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AGE AT MENARCHE OF UNIVERSITY STUDENTS IN BANGLADESH: SECULAR TRENDS AND ASSOCIATION WITH ADULT ANTHROPOMETRIC MEASURES AND SOCIO-DEMOGRAPHIC FACTORS

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Summary. Age at menarche has been shown to be an important indicator for diseases such as breast cancer and ischaemic heart disease. The aim of the present study was to document secular trends in age at menarche and their association with anthropometric measures and socio-demographic factors in university students in Bangladesh. Data were collected from 995 students from Rajshahi University using a stratified sampling technique between July 2004 and May 2005. Trends in age at menarche were examined by linear regression analysis. Multiple regression analysis was used to assess the association of age at menarche with adult anthropometric measures and various socio-demographic factors. The mean and median age of menarche were 13.12 ± 1.16 and 13.17 years, respectively, with an increasing tendency among birth-year cohorts from 1979 to 1986. Menarcheal age was negatively associated with BMI ($p<0.01$), but positively associated with height ($p<0.05$). Early menarche was especially pronounced among students from urban environments, Muslims and those with better educated mothers. Increasing age at menarche may be explained by improved nutritional status among Bangladeshi populations. Early menarche was associated with residence location at adolescence, religion and mother's education.

Introduction

The age at onset of the menstrual cycle (menarcheal age) is a significant period in the life of a female adolescent. It is also an important indicator for certain diseases, with an early onset of menarche having been shown to be a risk factor for breast cancer (Kelsey, 1993), pelvic inflammatory disease and spontaneous abortion (Helm *et al.*, 1996) and ischaemic heart disease (IHD) (Cooper *et al.*, 1999). One the other hand

delayed menarche has been implicated as a high risk factor for irregular menstrual cycles and low peak bone mass (Anai *et al*., 2001). Young woman with type I diabetes mellitus have been shown to have moderately delayed age at menarche compared with the general population (Danielson *et al*., 2005). The patterns of such diseases could be ameliorated with changes in the age at menarche over time.

Wyshak & Frisch (1982) reported that secular changes in age at menarche have been described since the 18th century, and other researchers have reported changes in age at menarche worldwide (Cole, 2000; Kac *et al*., 2000; Prebeg & Bralic, 2000; Okasha *et al*., 2001; Ayatollahi *et al*., 2002; Becker-Christensen, 2002; Hesketh *et al*., 2002; Wang & Murphy, 2002; Hwang *et al*., 2003; Junqueira *et al*., 2003; Padez, 2003; Padez & Rocha, 2003; Ersoy *et al*., 2004).

Okasha *et al*. (2001) have suggested that the nature of the relationship between menarcheal age and adult anthropometric measures may be important in understanding the significance of the effects of menarcheal age on disease in later life. Numerous researchers have shown that age at menarche is associated with adult height, weight and body mass index (Shangold *et al*., 1989; Georgiadis *et al*., 1997; Bharati & Bharati, 1998; Laitinen *et al*., 2001; Ersoy *et al*., 2004). It has also been shown to be related to socioeconomic and demographic factors (see, for example: Padez, 2003; Chavarro *et al*., 2004; Wronka & Pawlińska-Chmara, 2005).

Specifically with respect to Bangladeshi populations, researchers have studied the relationship of age at menarche with nutritional status, post-menarcheal growth and marriage (Chowdhury *et al*., 1977; Ogata, 1979; Haq, 1984; Riley *et al*., 1989; Chowdhury *et al*., 2000). Ogata (1979) investigated age at menarche of 775 Bangladeshi housewives born between 1938 and 1957; he reported that mean age at menarche remained stable over birth-year cohorts.

The purpose of the present study was to test for the presence of any secular trends in age at menarche in university female students in Bangladesh in the birth-year cohorts from 1979 to 1986. In addition, the association between age at menarche and various adult anthropometric measures and socio-demographic factors was assessed.

Data and Methods

Data

The study sample consisted of 995 healthy Bangladeshi adult female students residing in student halls at the University of Rajshahi, Bangladesh, between July 2004 and May 2005. The university has four female halls of residence accommodating a total of 2900 students at any particular time. The University of Rajshahi is the second largest university in Bangladesh, with students coming from all over the country. The sample was selected using stratified random sampling with a proportional allocation technique.

A total of 1000 selected students were asked by a female co-author (Saima Islam), using a standard questionnaire, to report their age at menarche, and socio-demographic characteristics were recorded for each subject. Five students who could not remember their menarcheal age were excluded from the current analysis. Consequently, 995 female students were included in this study to evaluate the secular

Table 1. Age at menarche of Bangladeshi adult female students by birth-year cohorts

Year of birth	*N*	Age at menarche				
		Mean	SD	Median	Minimum	Maximum
1979	148	12.86	1.10	12.89	10	15
1980	117	12.90	1.28	12.88	10	15
1981	127	13.02	1.09	13.05	10	15
1982	135	12.92	1.17	12.88	10	15
1983	117	13.15	1.09	13.20	10	15
1984	88	13.24	1.12	13.31	10	15
1985	110	13.38	1.17	13.51	10	15
1986	153	13.54	1.08	13.59	11	15
All	995	13.12	1.16	13.17	10	15

trend of age at menarche and association with anthropometric and socio-demographic factors. Body height was measured as the distance from the highest point of the top of the head in the mid-sagittal plane to the floor by anthropometer, and body weight was taken with thin clothing using a weighing scale. All measurements were done by a single researcher (Saima Islam). Body mass index (BMI), defined as the ratio of weight in kilograms to height squared in metres, was calculated.

Analysis

The sample was subdivided into eight classes according to birth-year from 1979 to 1986. Descriptive statistics were first used to calculate the mean and standard deviations for age at menarche by birth-year cohorts. Also, a probit method was used to calculate the median of age at menarche by birth-year cohorts (Table 1). The data were then subjected to further statistical analysis.

To examine the interclass variation of the response variable (age at menarche) the statistical linear model for one-way analysis of variance (ANOVA) was applied. The model corresponding to each variable is:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij} \tag{1}$$

$$i = 1, 2, \ldots, p,$$

$$j = 1, 2, \ldots, q,$$

where Y_{ij} is the j^{th} observation (response variable) for the i^{th} birth-year cohort; μ is the general mean effect; $\alpha_i = \mu_i - \mu$ (additional effect of i^{th} birth-year cohorts); μ_i is the average effect of ith birth-year cohorts; ε_{ij} is the random error term, which follows $N(0, \sigma^2)$; p is the number of cohorts; and q is the number of observations for each cohort.

The ANOVA procedure tests the hypothesis H_o:

$$\alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_p = 0,$$

or equivalently:

$$\mu_1 = \mu_2 = \ldots = \mu_p = \mu,$$

by means of a single *F*-test. If the hypothesis of the equality of cohort means is rejected, it may be concluded that there are differences among the cohort means. The randomness, normality and homogeneity of cohort variances were checked using the Kolmogorov–Smirnov non-parametric test, a normal probability plot, and the Levene test, respectively, for the validity of the ANOVA data.

Linear regression analysis was applied to detect the possible presence of trends in age at menarche among the birth-year cohorts from 1979 to 1986.

To examine the average relationship between the age at menarche and body measurements and socio-demographic factors, multiple regression analysis was utilized. The underlying multiple linear regression model corresponding to each variable is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_k X_k + \varepsilon, \tag{2}$$

where Y is the response variable (age at menarche), X_i (i=1, 2, 3,. . ., k) are the predictor variables (independent variables), β_0 is the intercept term, β_1, β_2,. . ., β_k are the unknown regression coefficients, and ε is the error term with a $N(0, \sigma^2)$ distribution. In multiple regression analysis, an important assumption is that the explanatory variables are independent of each other, i.e. there is no relationship between the explanatory variables to estimate the ordinary least squares (OLS). However, in some applications of regression, the explanatory variables are related to each other. This problem is called the multicollinearity problem (Chatterjee & Hadi, 2006). In this study, a variance inflation factor (VIF) was used to check for the multicollinearity problem among the predictor variables. The variance inflation for independent variables X_j is:

$$\mathrm{VIF}_j = 1/1 - R_j^2, \tag{3}$$

$$j = 1, 2 \ldots, p,$$

where p is the number of predictor variables and R^2_j is the square of the multiple correlation coefficient of the j^{th} variable with the remaining $(p-1)$ variables, where:

(1) if $0<\mathrm{VIF}<5$, there is no evidence of a multicollinearity problem;
(2) if $5 \leq \mathrm{VIF} \leq 10$, there is a moderate multicollinearity problem; and
(3) if $\mathrm{VIF}>10$, there is a serious multicollinearity problem of variables.

Finally, Student's *t*-test was used to find the differences between the religions (Muslim and Hindu), residence (urban and rural), father's occupation (government or non-government service and self-employed) and mother's occupation (government or non-government service and housewife). All statistical analyses were performed using SPSS (version 15.0) and MINITAB.

Table 2. Analysis of variance for age at menarche of Bangladeshi adult female students by birth-year cohorts

	Sum of squares		Degrees of freedom		Mean square		
	Between group	Within group	Between group	Within group	Between group	Within group	F_{cal}
Age at menarche	57.984	1247.058	7	987	8.283	1.263	6.556**

**1% level of significance.

Results

A total of 995 female students were interviewed and examined. The age at menarche of Bangladeshi adult female students varied from 10 to 15 years, with a mean menarcheal age of 13.12 ± 1.16 and a median 13.17 years (Table 1).

Secular trends

Since the current study was subdivided into eight cohorts by birth-year, this facilitated a study of possible trends over time. Before utilizing the ANOVA, it was necessary to ensure that the standard assumptions underlying the ANOVA model were satisfied. Consequently, it was necessary to first test the data for randomness, normality and homogeneity. The Kolmogorov–Smirnov non-parametric test and the normal probability plot showed that there were no serious problems concerning the randomness and normality of the data. In addition, the Levene test demonstrated that the data were homogeneous. Thus, the data satisfied the standard assumptions of the ANOVA model.

The variations of mean age at menarche of Bangladeshi adult students by birth-year cohort from 1979 to 1986 were statistically significant ($p<0.001$) (Table 2).

Linear regression

To examine the presence of secular trends a regression coefficient was computed. Mean age at menarche is depicted graphically in Fig. 1. This shows that there were yearly fluctuations in age at menarche, and this is a characteristic of such cohort studies. This fluctuation in age at menarche was further examined by linear regression analysis. The positive coefficient of linear regression analysis indicated that the age at menarche of university female students generally increased in value from the birth-year cohorts 1979 to 1986 (Table 3).

Multiple regressions

The multiple regression model used was:

$$\mathrm{AAM} = \beta_0 + \beta_1 \mathrm{Ht} + \beta_2 \mathrm{BMI} + \beta_3 \mathrm{MI} + \beta_4 \mathrm{FEL} + \beta_5 \mathrm{MEL} + \beta_6 \mathrm{NS} + \beta_7 \mathrm{OB} + \varepsilon, \qquad (4)$$

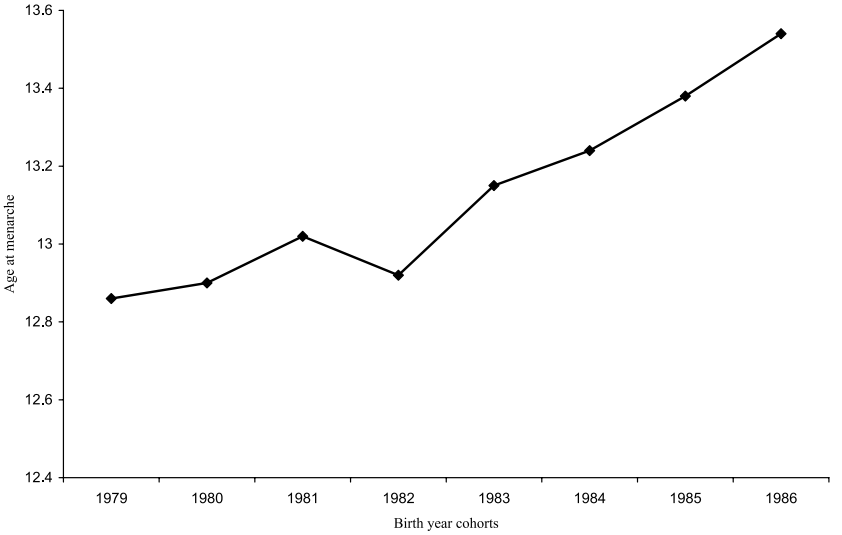

Fig. 1. Mean age at menarche by birth-year cohorts.

Table 3. Regression coefficient for the effect of year of birth on age at menarche of Bangladeshi adult female students

Variable	Regression equation	Regression coefficient[a]	R^2	p-value	95% CI	
					Lower bound	Upper bound
Age at menarche	y=12.70+0.096x	0.097	90.76%	0.0001**	0.065	0.126

[a]Test for linear trend.
**1% level of significance.

where age at menarche (AAM) is the response variable and the other variables are predictors: Ht, body height; BMI, body mass index; MI, family monthly income; FEL, father's education level; MEL, mother's education level; NS, number of siblings; OB, order of birth.

The estimated model was:

$$\begin{aligned}\text{AAM}\hat{} = {} & 12.60 + 0.0147\text{Ht} - 0.0778\text{BMI} - 0.000005\text{MI} \\ & + 0.0068\text{FEL} - 0.0911\text{MEL} + 0.0177\text{NS} + 0.00040\text{OB}. \end{aligned} \quad (5)$$

The regression coefficients and the VIF of the independent variables are presented in Table 4. The VIF showed that there was no evidence of a multicollinearity problem among the predictor variables. The coefficients of the multiple regression analysis showed that there was a significant positive association between age at menarche and height (p<0.05), and a negative association between age at menarche and BMI

Table 4. Multiple regression coefficients and the variance inflation factor (VIF) for body measurements and socio-demographic factors with age at menarche as the response variable

Predictor	Coefficient	*t*-value	*p*-value	VIF
Height (cm)	0.014720	2.00	0.046*	1.0
BMI (kg m^{-2})	−0.07776	−5.39	0.000**	1.0
Family monthly income (taka)	−0.00000501	−1.28	0.201	1.0
Father's education level	0.00678	0.19	0.850	1.4
Mother's education level	−0.09113	−2.54	0.011*	1.5
No. siblings	0.01766	0.54	0.586	2.6
Order of birth	0.00042	0.01	0.989	2.6

*5% level of significance;
**1% level of significance.

($p<0.01$) (Table 4). These results suggest that taller and slimmer females reached menarche later than shorter and heavier females. They also show that age at menarche tends to be higher with nutritional status using BMI as an indicator.

The coefficients of multiple regression analysis also show there was a significant negative association between a girl's age at menarche and her mother's education level ($p<0.05$), while social class (monthly family income), number of siblings and order of birth did not show association with age at menarche (Table 4). These results indicate that the daughters of better educated mothers reach menarche earlier.

The majority of students were Muslim (89.45%). The majority (64.49%) of student's fathers worked in government or non-government service, while only 11.66% of mothers worked in service (Table 5). To see if there was a significant difference in age at menarche between two groups, the *t*-test was applied. Students from rural locations had a later mean age at menarche than those who spent their adolescence in urban areas. Muslim students also tended to reach menarche earlier than Hindu students. Daughters of parents who worked in government or non-government service tended to reach menarche earlier than those whose parents were self-employed (Table 5).

Discussion

Secular trends in age at menarche

The study found that the mean menarcheal age of female students at Rajshahi University (data collected between July 2004 and May 2005) was 13.12 ± 1.16 years, which was older than the value of 12.88 years found by Ogata in 1979 for Bangladeshi females (Ogata, 1979). A more recent study (roughly 20 years later) found that the mean menarcheal age of Bangladeshi females was 13.00 ± 0.98 years (Chowdhury

Table 5. Differences between age at menarche of Bangladeshi female students by socio-cultural status

				Age at menarche		
		N	%	Mean	SD	*p*-value
Religion	Muslim	890	89.45	13.10	1.15	0.0262*
	Hindu	105	10.55	13.33	1.13	
Residence	Urban	516	51.91	13.01	1.16	0.0008**
	Rural	478	48.09	13.24	1.12	
Father's occupation	Service	641	64.49	13.07	1.17	0.0239*
	Self-employed	353	35.51	13.22	1.09	
Mother's occupation	Service	116	11.67	12.92	1.26	0.0212*
	Housewife	878	88.33	13.15	1.13	

*5% level of significance;
**1% level of significance.

et al., 2000). These results suggest that the secular trend toward an increase in age at menarche of Bangladeshi females is still continuing. The current study's investigation period, while limited to only eight years from 1979 to 1986, also displays a pattern of mean age at menarche that rises with cohort age (Fig. 1). Moreover, the regression coefficient (β=0.097) indicates that menarcheal age of Bangladeshi female students has increased over time (Table 3). Ogata (1979), who reported on the secular trend in age at menarche of Bangladeshi females, indicated that the age at menarche remained stable among birth-year cohorts from 1938 to 1957. The results of the current study are in agreement with those of Cole (2000), who pointed out that the mean menarcheal age of most European countries had stabilized at approximately 13 years but may be subsequently rising, as was found in a Germany study by Gohlke & Woelfle (2009). The current results are also in agreement with those of Dann & Roberts (1993), who reported that the mean age at menarche of Warwick University female students has also increased. This increasing tendency in age at menarche has also been found in the United States (Wyshak, 1983), Finland (Rimpelä & Rimpelä, 1993) and Croatia (Prebeg & Bralic, 2000).

Menarcheal age and anthropometric measures

The present study demonstrates that the age at menarche of Bangladeshi female students was negatively associated with adult BMI, but positively associated with adult height. These results are supported by the findings of Chowdhury *et al.* (2000), who found that the age at menarche of Bangladeshi females was related negatively with BMI and positively with height, and those of Ersoy *et al.* (2004), who reported an inverse relationship between age at menarche and post-menarcheal weight and BMI of Turkish female students. The present results also corroborate the study of Okasha *et al.* (2001), who found in female students at the University of Glasgow that

age at menarche was positively associated with adult height and negatively associated with weight and BMI.

Menarcheal age and socio-demographic factors

The present study demonstrates that mother's educational level and occupation have a significant influence on their daughter's age at menarche. To the authors' knowledge, there have been no comparable studies on this in Bangladesh to date. However, a similar study conducted on female university students in Portugal (Padez, 2003) found no association between a girl's age at menarche and her parent's educational level and occupation. The present study found that females from rural locations had a later age at menarche than those who spent their adolescence in urban areas. Identical results have been found in Portugal (Padez, 2003) and Spain (Marrodán *et al.*, 2000). The current study showed that female Muslim students tended to reach menarche earlier than Hindu students. A similar result was found by Chowdhury *et al.* (1977). Environment and social–cultural background, such as definitions of levels of education and classification of occupation types, vary significantly between different geographical areas. It may be difficult to make conclusions based on multiple studies from different parts of the world, and perhaps more local, regional studies should be conducted.

This study only investigated trends in age at menarche and its association with selected anthropometric measures and socio-demographic factors. It was not possible to look at other important factors directly related to age at menarche, such as birth weight (Silva *et al.*, 2002; Terry *et al.*, 2009), childhood living conditions (Kac *et al.*, 2000), food habits in childhood (Windham *et al.*, 2004), physical activity, life-style factors and nutrition (Merzenich *et al.*, 1993). Clearly, more research is required.

Conclusions

The mean age at menarche among Bangladeshi university students (data collected between July 2004 and May 2005) was found to be 13.12 ± 1.16 years and the median was 13.17 years, showing an increase over time when compared with previous studies. Menarcheal age was negatively associated with adult BMI, but positively associated with height. Early menarche was noted among students from urban areas, those of Muslim religion and those from households with an educated mother.

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