J HEALTH POPUL NUTR 2009 Dec;27(6):802-807
ISSN 1606-0997 | $ 5.00+0.20

Age of Onset, Nutritional Determinants, and Seasonal Variations in Menarche in Rural Bangladesh

Jee H. Rah[1], Abu Ahmed Shamim[2], Ummeh T. Arju[2], Alain B. Labrique[1], Mahbubur Rashid[2], and Parul Christian[1]

[1]Center for Human Nutrition, Department of International Health, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 21205, USA and [2]JiVitA Maternal and Child Research Project, Rangpur, Bangladesh

ABSTRACT

Menarche is an important milestone in the development of female adolescents. The study assessed the age at menarche using recall, its seasonality, and association with marital and nutritional status (using mid-upper arm circumference [MUAC]) among 3,923 female adolescents aged 12-19 years in a rural area of Bangladesh. At the time of assessment, most (88%) adolescents had attained menarche at the mean (standard deviation [SD]) age of 12.8 (1.4) years. Age of onset of menarche among married adolescents (13%) occurred earlier than in those who were unmarried (12.6±1.3 years vs 12.9±1.4 years, $p<0.01$). Age at menarche was negatively associated with MUAC after adjusting for age and marital status (β=-0.10, $p<0.01$). More than 50% of the adolescents had an onset of menarche during winter (χ^2=634.97; $p<0.001$), with peaks in December and January. In this rural population, the current age at menarche was found to be slightly lower than the previous estimates of 13.0 years in Bangladesh. An early onset of menarche was associated with season and better nutritional status of the female adolescents and may be associated with early marriage.

Key words: Age at menarche; Marital status; Menarche; Nutritional status; Seasonality; Bangladesh

INTRODUCTION

Menarche is a vital maturational event of puberty in female adolescents. Unlike other pubertal changes that are gradual and continuous, menarche is a distinct event with a sudden onset. It is highly correlated with other pubertal characteristics and is, therefore, preferred as a benchmark for sexual maturation. The timing of menarche is an important determinant of population size, reproductive performance, and other chronic outcomes, such as cancers of the reproductive organs (1). Early onset of menarche has been associated with premature marriage and first childbirth, especially in developing countries, and is a risk factor for breast-cancer, ovarian cancer, and other diseases (1,2).

During the past century, there has been a secular (time-related) trend towards an earlier onset of menarche in most developed countries, with a decline of 2-3 months per decade in Europe and the United States (3). General improvements in nutrition and health have been suggested to explain the downward trend (3,4). The earlier onset of menarche has also been observed in some developing countries, such as Bangladesh. The most recent study of unmarried female adolescents conducted in 1996 in a rural area of Bangladesh reported an average age at menarche of 13.0 years (4), which was substantially lower than the previous estimate of 15.8 years in 1976 (5). The relatively high age at menarche in 1976 was linked to severe malnutrition caused by inflation, famine, and flooding following Bangladesh's war for independence in 1971 (5).

The association between the nutritional status and the onset of menarche has been well-documented (4-6). In general, adolescents who are taller and heavier with a greater body-fat mass tend to reach menarche at younger ages (4-6). Female adolescents in Bangladesh, particularly those in rural areas, are largely affected by undernutrition, with 48% and 59% being stunted (height-for-age <3rd percentile) and thin (body mass index [BMI]-for-age <5th percentile) respectively, applying the National Center for Health Statistics reference (7). Considering the high prevalence of undernutrition and a lack of significant improvement in nutritional status during

Correspondence and reprint requests should be addressed to:
Dr. Parul Christian
Johns Hopkins Bloomberg School of Public Health
615 North Wolfe Street, Room W2041
Baltimore, MD 21205
USA
Email:pchristi@jhsph.edu
Fax: 410-955-0196

recent years (7), it is not clear whether the age at menarche has continued to decrease in rural Bangladesh.

A marked seasonal pattern of menarche has previously been reported such that the monthly occurrence of menarche is not uniformly distributed throughout the year but peaks show up in summer and winter (8,9). Seasonal factors, such as length of daylight, ambient temperatures, and the psychological effects of reduced stress and increased relaxation during school vacation, are some suggested explanations for this seasonal variation (8-11).

The present analysis was conducted to determine the age at menarche using self-reported date of onset in a group of female adolescents aged 12-19 years in a rural area of Bangladesh and to examine its association with marital and nutritional status and season. We believe that the study of onset of menarche is important not only from an anthropological point of view but also because the mean menarcheal age has been accepted as a "particularly sensitive indicator of the biosocial status of the population" (12). The mean age at menarche in rural Bangladesh was last estimated more than a decade ago, and a number of biological, social and ecological factors have likely changed since then. We believe that it is opportune to re-assess the onset of menarche and its association with various factors, particularly marital status, considering the numerous negative consequences of marriage and pregnancy in adolescence, which may be triggered by early onset of menarche.

MATERIALS AND METHODS

Data were collected as part of a cohort study of the consequences of pregnancy and lactation on growth of adolescents in Gaibandha district in rural northwest Bangladesh (13). This study was conducted in a smaller area (96 communities with ~200 households in four unions of Gaibandha district), which was part of the study area where a randomized community trial for assessing the impact of vitamin A and β-carotene supplementation on maternal and infant survival—called the JiVitA Project—was being conducted by our group. This rural and densely-populated (~1,000 per sq km) region is characterized by average to below-average socioeconomic status indicators, rates of health service-use, child health, and nutritional status compared to national statistics. At the outset, all the households in this area were visited by 96 local female workers from January to March 2005 to identify and list all married and unmarried adolescents aged less than 20 years. All enumerated adolescents were interviewed in the home to elicit dates of their birth, months and years of menarche, marital status, and pregnancy history using recall and to measure mid-upper arm circumference (MUAC). Home records of date of birth, when available, were requested and, in their absence, parental input was obtained to confirm the self-reported year and month of birth. Various probes, such as age at school enrollment, differences in age between siblings, year of marriage, and tools, such as a local events calendar, were used for determining the year and month of birth.

Adolescents who were post-menarcheal at the time of enumeration were asked to recall the year and month of menarche. Reference to age of school enrollment and the number of years spent in each class was used as recall probes as the majority of adolescents in the study area had received some schooling due to the government support for female education (14). For example, the adolescents were asked in which grade they had started menstruating, along with the highest grade completed and its corresponding calendar year. Also, the number of years for which a particular grade was repeated was recorded. Family events, seasons, school examinations, and a local events calendar were used for probing the month of menarche. In addition, the mother or other female relatives living in the household were asked to help with the recall of the age at menarche. The year and month of marriage were also elicited. MUAC was assessed as a measure of nutritional status to the nearest millimetre following standard procedures (15).

Of the 5,582 female adolescents enumerated, 100 (1.8%) refused to participate in the study, and 1,365 (24.4%) were excluded either due to not meeting the age criteria of 12-19 years or for not being able to provide years of their birth. Further, 29 (0.5%) adolescents who were unable to report months of their menarche and 165 (3.0%) who had previously been pregnant were excluded because the adolescent cohort study enrolled only never-pregnant adolescents (13). The resulting sample included in the analysis comprised 3,923 (70.3%) married nulliparous and unmarried female adolescents aged 12-19 years.

Statistical analyses

Of the 3,923 female adolescents, 483 (12.3%) were unable to report months of their birth. Thus, the mean age at menarche was assessed by assigning a random month of birth to this group using Microsoft Excel 2000 (Microsoft Corp, Redmond, WA, USA). As some households had more than

one female adolescent aged 12-19 years and age at menarche of those living in the same households could be correlated, we estimated the mean age at menarche adjusting for the clustering of girls of the same households.

The differences in age at menarche, age, and MUAC between married and unmarried adolescents and that in MUAC and age between pre- and post-menarcheal adolescents were examined using a *t*-test. A multiple linear regression analysis was conducted with age at menarche as the dependent variable and marital status, age, and MUAC as the independent variables.

To examine the seasonality of menarche, frequencies of onset by calendar month and season were computed. Seasons were defined as follows: winter=November~February; summer=March~June; and monsoon=July~October. The uniformity of monthly and seasonal distribution of menarche was examined using a χ^2 test (8,9), accounting for the different number of days in each month. The observed frequencies of menarche for each month and season were compared against the expected uniform distribution [31/365x3,452 (total number of adolescents), 28/365x3,452, etc.]. All analyses were performed using the Stata software (version 8.0) (Stata Corp, College Station, Texas, USA).

The Bangladesh Medical Research Council and the Institutional Review Board at the Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, USA, approved the study.

RESULTS

The mean (SD) age and MUAC of the adolescents included in the analysis (n=3,923) were 15.1 (1.8) years and 22.4 (2.3) cm respectively. Only 13% of the adolescents were married at the time of interview, although most (88%) were already menstruating. Of those who had already attained menarche, the mean age of onset of menarche was 12.8 (1.4) years.

A higher proportion of married vs unmarried female adolescents was post-menarcheal (99% vs 86%, p<0.01), and married adolescents had an earlier onset of menarche than unmarried girls (12.6±1.3 years vs 12.9±1.4 years, p<0.01), a difference that remained significant after adjusting for age and MUAC (β=-0.44, p<0.01) (Table). The mean MUAC was significantly higher among post- vs pre-menarcheal adolescents (22.8±2.0 vs 19.5±1.9 cm, p<0.01), and there was a negative linear association between age at menarche and MUAC, after adjusting for age and marital status (β=-0.11, p<0.001) (Table).

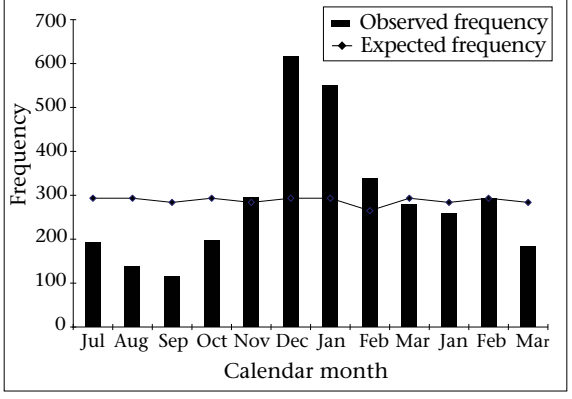
Table. Factors associated with mean age at menarche among adolescents in rural Bangladesh

Characteristics	β-coefficient	Standard error	p value
MUAC	-0.11	0.01	<0.01
Chronological age	0.35	0.01	<0.01
Marital status	-0.44	0.08	<0.01

R^2=0.20, F=250.31, p=<0.01; MUAC=Mid-upper arm circumference

The monthly occurrence of menarche was not uniformly distributed throughout the year (χ^2=885.97, df=11, p<0.001) but had peaks in December and January and troughs in August and September (Fig.). More than half of the female adolescents reached menarche during the winter months whereas less than 20% had an onset in monsoon (χ^2=634.97, df=2, p<0.001).

Fig. Frequency distribution of calendar month of onset of menarche among adolescent girls, aged 12-19 years, in rural Bangladesh; expected frequencies for each month calculated as 31/365x3,452 (total number of adolescents, 28/365x3,452, 30/365x3,452, etc.)



DISCUSSION

The estimated mean age at menarche of 12.8 years reported from this study indicated a slightly earlier onset of menarche of the female adolescents in a rural area of Bangladesh by ~2 months compared to the mean of 13.0 (0.9) years that had been estimated in Narayanganj district of Bangladesh in 1996 (4). While not directly tested, this apparent small difference in age at menarche compared to that found in a survey in 1996 may be attributable

to differences in the timing of studies, location of study areas, and sample characteristics. While the present study included both married and unmarried female adolescents aged 12-19 years, the previous study included only unmarried ones aged 10-17 years (4). On the other hand, one can conjecture that the mean age at menarche in rural Bangladesh has lowered slightly over the past decade and that the downward trend in age of onset of menarche observed elsewhere (3) may also be occurring in rural Bangladesh, albeit at a slower pace. In Europe, a trend towards an earlier onset of menarche by 2-3 months per decade has been reported, with the smallest magnitude of decline of 1.1 months per decade observed in France (3). Analysis of the National Health and Nutrition Examination Survey (NHANES) in the USA indicated declines in age at menarche for all race/ethnic groups, with non-Hispanic white females having a decline in the mean age at menarche from 13.3 years in the pre-1920 birth-cohort to 12.5 years in the 1980-1984 birth-cohort (16). While the declining trend in age at menarche has been attributed to improvements in health and nutrition in developed countries, a large proportion of female adolescents in rural Bangladesh is still affected by undernutrition as reflected by the high prevalence of stunting and thinness (7). If real, factors associated with a potential declining trend in age at menarche in rural Bangladesh remain to be elucidated.

Date of menarche was collected using self-reported date of onset. The accuracy of recall of the date depends on factors, such as interval of recall (17). In the present study, the mean interval of recall was 2.5 years, and 63% of the adolescents had reached menarche within three years of the time of interview. Previous studies that used a similar recall procedure reported a correlation coefficient of 0.83 and 0.67 between the actual and the recalled age at menarche when the mean interval of recall compared to occurrence of menarche was 4.8 years and 33 years respectively (18,19). Therefore, the recall errors are expected to be low in this study due to the relatively short interval of recall.

The married adolescents reached menarche at an earlier age than the unmarried adolescents. In developing countries, such as Bangladesh and Pakistan, age at menarche is suggested to be positively associated with age at marriage and first childbirth (20). A similar association has been found in some developed countries where the intervals between menarche and first marriage are much larger (20,21). Although the mechanisms of this positive association are poorly understood, in developing countries, menarche has been suggested to serve as a "marker of maturity and readiness for marriage", signalling the parents to place their daughters in the 'marriage market' (2,20). The mean age at marriage in the JiVitA study area is 16.5 years despite the legal age of marriage being 18 years in Bangladesh, and the first pregnancy (conception) occurs within an average of 13 months from marriage (13).

The inverse association between age at menarche and MUAC shown in this study corresponds with the previous findings that adolescents who are taller and heavier with a greater body-fat mass tend to attain menarche at younger ages (4,5). The nutritional status of the adolescents was assessed by MUAC in this study whereas most previous studies measured weight, height, BMI, or skinfold thickness. In general, MUAC is a good indicator of nutritional status, serving as a proxy for wasting malnutrition and weight, particularly in adult women (22). In a study of rural Senegalese female adolescents, the mean MUAC was shown to be higher among post- vs pre-menarcheal girls (23), coinciding with the present finding.

The winter peak of menarche found in our study corresponds with the previous findings from rural Bangladesh that about half of adolescents attained menarche in winter whereas less than 20% had an onset in May through August (5). A factor that most likely explains the winter peaking of menarche in rural Bangladesh is the increased food consumption during the harvest season. Food availability and consumption generally increases during the winter harvest season in Bangladesh, thereby improving nutritional status, a factor known to be associated with onset of menarche (5). In a study by Tetens *et al*. elsewhere in rural Bangladesh, the mean energy intake increased from 6.5 MJ per person per day in the lean season to 8.3 MJ per person per day in the harvest season in female adolescents (24). In the JiVitA study, the proportion of women consuming more than one egg per week increased from 37% in the lean season to 56% in the harvest season. Likewise, 73% of the women consumed dark green-leafy vegetables at least once a week in the harvest season compared to 60% in the lean season (data not shown).

Another potential explanation may be the psychological effects of reduced stress due to school vacation. During school season, adolescents have homework and regular examinations, including mid-term and final, which could contribute to the increased level of stress. In addition, the support for female education by the Government of Bangladesh, particularly for secondary school, is merit-based; so,

to receive continuous financial support from the Government, the student needs to perform well in school. Thus, a relaxing and less-stressful atmosphere during school vacation has been postulated to trigger the onset of menarche by influencing the hypothalamus (8-10). The winter school vacation which follows the final examination in December may explain the high frequencies of menarche in winter, especially in December. However, we are limited in supporting this hypothesis because, to our knowledge, there is no evidence showing that female adolescents in Bangladesh have reduced stress during school holidays, and we lack data to estimate the proportion of adolescents enrolled in school at the time of onset of menarche. The winter peak of onset of menarche in the present study is consistent with a previous finding in 1977 and may be related to increased intake of foods during the winter harvest season.

There are several limitations of this study. As mentioned above, the date of menarche was self-reported, and the associated recall bias cannot be ruled out despite the relatively short interval of recall. Although efforts were made to help elicit the date of birth of all the enumerated female adolescents, approximately 12% were unable to report the months of their birth. Assigning a random month of birth when only year was available; as done in our study, may have limitations due to the seasonality of birth reported in Bangladesh and other countries (25,26). In this study, MUAC was measured after the onset of menarche. Using the post-menarcheal MUAC measurement as a proxy for nutritional status before the onset of menarche is not ideal. In addition, the study sample comprised female adolescents, aged 12-19 years, living in a defined study area. Thus, our findings may not be generalizable to or comparable with other randomly-sampled populations of adolescents in Bangladesh.

In conclusion, the mean age at menarche of the adolescents in this rural area of Bangladesh was slightly lower than the previous estimate of 13.0 years in 1996 (4). Although the small difference in age at menarche could be an artifact of different study sites and sample characteristics, it may also reflect the downward trend of onset of menarche taking place in rural Bangladesh, as observed elsewhere. These findings need confirmation in random samples of married and unmarried adolescents in rural Bangladesh, assessing age at menarche using prospective and probit analysis methods (27,28). The negative association between the nutritional status and the onset of menarche in the present study was consistent with the previous findings that adolescents who are better-nourished tend to attain menarche at younger ages. It is likely that, in a rural setting in Bangladesh, in addition to the strong cultural and social norms favouring early marriage, an early onset of menarche may also trigger premature marriage and first childbirth. This is associated with numerous adverse birth outcomes, such as premature birth, low birthweight, and neonatal and maternal mortality. Meanwhile, it is accepted that maintaining optimal nutritional status during adolescence is important for future reproductive outcomes in adulthood. Thus, while continuing efforts should be made to improve the nutritional status of female adolescents, educational activities, advocacy, and strong policies need to be in place at the same time to help delay marriage and first childbirth among female adolescents in the developing world.

ACKNOWLEDGEMENTS

The JiVitA Project was conducted under a Global Research Activity cooperative agreement between the Johns Hopkins University and the Office of Health and Nutrition, US Agency for International Development, Washington, DC (GHS-A-00-03-00019-00), and the Bill & Melinda Gates Foundation, Seattle, Washington, DC (Global Control of Micronutrient Deficiency, Grant No. 614). Additional direct or in-kind support for this trial was provided by Sight and Life, Basel, Switzerland, the Sight and Life Research Institute, Baltimore, MD, Nutrilite Health Institute (Nutrilite Division, Access Business Group, Buena Park, CA, USA), the Canadian International Development Agency, and the National Integrated Population and Health Programme of the Ministry of Health and Family Welfare, Government of Bangladesh.

The authors thank the JiVitA Project National Adviser Dr. Halida Akhter, senior JiVitA Project staff, including Drs. Barkat Ullah, Hasmot Ali, Shafiul Alam, Shahab Uddin, and Sayeda Khatun Sharifa, and the JiVitA Field Management Team. Additional appreciation goes to the field staff of the JiVitA project for their excellent work and dedication during data collection. The authors acknowledge Keith West, principal investigator of the JiVitA trial, for his insightful comments and guidance throughout the study and Rolf Klemm for his helpful comments and support. Special thanks are due to Allan Massie, Maithilee Mitra, Ahasanul Haque, and Lee Wu for computer programming and data-management support; Jonathan Sugimoto and Salahuddin Ahmed for GIS support; and Andre Hackman for technical assistance.

REFERENCES

1. Kelsey JL. A review of the epidemiology of human breast cancer. *Epidemiol Rev* 1979;1:74-109.
2. Riley AP, Samuelson JL, Huffman SL. The relationship of age at menarche and fertility in undernourished adolescents. *In*: Gray R, Leridon H, Spira A, editors. Biomedical and demographic determinants of reproduction. Oxford: Clarendon Press, 1993:50-64.
3. Wyshak G, Frisch RE. Evidence for a secular trend in age of menarche. *N Engl J Med* 1982;306:1033-5.
4. Chowdhury S, Shahabuddin AK, Seal AJ, Talukder KK, Hassan Q, Begum RA *et al*. Nutritional status and age at menarche in a rural area of Bangladesh. *Ann Hum Biol* 2000;27:249-56.
5. Chowdhury AK, Huffman SL, Curlin GT. Malnutrition, menarche, and marriage in rural Bangladesh. *Soc Biol* 1977;24:316-25.
6. Osteria TS. Nutritional status and menarche in a rural community in the Philippines. *Philipp J Nutr* 1983;36:150-6.
7. Shahabuddin AK, Talukder K, Talukder MK, Hassan M, Seal A, Rahman Q *et al*. Adolescent nutrition in a rural community in Bangladesh. *Indian J Pediatr* 2000;67:93-8.
8. Matchock RL, Susman EJ, Brown FM. Seasonal rhythms of menarche in the United States: correlates to menarcheal age, birth age, and birth month. *Womens Health Issues* 2004;14:184-92.
9. Gueresi P. Monthly distribution of menarche in three provinces of north Italy. *Ann Hum Biol* 1997;24:157-68.
10. Park SH, Shim YK, Kim HS, Eun BL. Age and seasonal distribution of menarche in Korean girls. *J Adolesc Health* 1999;25:97.
11. Shakir A. The seasonal rhythm of menarche in girls attending schools in Baghdad. *Ann Hum Biol* 1974;1:95-102.
12. Silva HP, Padez C. Secular trends in age at menarche among Caboclo populations from Pará, Amazonia, Brazil: 1930-1980. *Am J Hum Biol* 2006;18:83-92.
13. Rah JH, Christian P, Shamim AA, Arju UT, Labrique AB, Rashid M. Pregnancy and lactation hinder growth and nutritional status of adolescent girls in rural Bangladesh. *J Nutr* 2008;138:1505-11.
14. Raynor J, Wesson K. The girls' stipend program in Bangladesh. *J Educ Int Dev* 2006;2:1-12. (http://www.equip123.net/JEID/articles/3/Girls'StipendProgramin Bangladesh.pdf, accessed on 22 July 2008).
15. Gibson RS. Anthropometric assessment of body composition. *In*: Gibson R, editor. Principles of nutritional assessment. New York, NY: Oxford University Press, 2005:273-98.
16. McDowell MA, Brody DJ, Hughes JP. Has age at menarche changed? Results from the national health and nutrition examination survey (NHANES) 1999-2004. *J Adolesc Health* 2007;40:201-3.
17. Koo MM, Rohan TE. Accuracy of short-term recall of age at menarche. *Ann Hum Biol* 1997;24:61-4.
18. Koprowski C, Coates RJ, Bernstein L. Ability of young women to recall past body size and age at menarche. *Obes Res* 2001;9:478-85.
19. Casey VA, Dwyer JT, Coleman KA, Krall EA, Gardner J, Valadian I. Accuracy of recall by middle-aged participants in a longitudinal study of their body size and indices of maturation earlier in life. *Ann Hum Biol* 1991;18:155-66.
20. Udry JR, Cliquet RL. A cross-cultural examination of the relationship between ages at menarche, marriage, and first birth. *Demography* 1982;19:53-63.
21. Sandler DP, Wilcox AJ, Horney LF. Age at menarche and subsequent reproductive events. *Am J Epidemiol* 1984;119:765-74.
22. Krasovec K, Anderson MA. Maternal nutrition and pregnancy outcomes: anthropometric assessment. Washington, DC: Pan American Health Organization, 1991. 214 p.
23. Simondon KB, Simon I, Simondon F. Nutritional status and age at menarche of Senegalese adolescents. *Ann Hum Biol* 1997;24:521-32.
24. Tetens I, Hels O, Khan NI, Thilsted SH, Hassan N. Rice-based diets in rural Bangladesh: how do different age and sex groups adapt to seasonal changes in energy intake? *Am J Clin Nutr* 2003;78:406-13.
25. Becker S, Chowdhury A, Leridon H. Seasonal patterns of reproduction in Matlab, Bangladesh. *Popul Stud* 1986;40:457-72.
26. Anand K, Kumar G, Kant S, Kapoor SK. Seasonality of births and possible factors influencing it in a rural area of Haryana, India. *Indian Pediatr* 2000;37:306-12.
27. Finney DJ. Probit analysis: a statistical treatment of the sigmoid response curve. 2nd ed. Cambridge: Cambridge University Press, 1952. 318 p.
28. Anderson SE, Must A. Interpreting the continued decline in the average age at menarche: results from two nationally representative surveys of U.S. girls studied 10 years apart. *J Pediatr* 2005;147:753-60.