		Present Study	Darjeeling, West Bengal	390	11–17	24.4%	28.9%	26.7%

Gender has been found to be associated with obesity among adolescents [5], but our study did not find such an association. The present study found that the number of siblings was associated with both general and central obesity among the Bengali adolescents. Kuriyan et al. reported that younger siblings' abdominal/central adiposity was associated with the obesity of his/her siblings and parents [44]. Some studies [45, 46] have reported that single children were more likely to be overweight and obese than those having more siblings. Differences in obesity prevalence between boys and girls can be influenced by socio-cultural factors such as parents, family, dietary habits and consuming more junk foods. Some evidence suggests that girls from higher income countries may prefer to consume low-calorie and nutrient-dense foods whereas boys tend to eat more meat and calorie-dense foods [47]. In our study, the probable reason for no clear gender difference may be the data collection period. As the data were collected

during the post-covid period just after the reopening of schools, both boys and girls had been living a sedentary life for a longer time without any outdoor physical activities. Our finding related to the association of a greater number of siblings with adolescent obesity was just opposite to the previous findings [45–46]. It is not possible to give a clear-cut explanation as this study lacks some necessary data, but the reasons may be the sedentary lifestyle during data collection period, family history of obesity, dietary pattern, and/or less physical activity. Differences in the measurement methods, population characteristics (such as ethnicity, gender, age, socioeconomic status, etc.), the study design and/or methodology can cause a significant variation which could be the reason for differences in general and central obesity in different studies.

Gautam and Jeong have also reported father's occupation as an associated factor for adolescents' obesity, but parents' education did not exhibit any significant association with obesity in their study [48]. Alqarni et al. showed no significant relation between BMI categories and father's and mother's education, but they found that children were obese if they had an employed father and a non-working mother [49]. Costa de Oliveira Forkert et al. found an inverse association between parents' education levels and father's occupation levels ($p < 0.001$) with WHtR and WC in HELENA-CSS (Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study) girls, and in boys the same significant association was found with maternal occupation. The same study reported that socio-economic indicators by socio-economic status and maternal occupation level were associated with WHtR, and in boys an association was found between parents' education and WHtR [50]. Ferreira et al. found that the prevalence of general and abdominal obesity was high among the adolescents who resided in the low-income region. They also found that the boys from families with a high socioeconomic status were more prone to have both general and abdominal/central obesity [51]. The present study found that father's occupation, mother's education and family income were associated with central obesity. Hence, it can be said that the present findings were in line with the findings of the previous studies.

The prevalence of overweight and obesity in schoolchildren and adolescents has been found to have doubled or tripled throughout several developed and developing countries [32]. Kesztyüs et al. have reported that central obesity in children was found to be associated with higher rates of school absence, more visits to physicians and lower health-related quality of life [12]. Hence, it is important to prevent both central and general obesity among children and adolescents. Although this study might add some knowledge to the existing

literature, it also had some limitations, such as being cross-sectional with a small sample size. The study also lacks data on physical activities or sedentary behaviour and/or eating habits, which might have some direct or indirect impact on obesity among adolescents.

CONCLUSION

The present study reported a high prevalence of obesity (either general or central) among adolescents. Girls were more obese compared than boys. Several socioeconomic and demographic factors significantly influenced the prevalence of central obesity among adolescents, such as the number of siblings, father's occupation, mother's education, and family income. General obesity showed a significant association with the number of siblings. As the tendency to be obese was so high among the studied participants, urgent steps should be taken to combat such a situation. Proper awareness related to dietary habits and exercise can alter the situation.

ACKNOWLEDGEMENTS

The authors acknowledge greatly the extended help and cooperation of the school authorities, the participants and their parents, along with the Department of Anthropology, University of North Bengal.

Conflict of interest: None

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