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Original Research Article

A study of the factors affecting the receding age of onset of menarche in young girls

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ABSTRACT

Background: Present study highlights that the worldwide trend of declining age at menarche is also seen in urban Indian girls. The aim of the study was to evaluate the age of menarche and to find out the factors associated with the timing of menarche.

Methods: The study was an observational cross sectional study. 258 healthy, menstruating, adolescent girls aged 10-16 years, were selected by simple random sampling. Pre-designed structured questionnaires were distributed after taking informed consent. Anthropometric measurements were taken using standard techniques. The average age of menarche was calculated. The association of the age at menarche with the proposed factors was analyzed using chi square test and Pearson's correlation coefficient. "P value" less than 0.05 was considered as significant.

Results: The mean age at menarche was found to be 12.23±1.09 years. The study found a strong association between the respondent's age at menarche and her sister's age at menarche (p=0.002). The study also found a strong association between age at menarche and the socioeconomic status (p=0.021). This study however found no association of menarcheal age with factors like birth weight, type of diet, frequency of milk intake, body mass index, waist hip ratio, amount of exercise, unstable environment at home and psychosocial stress.

Conclusions: The worldwide trend of declining age at menarche is also seen in urban Indian girls. This trend underlines the importance of investigating the factors associated with it and studying the future implications of a lower age at menarche.

Keywords: Adolescent gynaecology, Early menarche, Menarche, Puberty

INTRODUCTION

Early age at menarche is a universal trend nowadays, and determining the correlating factors and associated consequences is important.

Early menarche has biomedical, emotional, and socio-cultural consequences, including predisposition to diseases such as cancer and heart disease and early participation in risky behaviours, such as cigarette smoking, drug abuse, and sexual activity. Early pubertal

development is also linked with slightly decreased adult height and an increased risk for obesity, compared to later age of menarche.

The aims and objectives of this study were to evaluate the age of menarche in adolescent girls, to detect the factors affecting age at menarche and to find the association of these factors with the age at menarche.

The exact causes of a changing age at menarche are indefinite and multifactorial. Age at menarche depends

on both genetics and environmental and social experiences. If the age of menarche was determined only by genetics, young girls everywhere would reach menarche around the same age. However, it is clearly not the case. Thus, environment and culture also have an influence on menarcheal age.

Although scholars do not know what exactly triggers puberty in humans, we do know the process starts in the brain in connection to the endocrine system.

Steingraber in 2007 suggested that the HPO axis is an internal monitor, which is very sensitive to disruptions, and can trigger the premature release of estrogen in girls.¹ Therefore, the relationship between the brain and the external environment is a crucial element in the onset of puberty.

While Delemarre-van de Waal suggests that environmental factors could outweigh the influence genetics has on timing of menarche, a consideration of genetic predisposition to timing of menarche still needs to be considered.²

Belsky et al, in suggested that even societal factors affect timing of puberty because children are socialized to be sensitive to availability and reliability of resources, both biological and emotional.³

METHODS

It was an observational cross sectional study

Adolescent girls aged 10-16 years attending Gynecology OPD at Dr. Babasaheb Ambedkar Central Railway Hospital, Byculla, Mumbai, Maharashtra, India were recruited from August 2015 to March 2017.

Data collection

Using the observational method, questionnaires were distributed to girls after obtaining informed consent. The questionnaire included socio-demographic information about the respondent age, educational status of self and family income and residence. The questions related to menstruation comprised age of menarche, dietary habits, weight, height, level of physical activity, stress levels, age of menarche in sisters, exposure to cigarette smoke, divorce of parents.

The questionnaire was verbally interpreted in simple language and properly explained to avoid any form of misunderstanding and to facilitate accurate response by the subject. The respondents were instructed not to discuss answers amongst themselves and the questionnaires were collected immediately after completion to minimize interpersonal communication amongst the subjects and to prevent the influence of friends on individual response.

Inclusion criteria

10-16 year old girls with onset of menarche present.

Exclusion criteria

Girls with chronic medical/surgical/chromosomal disorders.

For this study, data was obtained by simple random sampling. Girls aged 10-16 years, having attained menarche and not fitting the exclusion criteria were recruited at random from the adolescent girls attending gynaecology OPD.

Variables

- Age of participants: age of the participant in completed years.
- Socioeconomic status: socioeconomic status according to Kuppaswamy Status Scale (2017) taking CPI as 274.⁴
- Age at menarche: Age in years closest to the completed year.
- Sister's age at menarche: Age in years closest to the completed year.
- Birth weight: Birth weight in kilograms, as recalled by the participant to the nearest 100 grams.
- Frequency of milk intake: Number of servings of milk consumed by the participant in a week.
- Body mass index: Weight (in kilograms) divided by square of the height (in metres). Classified according to Asian cut-offs as underweight (less than 18.5 kg/m²), normal (18.5-23 kg/m²), overweight (23-27.5 kg/m²) and obese (more than 27.5 kg/m²).⁵
- Waist-Hip ratio: Waist circumference (in inches) divided by hip circumference (in inches). Classified as excellent (less than 0.75), good (0.75-0.79), average (0.80-0.86) and at risk for cardiovascular disease (more than 0.86).⁶

Data sources/measurement

Pre-designed structured questionnaires were distributed. After a brief explanation of the work and nature of questions raised in the questionnaire, respondents who agreed to participate in the study were advised to feel free to ask any of the research assistant's questions they found difficult to understand. Permission to conduct the study was obtained from the mother/guardian. To assess age at menarche, each participant was asked if she had had her first menstrual period. Anthropometric measurements of weight, height, hip and waist circumferences were measured height was measured with a stadiometer (190 cm long).⁷ Subjects stood bare-foot with arms straight and relaxed and the head held in the Frankfort plane. Weight was taken using a beam scale (capacity 120 kg). Subjects wore only light clothing, and the scale was checked each day for accuracy and precision. Waist and

hip circumference was measured with an inelastic tape (140 cm long) while subjects stood with shoulders and arms relaxed. The research assistant faced the subject while passing the tape around the waist and hip. Waist circumference was measured with the tape wrapped around the smallest part of the abdomen. Hip circumference was measured with the tape wrapped around the largest part of the buttock. All circumferences were measured with subject standing. BMI was calculated as weight (kg) divided by the square of height (m) and classified according to Asian cut-offs as underweight (<18.5), normal (18.5-23), overweight (23-27.5) and obese (>27.5). Waist hip ratio was calculated by dividing the waist circumference by the hip circumference and classified as excellent (<0.75), good (0.75-0.79), average (0.80-0.86) and at risk for cardiovascular events (>0.86).

Bias

There was a recall bias in questions pertaining to exact age at menarche and birth weight. This was reduced by getting the questionnaires filled in the presence of the respondent’s mother. However, certain sensitive questions related to sexual debut and drug abuse faced response bias as girls were uncomfortable answering these questions in their mothers’ presence. To reduce this response bias, these questions were asked in private by the principal investigator while taking anthropometric measurements.

Study size

Sample size for this study was 258.
Justification of sample size-
To calculate sample size, following formula is used:

$$N = Z^2 \times P(1-P) / d^2$$

Where
Z= standard normal deviate=1.96 (at 95% confidence interval)
d= margin of error (precision) will be 0.05
P= prevalence of girls attaining menarche around 12 years of age

According to recent studies, maximum numbers of girls are achieving menarche around the age of 12 years Mane K.S. et al.⁸ Hence we take rough estimate of prevalence of age at menarche as 12 years to be 80%.

So, p= 80%= 0.8
That makes N= 245.86
So calculated sample size is 246.

However data available in OPD shows about 900 adolescent girls attended our hospital in a year. A finite population correction formula was used to adjust sample size, so that it provides proportionately more information for small population N.

Final sample size

$$n = \frac{N}{1 + [(N - 1)/ne]}$$

Where,
n=final minimum sample size
N= sample size calculated using the above formula
ne= number of adolescent girls attending paediatric OPD in a year.
That makes n=193.36
So, final sample size is 194.

Though the calculated sample size was 194, we took 258 girls from the railway population in Mumbai, Maharashtra, India for our study. As this is a population based study, increasing the study sample will only increase the strength of study and give results which might be extrapolated to the entire population.

Statistical methods

The data was entered in Microsoft Excel and the average age of menarche was calculated.

Data was analyzed using SPSS version 20.0. Qualitative data was represented in the form of tables, bar diagrams and pie chart and quantitative data was represented with mean and standard deviation. The association between two qualitative data was done by chi square test. The correlation between two variables was done with Pearson’s correlation coefficient and p value less than 0.05 was considered as significant.

Only completely filled questionnaires were included in the study. Forms with missing data were excluded. After excluding the incompletely forms, 258 questionnaires were remaining, which were taken up for the analysis.

RESULTS

The study found the mean age at menarche to be 12.23±1.09 years.

Table 1: Distribution of study participants according to age at menarche.

Age at menarche (in years)	Number	Percentage
9.0 - 9.9	4	1.6
10.0-10.9	15	5.8
11.0-11.9	35	13.6
12.0-12.9	128	49.6
13.0-13.9	30	11.6
14	46	17.8
Total	258	100.0

The study found a strong association between the respondent's age at menarche and her sister's age at menarche (p=0.002).

Table 2: Distribution of study participants according to sister's age at menarche.

Sister's age at menarche in years (n = 121)	Number	Percentage
10-12	34	28.1
12-14	61	50.4
14-16	26	21.5
Total	121	100.0

Table 4: Association between socioeconomic status and age at menarche.

Socioeconomic status	Age at Menarche		Total
	≤12 years	>12 years	
High (Class I and II)	52 (23.2%)	172 (76.8%)	224 (100.0%)
Low (Class III and IV)	02 (5.9%)	32 (94.1%)	34 (100.0%)
Total	54 (20.9%)	204 (79.1%)	258 (100.0%)
Chi square = 5.358, df = 1, p value = 0.021			

In high socioeconomic classes, 23.2% of the participants had age at menarche ≤12 years while in low socioeconomic classes it was only 5.9% and the difference was found to be statistically significant.

Birth weight (p value= 0.736): In low birth weight (<2.5 kg) group, 22.8% respondents had age at menarche ≤12 years while in normal and high birth weight babies (>3.5 kg), it was 20.1% and 15.4% respectively. The association between two variables were not statistically significant.

Type of diet(vegetarian/non-vegetarian) (p value = 0.783): 22.0% of the vegetarian had age at menarche ≤12 years while 20.5% of participants who consumed mixed diet had attended the same and the difference was not statistically significant.

Frequency of milk intake (p value = 0.797): Participants who all consumed milk, 21.4% had age at menarche ≤12 years while those who didn't consume milk had 20.0% of the same. This difference was not statistically significant.

Body mass index (p value = 0.116): Overweight and obese participants (30.8%) had comparatively early menarche as compare to normal (23.0%) and underweight (16.0%) participants but the association is not statistically significant.

Waist hip ratio (p value = 0.731): Participants with waist hip ratio ≤0.86 (21.2%) had comparatively early

Table 3: Correlation between participants' age of onset of menses with her sister's age of onset of menses.

Pearson's correlation	Sister's age at menarche
Participant's age at menarche	0.273
P value	0.002

The correlation between participant's age at menarche and her sister's age at menarche was found to be having a positive association and it was statistically significant.

The study also found a strong association between age at menarche and the socioeconomic status (p=0.021).

menarche as compared to those who had >0.86 (17.6%) and the association is not statistically significant.

Amount of exercise (p value = 0.157): Participants with low exercises, early menarche was attended by 18.1% of respondents while in moderate exercises it was 25.5%. The association between exercise and age at menarche was not statistically significant.

Unstable environment at home (p value = 0.354): Participants with unstable environment had comparatively late menarche (83.3%) as compared to those had stable environment (77.8%) and the difference is not statistically significant.

Psychosocial stress (p value = 0.243): 23.2% of the participants with stress had attended early menarche as compare to 17.0% in without stress group and this difference is not statistically significant.

DISCUSSION

The receding age of menarche is a universal trend nowadays, as reported by several studies and is associated with serious future implications.⁹⁻¹⁸ Thus determining the age of menarche in our urban Indian population and the associated factors is of paramount importance.

Various factors have been studied in several studies, yet the exact causal relationship is yet to be established.

Our study aims to fill the lacunae in literature and to add to our existing knowledge about the age at menarche and the degree of association with the implicated factors in the present day scenario.

We did an observational cross section study on 258 girls aged 10-16 years, selected from the OPD population by simple random sampling. These girls filled a pre-designed questionnaire and standard anthropometric measurements were taken for each participant. Data were analyzed using SPSS V20.0 (Statistical Package for Social Sciences, Version 20.0)

All the girls in the present study were city dwellers, staying at Mumbai, Maharashtra, India.

We found the mean age at menarche to be 12.23 ± 1.09 years and most (49.6%) respondents reported that they attained menarche between 12-12.9 years of age. This declining trend of age at menarche has also been seen in several other Indian studies, for example, a similar study done by Mane KS et al, found the mean age at menarche to be 12.14 years. Studies by P. Iyer et al and by S. Sinha et al, found the mean age at menarche to be 12.7 and 12.69 years respectively.^{9,10}

This trend of declining puberty has also been reported by several studies done in other countries, for instance, by Noipayak P et al, in 2017 in Dusit district, Bangkok and by Mpora BO, Piloya in northern Uganda.^{11,12} Steingraber S, reported a similar trend in Europe, Anderson SE, Must. A in USA, and Ulijaszek SJ, Evans E among Indo-Pakistani girls.^{1,13,14} This declining age at menarche has been linked to a disparity between biological maturation and psychosocial maturation, as found by a study done in 2006 by Gluckman P, Hanson M.¹⁹

Our study found a strong association between the respondent's age at menarche and her sister's age at menarche ($p=0.002$) as 50.4% respondents reported their sister's age of menarche to be between 12-14 years. The mean age at menarche for the respondents' sisters was observed to be 12.26 ± 1.144 years

Our study is supported by the studies done by Graber JA et al and Meyer et al which support genetics as a cause for earlier menarche.^{20,21} However, studies done by Towne et al, and Susman and Dorn have suggested that genetics accounts for about half of the variance in timing of menarche, but no single gene has been found that controls timing of puberty and that intrinsic factors are not the only determinates of age at menarche for a girl.^{22,23}

61.2% girls taken in our study belonged to upper middle socioeconomic status according to the latest Kuppaswamy scale (2017). Our study found a strong correlation between age at menarche and the socioeconomic status ($p=0.021$), that is, higher socioeconomic class was strongly associated with earlier

age at menarche. Similar findings were reported by Mane KS et al, Yarmehenko et al.^{18,24} Our finding was also supported by the study done by Dvornyk et al in developing countries.²⁵

Our study found no significant association between birth weight and age at menarche ($p=0.736$). Upon reviewing the literature, we found conflicting data about the role of birth weight on the age of menarche. Our finding was supported by studies done by Raveendran RC et al, which also found no statistically significant correlation between birth weight and age at menarche.²⁶ However, our study was in contrast with studies done by Steingraber which found that birth weight is a significant predictor of age at menarche.¹

Type of diet, especially intake of animal fat and protein has been proposed as a possible factor in determining age at menarche. However, our study found no significant correlation between age of menarche and the type of diet ($p=0.783$), and similar ages at menarche were reported for vegetarians and non-vegetarians. This indicates that some other factors, apart from diet are responsible for predicting the age at menarche. Our finding is supported by the study done by Castilho SD et al.²⁷ However, our findings were contrasting with those of the studies done by Gunther ALB et al, which have linked animal fat and protein intake to lower age at menarche.²⁸

We found no significant association with frequency of milk intake and early age at menarche ($p=0.797$). Our study is supported by the study done by Carwile JL et al, which also found no significant association of milk intake with age at menarche.²⁹ On the other hand, studies done by Hoppe C et al, in 2004 have associated milk intake to pubertal development, and the study done by Chevalley T. et al, has linked high calcium intake to early age at menarche.^{30,31}

With increasing prevalence of childhood obesity and metabolic syndrome, special emphasis is being put on body mass index and waist hip ratio among adolescents. Physical exercise, which a direct predictor of obesity and BMI, is also on the decline among adolescents, with an ever increasing number of girls leading a sedentary life, spending their free time watching TV or playing games on cell phones.

Our study found no significant correlation between BMI and age at menarche ($p=0.116$). Our findings are consistent with those of Raveendran RC et al, that there is no significant correlation was found between BMI and age of menarche.²⁶ Our study is also supported by Rao S et al, who challenged the critical weight hypothesis.³² However our result is contrasting with several studies by Guo and Ji and Qing et al, which reported decrease in age at menarche with every unit increase in BMI.^{33,34}

We found no significant association between waist hip ratio and age at menarche ($p=0.731$). Our study correlates

with the study done by W.D. Lassek et al, who concluded that unit increase in waist circumference lowers the odds at menarche by 7%.³⁵ They also found that increase in gluteofemoral fat distribution increases the odds at menarche by 22%. Our result is however in contrast with the study done by Guo and Ji, who have given a strong association between age at menarche and increased waist circumference.³³ Also, present study found no significant association between age at menarche and amount of exercise ($p=0.157$). This was in contrast to studies reported by Steingraber and Grumbach and Styne.^{1,36}

Stress is an important psychological factor affecting teenagers nowadays. The causes of stress are varied, and may be due to negative body image, peer pressure, increased competition and academic pressure, stress due to unstable environment at home, alcoholic father and broken families, among many other possible stressors. Our study did not show any significant association of age at menarche with unstable environment ($p=0.354$) or with psychological stress ($p=0.243$). Our result is supported by studies done by Meulenijzer E et al and Mpora and Piloya.^{11,37} However several studies have reported that in father's absence, in the presence of psychological stress and in disrupted families, girls attain menarche earlier.^{3,38-40}

CONCLUSION

Our study has thus shown that the age at menarche is showing a declining trend. This trend underlines the importance of investigating the factors associated with it and studying the future implications of a lower age at menarche. This study revealed the mean age at menarche to be 12.23 ± 1.09 years, which parallels the trend seen in several studies. The outcome of our study is that socioeconomic status and genetic factors have a bearing on the mean menarcheal age.

A majority of girls in our study who attained menarche at an early age had normal BMI. This point to the fact that there could probably be a role of other external factors like endocrine-disruptive chemicals with oestrogen like properties responsible for the receding age of menarche in urban India, which needs to be further, studied.

To conclude, earlier occurrence of menarche is an ominous event with long term risks which can be prevented by identifying the associated risk factors, adopting a healthy life style and self-care.

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