ORIGINAL RESEARCH ARTICLE

Early Menarche and its Possible Predictors: A Cross-Sectional Study in Southwestern Region of Karnataka, India

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ABSTRACT

Background: Early menarche has emerged as a significant global concern due to its myriad health implications. Divergent findings characterize existing research on its determinants, prompting the necessity for this study to elucidate the discordance among them and to broaden the spectrum of predictors of early menarche. The primary objective of this study is to determine the mean menarcheal age and to study the influence of various factors, including socio-demographic characteristics, body mass index (BMI), and lifestyle habits, on the onset of menarche in our study population.

Methodology: This was a questionnaire-based cross-sectional study carried out in the southwestern region of Karnataka between 2016 and 2017. A total of 700 high school girls aged between 14 and 16 years were recruited for the study via a simple random sampling technique.

Results: The mean menarcheal age was found to be 12.67 ± 1.19 years, with 33% experiencing it before the age of 12. Factors accelerating menarche included high BMI, excessive exposure to audio-visual media, lack of exercise, non-vegetarian diet, and late sleeping habits, as determined by stepwise logistic regression analysis.

Conclusions: Findings emphasize the significance of monitoring menarcheal trends and identifying modifiable factors influencing its onset. There is a need for educational programs focusing on the holistic health of girls.

Keywords: Early menarche, Audio-visual media exposure, Body Mass Index, Diet, Exercise training, Sleep timing

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INTRODUCTION

The first occurrence of menstruation, known as menarche, represents the final stage of pubertal changes in females, following thelarche and pubarche. Extensive research is being conducted on menarche due to its occurrence at much earlier ages than previously expected among girls in recent times. Statistics provide ample evidence of a steady decline in the average age of menarche over the past century worldwide, from 16-17 years to 12-13 years in present times.[1,2] Unfortunately,this declining trend is also observed in India.[3,4]

This variability and departure, in the age of menarche, from the biological norm is not a healthy and progressive trait.[5] Early menarche poses significant risks to a girl's health and normal development.[6] Research suggests that early menarche exerts a profound influence on girls' behaviour, potentially leading to severe psychosocial problems such as anxiety, depression, substance abuse, smoking, alcohol consumption, early sexual activity, and even suicidal tendencies.[7] Furthermore, in later life, early menarche has been linked to metabolic disorders like obesity, hypertension, type 2 diabetes, increasing the risk of cardiovascular diseases and female specific cancers like breast, endometrial and ovarian cancers.[8] Other consequences include impaired respiratory health, short adult stature, chronic pain outcomes, and heightened mortality.[6] For years, investigators have speculated on the myriad factors influencing the age of menarche including genetics, socio-economic status, nutritional, dietary patterns, mode of living, environmental factors, and geographical location.[9,10] However, findings from various studies on these determinants are widely at variance.

Given the declining trend of the age of menarche in India and the diverse health implications associated with early menarche, this present study was conducted to ascertain the age of menarche among schoolgirls in the Southwestern region of Karnataka. Additionally, as existing research on the determinants diverges, our study aimed to clarify the discordance among them and to expand the range of predictors of early menarche by examining the influence of various factors such as socio-demographic characteristics, body mass index (BMI), and lifestyle and personal habits.

METHODOLOGY

This was a cross-sectional study carried out in Southwestern region of Karnataka i.e., in and around the Mangalore city, between the year 2016-2017. A total of 700 high school girls between 14- 16 years of age were recruited in the present study. Simple random sampling technique was used to select schoolgirls for the study. The study was approved by the institutional scientific and Ethics committee (IEC KMC MLR 09-15/219).

Structured and validated questionnaires, available in both English and Kannada languages, were used to gather data on Menarcheal age and its potential predictors. The questionnaire included questions about participant's date of birth, present age, age of menarche in months and years, recent medical history, anthropometric measurements (height and weight), mother's age of menarche, parent's education and occupation, family history of endocrine disorders as well as lifestyle and personal habits of the participants (diet, physical activity, sleep patterns, exposure to audiovisual media, bowel movements, clothing preferences). Additionally, participants were asked about any history of excessive leucorrhoea before experiencing menarche.

Body mass index (BMI) was calculated as weight (kg) divided by the square of height (m^2) and it was interpreted according to BMI-for-age z score (BAZ) criteria. The participants were categorized as overweight or obese if BAZ was ≥+1SD, thin/ extremely thin if BAZ was <-2SD, and normal weight if BAZ -2 to +1 SD.[11]

The questionnaires, along with the consent forms of participants and their parents, were distributed to the girls after explaining the study and its significance in their preferred language, in consultation with their teachers. Those willing to participate signed the consent form and completed the questionnaires at their homes. Sealed envelopes containing the completed forms were collected the following day or within a week, as soon as possible.

Statistical Analysis: Data analysis was done using SPSS software (IBM version 24). Questionnaires were verified for their completeness and consistency. Age at menarche was assessed using Recall (Retrospective) method. Participants who could provide their complete date of birth and date of menarche, their menarchal age was assessed by subtracting date of menarche from date of birth. Those participants who could provide only their month and year of menarche, 15th day of the respective month was used to estimate age at menarche. Few participants could recollect only the year of their first menstruation, for them age of menarche was calculated by adding 15th day of June (sixth month) to the year of menarche.[12]

Age of menarche is reported as means and standard deviation. Unpaired t-test was used to compare mean menarcheal age between daughters and their mothers. In this study, outcome/dependent variable was mean age of menarche. The independent /predictor variables included the factors potentially influencing menarche. Chi-square test was used to understand the association between BMI and age of menarche.

Logistic regression analysis was used to determine the factors strongly associated with early menarche. Those participants who attained menarche below the mean age at menarche were considered to have attained menarche at an early age. Crude odds ratio

(95% CI) of the age at menarche with various predictable factors were calculated at the bivariate level. Further, multivariate stepwise logistic regression was employed to select the optimal set of variables from those used in the simple logistic regression model. This method automates the addition and removal of predictors based on specific criteria until the final, most effective model is achieved, revealing only the significant variables. Adjusted odds ratio (95% CI) was presented. All statistical significance was accepted at p-value of <0.05.

RESULTS

Mean age at menarche: In the present study, data from a total of 700 participants were analysed. The mean menarchal age of the study participants was determined to be 12.67 ± 1.19 years. The earliest reported age of first menstruation was 8.67 years, while the latest reported age was 16.17 years. In majority (n=231), the onset of cyclic bleeding was informed at the age of 12 years. Fig 1 summarizes the percentage of girls reporting the onset of their first menstruation at various ages.

Among the 700 participants, only 426 provided information regarding their mother's age at menarche age. The average age of menarche of the daughters was 12.63 ± 1.23 years, significantly lower than their mother's age of menarche which was 13.77 ± 1.29 years, representing a difference of 1.14 years (t=14.73, p= 0.000). Fig 2 illustrates the distribution patterns of menarcheal age for both mothers and their daughters. It was noted that the majority of mothers experienced menarche between the ages of 13 and 15. Few mothers reached menarche before the age of 12, and hardly any reported experiencing it before the age of 11. In contrast, most daughters attained menarche between the ages of 12 and 13. Few daughters experienced menarche after the age of 15.

Factors Influencing Age at Menarche

Menarche and BAZ: We witnessed a significant association between the age of menarche and BAZ ($\chi 2 = 27.694^{a}$, p value= 0.001) as shown in Fig 3. Among girls classified as overweight or obese (BAZ ≥+1SD), 19.2% experienced early menarche before the age of 11 years, while only 7.7% reached menarche after 14 years. Conversely, among girls categorized as thin or extremely thin (BAZ <-2SD), only 3.1% reported early menarche before the age of 11 years, whereas 22% experienced late menarche, occurring after the age of 14 years.

Menarche and Lifestyle and personal habits: Table 1A shows the factors influencing the age of menarche. The bivariate analysis employing a simple regression model has unveiled several factors correlated with an earlier onset of menstruation. These factors include the presence of endocrine disease within the family, non-vegetarian dietary habits, frequent consumption of more than three meals per day, indulgence in heavy dinners, prolonged periods of sitting, absence of engagement in exercise training, excessive daily exposure to audio-visual media, late bedtime extending beyond 9pm, and wearing tight clothing.

Following simple regression, a stepwise multiple logistic regression model was employed to identify the factors exhibiting the strongest association with early menarche, as outlined in Table 2.

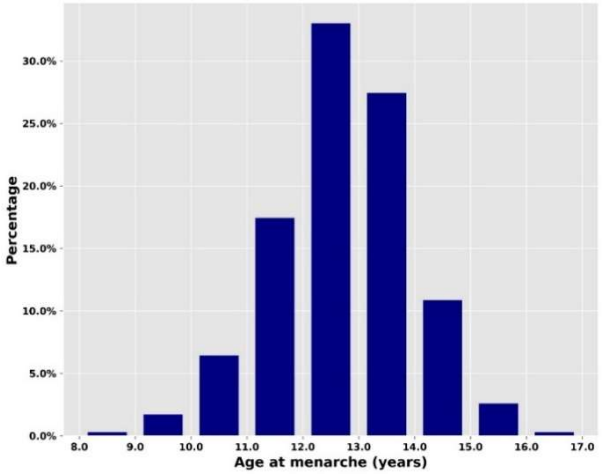

Figure 1: Distribution of participants by their age of menarche

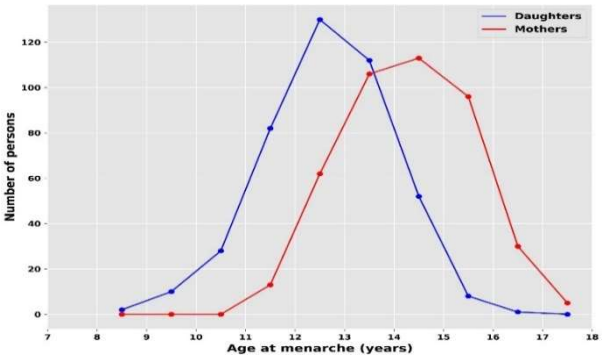

Figure 2: Distribution pattern in the age of menarche of Mother's and their daughters

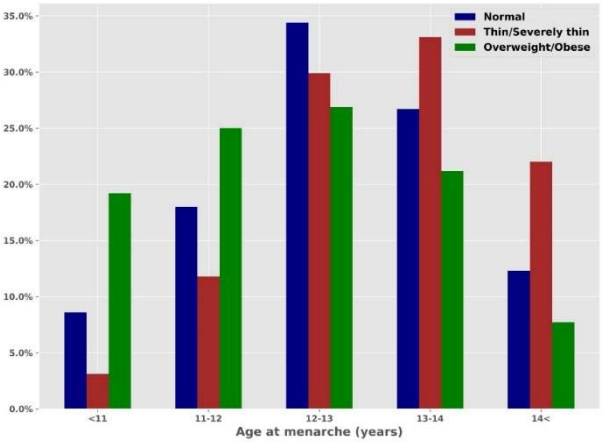

Figure 3: Relation between the age of menarche and BAZ

Table 1A: Factors influencing age at menarche (Before 13 years)

Variable	Age of menarche		Bivariate Analysis		
	<13 years (%)	>13 years (%)	COR	95% CI	P value
Family size					
≥5	188(56.1)	147(43.9)	0.810	0.599 - 1.096	0.172
1-4 (R)	221(61.2)	140(38.8)	1		
Mother's education					
Illiterate	94(60.3)	62(39.7)	0.657	0.416 - 1.037	0.072
Primary	57(50.9)	55(49.1)	0.449	0.274 - 0.735	0.001
Secondary	141(54.2)	119(45.8)	0.513	0.342 - 0.771	0.001
College (R)	120(69.8)	52(30.2)	1		
Father's education					
Illiterate	96(64.9)	52(35.1)	0.959	0.612 - 1.504	0.857
Primary	50(49.0)	52(51.0)	0.500	0.306 - 0.815	0.005
Secondary	139(54.1)	118(45.9)	0.612	0.416 - 0.900	0.013
College (R)	127(65.8)	66(34.2)	1		
Mother' Occupation					
Service	61(71.8)	24(28.2)	0.564	0.339 - 0.938	0.027
Unskilled (R)	258(58.9)	180 (41.1)	1		
Father' Occupation					
Service	182(68.4)	84(31.6)	0.480	0.336 - 0.684	0.000
Unskilled (R)	132(51.0)	127(49.0)	1		
History of endocrine disease					
Yes	77(67.5)	37(32.5)	1.593	1.041 - 2.436	0.032*
No (R)	328(56.6)	251(43.4)	1		
BAZ					
<-2	57(44.9)	70(55.1)	0.520	0.351 - 0.769	0.001
≥+1	37(71.2)	15(28.8)	1.575	0.843 - 2.943	0.155
-2 to +1 (R)	318(61.0)	203(39.0)	1		
Diet					
Non-vegetarian	391(59.9)	262(40.1)	1.848	1.018 - 3.353	0.043*
Vegetarian (R)	21(44.7)	26(55.3)	1		
Frequency of meals per day					
≥3	310(62.4)	187(37.6)	1.710	1.224 - 2.388	0.002*
<3 (R)	96(49.2)	99(50.8)	1		
Dinner time					
Beyond 9pm	124(62.0)	76(38.0)	1.468	0.957 - 2.252	0.078
8-9pm	188(58.9)	131(41.1)	1.292	0.876 - 1.905	0.197
6-8 (R)	80(52.6)	72(47.4)	1		
Dinner type					
Heavy	321(62.7)	191(37.3)	1.791	1.278 - 2.511	0.001*
Light (R)	91(48.4)	97(51.6)	1		
Number of hours spent in sitting					
6-9	177(64.4)	98(35.6)	1.759	1.229 - 2.518	0.002*
>9	104(62.7)	62(37.3)	1.634	1.086 - 2.457	0.018*
<6 (R)	115(50.7)	112(49.3)	1		
Number of hours spent in physical activity per day					
<1	172(58.3)	123(41.7)	1.289	0.814 - 2.039	0.279
1-2	189(61.6)	118(38.4)	1.476	0.934 - 2.334	0.096
>2 (R)	51(52.0)	47(48.0)	1		
Exercise training					
No	271(63.3)	157(36.7)	1.604	1.178 - 2.183	0.003*
Yes (R)	141(51.8)	131(48.2)	1		
Audio-visual media exposure					
1-3 hours /day	150(68.5)	69(31.5)	2.446	1.658 - 3.607	0.000*
≥3 hours/day	116(59.5)	79(40.5)	1.652	1.119 - 2.438	0.011*
<1 hour/day (R)	104(47.1)	117(52.9)	1		
Number of hours spent in sleep					
8hr	163(60.6)	106(39.4)	0.917	0.619 - 1.358	0.665
≥9 hrs	115(52.8)	103(47.2)	0.666	0.444 - 0.999	0.050
<7hrs (R)	109(62.6)	65(37.4)	1		
Sleep time					
Beyond 10 pm	150(63.8)	85(36.2)	2.118	1.356 - 3.308	0.001*
9- 10pm	207(60.2)	137(39.8)	1.813	1.194 - 2.754	0.005*
8-9 pm (R)	55(45.5)	66(54.5)	1		
Wake up time					
>6am	198(62.7)	118(37.3)	1.333	0.983 - 1.807	0.064
<6am (R)	214(55.7)	170(44.3)	1		
Freq of bowel movements					
Not Daily	105(54.4)	88(45.6)	0.808	0.577 - 1.132	0.215
Daily (R)	285(59.6)	193(40.4)	1		
Delay in natural calls					
Yes	219(61.2)	139(38.8)	1.216	0.900 - 1.644	0.203
No (R)	193(56.4)	149(43.6)	1		
Type of clothing					
Tight clothing	198(68.8)	90(31.3)	2.025	1.432 - 2.863	0.000*
Normal/ loose clothing (R)	138(52.1)	127(47.9)	1		
History of excessive white discharge before attaining menarche					
Yes	300(60.7)	194(39.3)	1.291	0.914 - 1.825	0.147
No (R)	97(54.5)	81(45.5)	1		

BAZ: Body Mass Index-for-Age Z score; COR: Crudes Odds Ratio; CI: Confidence Interval; R: Reference case; *5% level of significance

Table 2: Factors influencing age at menarche (Before 13 years) using Stepwise Logistic Regression: Multivariate Analysis

Variable	AOR	95% CI	P value
Audio-visual media exposure			
1-3 hours /day	2.977	1.644 – 5.394	0.000*
≥3 hours /day	1.459	0.797 - 2.673	0.221
<1 hour /day (R)	1		
BAZ			
<-2	0.486	0.250 - 0.945	0.033*
≥+1	2.606	0.825 - 8.232	0.103
-2 to +1 (R)	1		
Exercise training			
No	1.631	0.978 - 2.718	0.061
Yes (R)	1		
Diet			
Non-vegetarian	2.710	1.043 - 7.040	0.041*
Vegetarian (R)	1		
Sleep time			
Beyond 10 pm	2.448	1.164 - 5.148	0.018*
9- 10pm	2.099	1.043 - 4.224	0.038*
8-9pm (R)	1		

BAZ: Body Mass Index-for-Age Z score; No.: Number; AOR: Adjusted Odds Ratio; CI: Confidence Interval; R: Reference case
*5% level of significance

DISCUSSION

Menarche serves as a pivotal milestone in assessing pubertal maturation, with its age more accurately recalled by study participants compared to thelarche or pubarche. In our study, the mean age of menarche was 12.67 ± 1.19 years. Contrasting findings from neighbouring states in the same year reported higher ages of menarche, approximately 13 years, among girls in the Konkan region of Maharashtra[13] and Mysore[14]. Conversely, in states like Kerala[15] and Tamil Nadu[16] the age of menarche was lower, around 12.3 years.

Predictors of early menarche are multifaceted, with factors such as excessive exposure to audio-visual media emerging as significant influencers. In our study we found that menarche was 2.977 times more likely to start earlier for the participants who were exposed to audio-visual media for more than hour daily compared to those who were less exposed. {AOR =2.977 (95% CI: 1.644-5.394), P-value: 0.000}. Several other studies also reported that excessive exposure to audio visual media significantly influence the sexual development of girls and increases the likelihood of early menarche in them.[17,18] Premature excitation of Hypthalamic-pituitary-gonadal (HPG) axis due to psychological and emotional arousal triggered by excessive exposure to audio-visual media rich in adult content.[18] Moreover, excessive exposure to audio-visual media is often associated with physical inactivity and obesity, both of which further modulate pubertal maturation.[19] Notably, recent research conducted by AK Ugurlu et al. investigated the effects of blue light emitted from tablets and smartphones on prepubertal female rats. Their findings revealed that undue exposure to such light altered melatonin levels, increased Follicle-Stimulating Hormone (FSH) and Estradiol levels and accelerated the onset of puberty in these rats.[20]

The second most significant predictor of early menarche identified in our study was Body Mass Index (BMI). Prior research has consistently shown an inverse relationship between age at menarche and BMI[21], a trend which we have confirmed in our investigation. We observed that girls with a BMI-for-Age Z-score (BAZ) <-2 were less likely to experience early menarche (Adjusted Odds Ratio [AOR] = 0.486; 95% CI: 0.250-0.945; P-value: 0.033) compared to those with normal BAZ. Additionally, we found that the onset of menarche was 2.6 times more likely among students with a BAZ ≥+1 compared to those with normal BAZ, although this difference was not statistically significant (95% CI: 0.825 to 8.232). One possible explanation for these findings is that obesity, characterized by increased adipose tissue, leads to elevated levels of the adipokine leptin. Leptin serves as a permissive factor for Gonadotropin-Releasing Hormone (GnRH) secretion, signalling to the brain and initiating puberty onset. Moreover, obesity is associated with heightened levels of estrogen and androgen, as well as reduced levels of sex hormone-binding protein. These hormonal changes collectively promote the maturation of the Hypothalamic-pituitary-gonadal (HPG) axis, thereby influencing the timing of puberty.[22]

Exercise training is recognized to influence female neuroendocrine and reproductive function. Studies have demonstrated that prepubertal girls engaging in various forms of exercise training, such as swimming, tennis, volleyball, and dance, often experience a delay in the onset of menstruation.[23,24] Our study, employing simple logistic regression analysis, further indicated that girls not participating in exercise training were 1.6 times more likely to reach menarche compared to their counterparts (Adjusted Odds Ratio [AOR] = 1.604; 95% CI: 1.178-2.183; p-value = 0.003). Moreover, in stepwise multiple logistic regression, we observed a discernible trend (AOR = 1.631; 95% CI: 0.978-2.718; p = 0.06). However, we found no correlation between the duration of daily physical activity and the onset of menarche. It is postulated that vigorous physical activity alters the set point of the Gonadotropin-Releasing Hormone (GnRH) system in the hypothalamus, resulting in delayed pubertal changes.

Discrepancies exist among the findings of various investigators regarding the relationship between diet and menarche due to differences in study design and methodology.[25] Our data strongly suggests that a non-vegetarian diet may contribute to the early onset of menarche. We discovered that, compared to vegetarians, non-vegetarians had higher odds of experiencing early menarche (Adjusted Odds Ratio [AOR] = 2.71; 95% CI: 1.043-7.040; P-value: 0.041). However, the precise mechanisms underlying this association remain unknown. One potential explanation is that the higher BMI commonly observed in non-vegetarians could indirectly influence menar-

che.[26] Additionally, there is substantial evidence indicating that animal protein in the diet tends to hasten menarche, while an increase in pre-menarcheal dietary intake abundant in vegetables, fruits, and grains could delay the onset of menarche by reducing the bioavailability of estrogen.[27]Another plausible reason linking a non-vegetarian diet to early menarche is its potential to evoke erotic emotions among girls.[28]

Another notable predictor of early menarche in our study was sleep patterns. Intriguingly, we observed that girls who habitually slept late, beyond 9 pm at night, showed a heightened likelihood of experiencing early menarche (Adjusted Odds Ratio [AOR] = 2.099; 95% CI: 1.043-4.224; P-value: 0.038). Furthermore, the risk was notably amplified for those who preferred sleeping beyond 10 pm (AOR = 2.448; 95% CI: 1.164-5.148; P-value: 0.018) compared to their counterparts who slept earlier than 9 pm. Our findings resonate with those of a US-based study where girls with late bedtimes demonstrated early onset of puberty.[29] This observation can be elucidated by the decline in melatonin levels among individuals with late bedtimes, which typically regulates human reproductive cycles, thereby expediting menarche.

In our final analysis employing stepwise multiple logistic regression, novel factors such as dinner time, wake-up time, history of excessive leucorrhoea (white discharge) before attaining menarche, delay in natural calls, and bowel habits did not demonstrate any significant correlation with early menarche. However, in bivariate analysis using a simple regression model, tight clothing preferences exhibited a noteworthy association with early menarche, possibly due to its impact on sexual arousal.[30] We observed that girls who favoured tight clothing like jeans and leggings were nearly twice as likely to experience early menarche compared to those who preferred loose clothing such as loose pants and frocks (Crude Odds Ratio [COR] = 2.025; 95% CI: 1.432-2.863; P-value: 0.000).

Despite being collected few years ago, the data from this study remains highly pertinent. The lifestyle-related variables have not significantly changed since modernization, and their impacts are, in fact, intensifying. Furthermore, certain variables concerning menarche have not been previously examined. Thus, it is essential to disseminate these findings to the public domain to facilitate further research.

Our study encompassed a sufficiently large sample size of 700 students from both private and government high schools. We meticulously analysed the impact of over twenty variables on the age of menarche, including novel factors such as dinner timing, sleep patterns, waking hours, frequency of bowel movements, attire preferences, and a history of excessive leucorrhoea. However, there are some limitations in this study. Given its questionnaire-based design, information bias is inevitable due to potential inaccuracies in recall. Furthermore, as this is a cross-sectional study, it is challenging to draw accurate conclusions about the possible predictors of menarche. Therefore, we recommend conducting a longitudinal study on the same subject in the near future, as no prior studies have been conducted in this area. This would provide additional insight into the age of menarche and enhance our understanding of its predictors.

Conclusion

In our study, the mean menarchal age of the study participants was 12.67 ± 1.19 years. There was a shift in the age of menarche of the daughters towards lower age when compared to their mothers with around 33% of the participants attaining menarche below 12 years of age. The best predictors of early menarche are excessive exposure to audio-visual media, being overweight, not engaging in exercise training of any form, non-vegetarian diet, and late bedtimes. Interventions in the form of regular surveys on menarche and identification of modifiable factors which influence menarche is recommended along with the development, and implementation of educational programmes on Girls Reproductive Health so that complications caused by low menarcheal age can be prevented.

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