

Risk Factors Associated with Very Early Menarche Among School Children: An Analytical Cross-Sectional Study

Dr. Vijaiyalakshmi Praveen¹; Dr. Harshana Devi²;
Dr. Induja S.³; Dr. Pavithra K.⁴; Dr. Arun Murugan⁵

¹Assistant Professor, Department of Community Medicine, Government Medical College, Omandurar Government Estate

²RA, CRMI, M.B.B.S, Government Medical College, Omandurar Government Estate

³CRMI, M.B.B.S, Government Medical College, Omandurar Government Estate

⁴Assistant Professor, Department of Community Medicine, Government Medical College, Omandurar Government Estate

⁵Head of Department, Department of Community Medicine, Government Medical College, Omandurar Government Estate

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Abstract:

➤ *Background*

The term puberty can be described as the stage during which an individual reaches his/her sexual maturity. Alternatively, the term menarche refers to the age during which women undergo their first menstrual cycle. In India, the average age at which women have their first menstruation is 13.76 years. Very early menarche, especially those who have menarche before 11 years, leads to numerous ailments including breast cancer, Type 2 diabetes, depression, metabolic syndrome, and psychosocial diseases. Consumption of sweet beverages is one of the risk factors for menarche. Nonetheless, there is no study conducted on the relationship between consumption of sweet beverages and menarche among girls in south India.

➤ *Objective*

To determine the prevalence rate of very early menarche (<11 years) among the government school-going females aged 8-16 years in Chennai, Tamil Nadu, India, as well as the different factors leading to menarche.

➤ *Methods*

An analytical cross-sectional study was carried out in January 2023-March 2023 among 361 government school girls within the age group of 8-16 years in Chennai, Tamil Nadu. Convenience sampling was done for schools while simple random sampling was employed to select study subjects. Data on beverage consumption, physical activity, sleeping patterns, and food preferences were obtained through a valid semi-structured questionnaire. Chi-square test was performed for bivariate analysis.

➤ *Results*

Total of 275 respondents (76.2%) were categorized as having very early menarche aged <11 years old. There is a significant association between consumption of sugar and honey in drinks and the groups of menarche ($\chi^2=10.041$, $df=4$, $p=0.040$). High consumption frequency of sugar category (≥ 3 times per week) was more prevalent in the standard group (39.5%) compared to very early menarche group (24.0%), with the odd ratio being 0.48 (95% CI 0.29–0.81). Having a taste of flavoured juices also had significant correlation with groups of menarche ($\chi^2=13.640$, $df=4$, $p=0.009$). Respondents from very early menarche had 45.5% going to bed after 11:00 PM, 72.4% of them engaged in exercise less than twice a week and 49.8% of them prefer to have packaged foods.

➤ *Conclusion*

Very early menarche is frequent among our cohort. There have been some significant associations found with sweetened drinks intake and preference for the type of drinks. The unique association must be interpreted cautiously in view of the reality that more analysis needs to be done based on the standard definition of early menarche (<12 years) after controlling for confounders such as BMI and socio-economic status.

Keywords: *Very Early Menarche; Early Menarche; Sugar-Sweetened Drinks; Eating Practices; Lifestyle Variables; Teenage Wellbeing; Chennai; Cross-Sectional Survey.*

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I. INTRODUCTION

Menarche is defined as the first time that a girl gets her period, marking the beginning of her fertility.[1,29] Menstruation is characterized by the release of hormones through the hypothalamus, pituitary, and ovaries. The increase in estrogen level causes the uterus to develop enough to shed its lining.[1] It is necessary to assess the menstrual cycle to determine the hormonal state and identify any problems that might arise in the future.[1] Many studies have been conducted on Indians, revealing that the average age of menarche is about 13 years, although there is a downward trend among younger individuals.[3,22]

Early menarche or premature menarche is defined as menarche in women below 12 years, while premature menarche or early menarche is menarche in girls below 11 years, which will be the focus of this research.[2] Genes significantly influence the age of menarche. Children whose mothers had menarche early have a 2.16 times greater likelihood of developing premature menarche than children whose mothers had menarche at an expected age.[7] Behaviors have a significant impact on premature menarche as consuming high-calorie fast foods leads to obesity and consequently high estrogen and leptin levels.[8,18]

A number of negative effects are associated with precocious and early menarche, which include metabolic syndrome, type 2 diabetes, insulin resistance, dyslipidemia, cardiovascular disease, and stroke.[24,2] Psychosocial problems such as depression, anxiety, suicidal behaviors, and abuse of alcohol and other drugs are mentioned among the associated factors.[5,2]. Early menarche poses a higher risk of developing breast cancer at 23% greater risk than that developed after menarche occurring when the child reaches 15 years of age.[23] Early closure of the epiphysis due to increased estrogen exposure causes stunted growth as opposed to genetically programmed growth.[2]

Though much evidence exists about the effects of very early menarche, information in literature on risk factors that could be modified by food habits and lifestyle of urban schoolchildren in South India is sparse.[28] This study was therefore undertaken to assess the prevalence of very early menarche among girls attending government schools in Chennai and analyze possible dietary and lifestyle risk factors, particularly intake of SSBs.[26,21,25]

II. MATERIALS AND METHODS

➤ *Study Design and Site of the Study*

The cross-sectional study design was employed from January 2023 to March 2023 based on school-aged children in the Government Schools present in Chennai, Tamil Nadu state, India. Chennai is one of the largest metropolitans of South India with an estimated population of 7.1 million and most of the lower-middle socioeconomic status people use the Government schools.

➤ *Participants*

Participants in this study consisted of young female students aged between 8 and 16 years studying at schools within the study location of Chennai. Criteria for inclusion in this study were: young females aged 8-16 years; participants must be enrolled at one of the schools participating in the study and provide assent (participants) and parental consent (parent/legal guardian). Criteria for exclusion in this study were: below 8 years or above 16 years; non-participation in this study; lack of parental/guardian consent; genetic/endocrine disorders that affect pubertal development; lack of school consent to use the relevant data.

➤ *Sampling Strategy*

The two stages of sampling involved convenience sampling of schools based on a list of schools in Chennai followed by enumeration and then selection using simple random sampling of young female participants who fulfilled the eligibility criteria in the selected schools.

➤ *Sample Size*

The number of participants was calculated using the formula to find the number of people needed for one proportion:

$n = Z^2 \times p(1-p) / e^2$, where $Z = 1.96$ (confidence interval at 95%), $p = 0.50$ (expected prevalence rate of early menarche; sample size will be largest if there is no prior information on the prevalence rate), and $e = 0.05$ (error margin). The total number of participants required was 384 or more. Allowing for 10% non-response and participant availability from selected schools, the target number of participants was 360.

➤ *Outcome and Exposure Variables*

The outcome variable was very early menarche, which was defined for this study as menarche occurring at under 11 years old. The definition is stricter than the generally accepted benchmark of age less than 12 years, considering the ages of subjects included in this research (8 to 16 years) and the anticipated few subjects above 12 years who had not experienced menarche. Anyone intending to make comparisons between the results from this study and others published previously will require doing sensitivity analysis using the benchmark.

The exposure variable was the frequency of drinking sugar and/or honey in their hot drinks (tea, coffee, and lassi). Other secondary exposure variables were: most commonly consumed drink (flavoured juice, soft drinks and soda, coffee or tea, energy drinks, fresh fruit juice), bedtime routine, exercise habits once a week, and preference for food types when eating out of home (fast food, packaged food, and restaurant meals).

➤ *Data Collection Instrument*

Data was collected using a structured questionnaire which contained five components: (i) sociodemographic information; (ii) menstrual history including recollection of the age of menarche; (iii) beverage intake; (iv) physical activity; and (v) sleep and dietary practices. This was done using a questionnaire designed by the researchers with items drawn from existing literature on adolescence health research. The questionnaire was first pilot-tested among twenty students who did not take part in the study and then refined to increase readability. The questionnaire was administered in Tamil with English translations provided. Data was entered by two separate data entry operators into Microsoft Excel.

➤ *Bias Mitigation*

The following sources of bias were expected and addressed before the conduct of the study. Selection bias was eliminated through random sampling among participants in each class rather than voluntary participation. Social desirability bias was reduced by conducting the survey anonymously in a closed room without teachers being present. Recall bias was minimized by allowing students to check their diary entries or maternal records and have mothers or guardians present for assistance. Interviewer bias was reduced through female interviewers. Despite these measures, residual recall bias cannot be excluded, particularly for participants who experienced menarche several years before the study date.

➤ *Ethical Considerations*

Approval for the study was provided by the Ethics committee of Government Medical College, Omandurar Medical College. Informed consent forms were signed by the parents/ guardians of the study participants, while written assent was signed by individuals who were 12 years or older.

III. STATISTICAL ANALYSIS

Data analysis was done using the software IBM SPSS Statistics. The use of descriptive statistics (frequencies, percentages, means, and standard deviations) was employed to describe the characteristics of the sample population under study. Associations were determined by use of chi-squared analysis (χ^2). Odds ratios (OR) with 95% confidence intervals (CI) were computed where a two-by-two comparison could be done. Statistical significance was set at p-value < 0.05. Logistic regression analysis adjusted for age, BMI, and socioeconomic status would have been carried out, however, it proved impossible because BMI and SES information was not obtained from the respondents. This is a critical shortcoming and highly advised in subsequent researches. Missing values were determined; no case was found of missing data in the main variable. Only one completed questionnaire failed to provide full information in the sociodemographic part; the respondent was included in the analysis for all the other variables leading to N = 361 in the chi-square calculations instead of the N = 360 set in the beginning.

IV. RESULTS

➤ *Study Participants and Baseline Data*

Of the 420 students evaluated from the selected schools, 59 students were considered ineligible (34 because their parents denied consent, 15 because of student refusals, and 10 due to ineligible ages). A total of 361 students were thus included and participated in completing the survey. The response rate among those eligible and providing consent was 100% because this was a one-time cross-sectional analysis.

The baseline characteristics of study participants are shown in Table 1. Mean age of study participants was 12.3 ± 2.1 years (range 8-16). The study participants had all studied in government schools in Chennai. No information was obtained about BMI and socioeconomic status because they were not considered in the current study; however, these should be taken into consideration in future studies.

Table 1. Baseline Characteristics of Participants by Menarche Group (n = 361)

| Characteristic | Total (n = 361) | Very early menarche < 11 yrs (n = 275) | Standard menarche ≥ 11 yrs (n = 86) | p-value |
|---------------------------------|-----------------|--|-------------------------------------|---------|
| Age group (years), n (%) | | | | |
| 8 – 9 years | 41 (11.4) | 35 (12.7) | 6 (7.0) | |
| 10 – 11 years | 98 (27.1) | 85 (30.9) | 13 (15.1) | |
| 12 – 13 years | 142 (39.3) | 101 (36.7) | 41 (47.7) | |

| | | | | |
|----------------------------------|------------|------------|------------|---------|
| 14 – 16 years | 80 (22.2) | 54 (19.6) | 26 (30.2) | |
| School type | Government | Government | Government | — |
| Menarche age — mean ± SD (years) | — | 9.7 ± 0.9 | 12.1 ± 0.8 | < 0.001 |

➤ *Very Early Menarche Prevalence*

Out of 361 subjects, 275 (76.2%) were from the very early menarche category, where they started menstruating

before reaching 11 years of age, while 86 (23.8%) were from the standard menarche category, where they began menstruating at the age of 11 years or above.

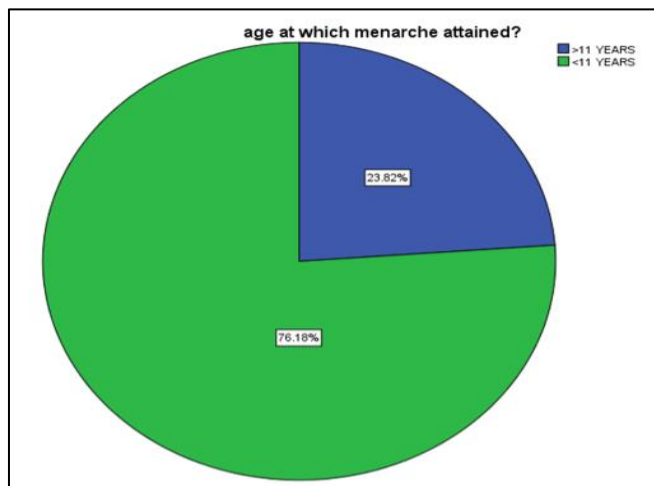


Fig 1. Age at Which Menarche was Attained (n = 361)

➤ *Frequency of Intake of Sugar or Honey in Beverages*

Figure 2 shows the frequency of intake of sugar or honey in hot beverages such as tea, coffee, and lassi among the two menarche categories. Both categories reported moderate consumption of sugar (once or twice per week) as the most common practice. Intake of high frequency of sugar or honey (three times or more per week or daily basis) was observed higher in the standard menarche category compared to very early menarche. The chi-square test of total data was significantly different ($\chi^2 = 10.041$, $df = 4$, $p = 0.040$).

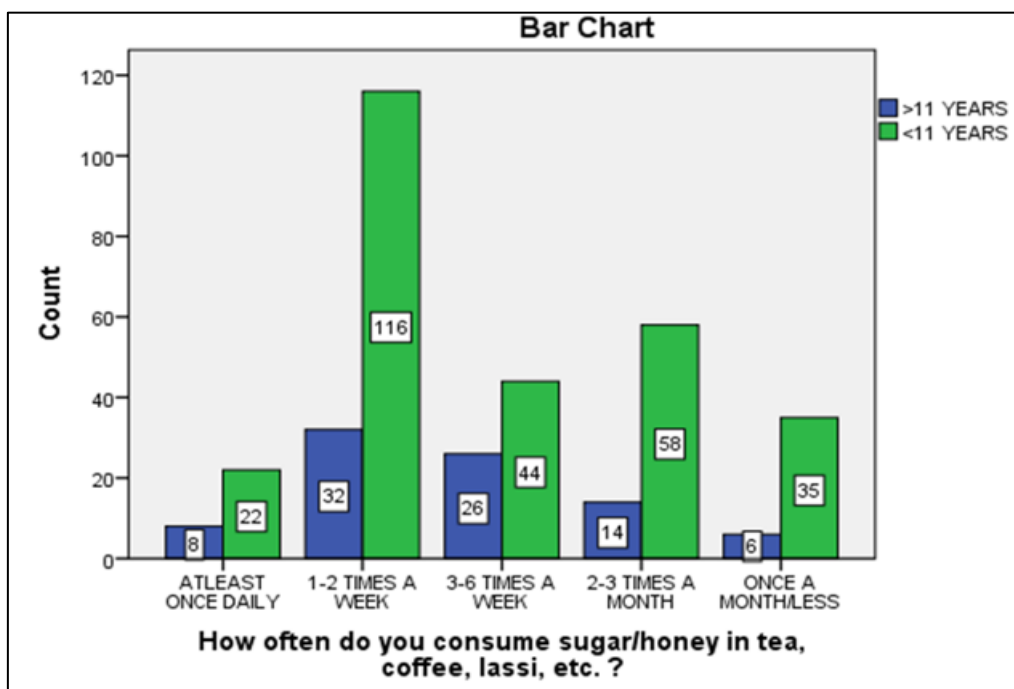


Fig 2. Bar chart: Frequency of Sugar/Honey Consumption in Beverages by Menarche Group

Table 2. Chi-Square Test: Frequency of Sugar/Honey in Beverages vs. Menarche Group (n = 361)

| | Value | df | Asymp. Sig. (2-sided) |
|--------------------|--------|----|-----------------------|
| Pearson Chi-Square | 10.041 | 4 | .040 |
| Likelihood Ratio | 9.636 | 4 | .047 |
| N of Valid Cases | 361 | | |

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.15.

➤ Preferred Types of Drinks

Figure 3 depicts the frequency distribution of preferred types of drinks. Flavored juice emerged as the preferred type of drink among the girls who started their menstruation cycle very early at 41.5% against 32.6% for the standard age of menarche. There was a statistical significance between these variables ($\chi^2 = 13.640$, $df = 4$, $p = 0.009$).

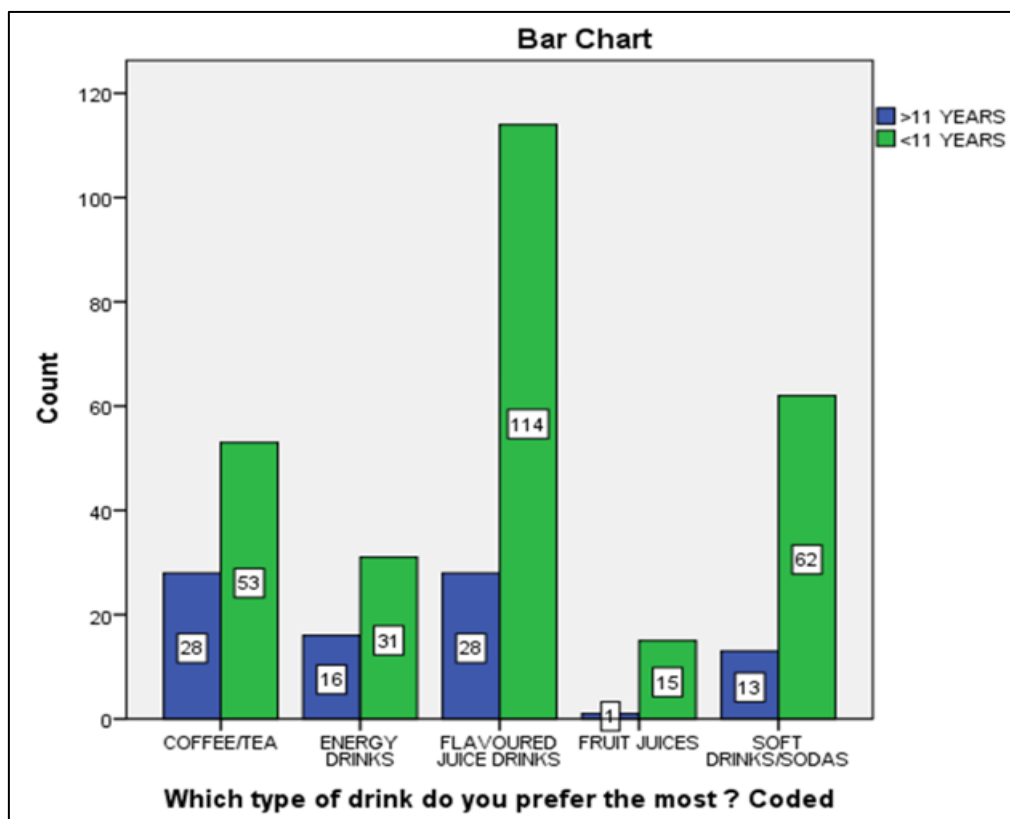


Fig 3. Bar Chart: Preferred Drink Type by Menarche Group

Table 3. Chi-Square Test: Preferred Drink Type vs. Menarche Group (n = 361)

| | Value | df | Asymp. Sig. (2-sided) |
|--------------------|--------|----|-----------------------|
| Pearson Chi-Square | 13.640 | 4 | .009 |
| Likelihood Ratio | 14.018 | 4 | .007 |
| N of Valid Cases | 361 | | |

a. 1 cells (10.0%) have expected count less than 5. The minimum expected count is 3.81.

V. DISCUSSION

A cross-sectional study was conducted to assess factors that are responsible for very early menarche (< 11 years) in government schoolgirls aged 8-16 years in Chennai, Tamil Nadu. Significant associations were found with sugar/honey consumption frequency in drinks ($p = 0.040$) and drink preference ($p = 0.009$). These are preliminary findings from this study and the remaining discussion explains them in relation to the available literature.

➤ Prevalence of Very Early Menarche

The prevalence of very early menarche (76.2%) obtained in this study was much higher compared to other Indian population-based studies that reported 10%-30% prevalence of early menarche based on < 12 years as the cutoff. This high prevalence can be mainly attributed to the stricter cut-off age and age distribution of the current sample as well. For comparison with population studies, analysis has to be conducted using the < 12 years cut-off age.

➤ *Consumption of Sugary Beverages*

However, against the hypothesis, frequent intake of sugars in hot drinks (≥ 3 per week) occurred more often in the standard menarche group than the very early menarche group (39.5% and 24.0%, respectively; OR 0.48, 95% CI 0.29-0.81). The overall chi-square was statistically significant ($p = 0.040$), indicating a significant disparity in the distribution of frequency of sugar intake between the two groups, but not in the predicted direction for high frequency of consumption. Some possible reasons for this include that the <11 -year cut-off may have coincidentally selected those whose menarcheal status depends more on their genetic make-up than dietary habits; older adolescents in the standard group (still awaiting or who have just undergone menarche within 11 to 13 years) would have been under the influence of sugary drinks for longer periods. Multivariate logistic regression analysis adjusted for the effect of age, BMI, genetic susceptibility, and socio-economic background is needed before the direction of this relationship could be conclusively stated. Studies using <12 years cut-off have found a positive correlation between SSBs and menarche (Carwile et al., 2015; Mueller et al., 2015); this is worthy of elaboration in the Discussion section of the paper.

➤ *Preferred Drink*

There was a significant overall chi-square value for preferred drink ($p = 0.009$) due to its distribution across all five groups rather than a binary comparison between flavoured juice and other drinks. The former was significantly preferred among those with very early menarche (41.5%) while the latter (coffee/tea) was significantly preferred among those with standard menarche (32.6%). The binary OR of flavoured juice was 1.47 (95% CI 0.88–2.44). Thus, it could not be statistically concluded that there was a significant relationship between the consumption of flavoured juice and very early menarche without the individual level test.

➤ *Lifestyle Factors: Sleep and Physical Activity*

In the very early menarche group, 45.5% stayed up past midnight, while 72.4% did physical exercise two times or less per week. The first value is consistent with scientific literature that links staying up late with hormonal dysregulation due to melatonin suppression. Likewise, the second value aligns with scientific literature that links a sedentary lifestyle with obesity and hence high oestrogen levels. However, no statistical inference could be made about the differences between the two groups since there was a lack of comparative data on such variables for the standard menarche group.

➤ *Dietary Preferences*

Nearly half of the very early menarche group (49.8%) had preferences for packed foods. Packaged foods generally include sugar, trans-fat, chemicals for preservation, and plasticisers, which are known to cause hormonal disturbances and thus lead to an advance in the onset of puberty. Just like sleep and physical activity, there is no comparable data available on the control group for carrying out statistical analyses.

➤ *Generalisability*

The study was carried out among government schools of only one city – Chennai, in the state of Tamil Nadu. The government schools in Chennai cater to families belonging to the poorer economic strata; thus, their lifestyle and diet may vary from those of private schools in other regions of the country, including rural communities and urban areas of other cities in India. The results of this study therefore are not generalisable to all adolescent girls in India. In addition, the fact that this study includes exclusively girls from the city of Chennai means that the results cannot be generalised to other ethnic groups in India.

VI. CONCLUSION

The current cross-sectional study showed a high prevalence rate of very early menarche (< 11 years) in government schoolgirls from Chennai and found significantly related to the patterns of intake of sweetened drinks and preferred type of drink. Surprisingly, increased frequency of sugar intake in hot drinks correlated negatively with the likelihood of very early menarche among subjects in the current study, and these findings cannot be generalized due to the unusual age limit criterion applied here and lack of multivariate analysis. It is imperative to provide information regarding sleep habits, level of physical activity, and other food preferences of the menarche group using standard age criteria for comparison prior to multivariate analysis. The future research studies should: (1) utilize standard early menarche criterion of < 12 years; (2) consider BMI, family history, and socioeconomic data collection; (3) conduct multivariate logistic regression analysis; and (4) employ probability sampling method.

RECOMMENDATIONS

- School health programs can monitor the menarcheal age of students and educate them on the importance of a healthy diet and good lifestyle from age eight years.
- The consumption of sugar-sweetened drinks and ultra-processed food should be avoided, and alternative sources suggested under the policy of school canteens.
- The practice of regular exercise, for at least 60 minutes daily as stipulated by WHO for ages five to seventeen years, should be recommended.
- Advice on sleep hygiene, including having bed times before 10:00 pm, should be included in the curriculum of schools.
- The future study should utilize the early menarche definition (<12 years), measure the BMI and conduct a multivariable analysis to determine the independent role of risk factors adjusted for confounders.

LIMITATIONS

- Non-traditional use of the dependent variable ("less than 11 years") rather than the commonly used "less than 12 years" reduces comparability with existing literature and might even change the direction of associations.
- Self-reports of past age of menarche might create problems of recall bias with the accuracy decreasing the

- younger respondents are or the greater the interval between the onset of menarche and the current interview.
- Only one city-based sample of students from government-owned schools was used. This means that there is a possibility of selection bias and generalizability is severely limited.
 - Several important confounding variables that could affect the results include BMI, family history of early menarche, genetics, hormonal status, SES, mother's education. None were collected or tested.
 - For the control group of girls who entered menarche earlier, no comparisons can be made regarding dieting, exercise and sleep patterns due to lack of such information.
 - Multivariate logistic regression was not conducted, therefore all findings presented are unadjusted associations only. These findings should not be seen as causal relationships.
 - Cross-sectional study design makes it impossible to draw any conclusions regarding temporality and causality of associations found.

FUNDING AND CONFLICT OF INTEREST

This study received no external funding. The authors declare no conflicts of interest. Ethical approval was granted by the Institutional Ethics Committee of Government Medical College, Omandurar Government Estate. All participants and their guardians provided written consent/assent prior to data collection.

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