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Menstrual characteristics and its association with socio-demographic factors and nutritional status: a study among the urban slum adolescent girls of West Bengal, India

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ABSTRACT: Menstrual health is one of the major areas of concern in reproductive health, and affects a large number of women throughout their reproductive life from adolescence. Menstruation is a biological phenomenon imbued with social-cultural, nutritional and personal significance. The present study aims to focus on the menstrual characteristics and its association with socio-demographic factors and nutritional status among the urban slum adolescent girls of North 24 Parganas district, West Bengal. This community-based study was conducted among a group of 90 Bengali speaking Hindu adolescent girls aged between 16 to 18 years. A pre-tested structured schedule was used to collect detailed information about the socio-economic conditions and menstrual characteristics. All anthropometric measurements were taken using the standard procedures. Results of the study revealed that underweight girls attained menarche comparatively in later age (12.67±1.23) than that of healthy and overweight girls. Mean length of the menstrual cycle, mean duration of menstrual bleeding and mean number of days of peak discharge were maximum among the girls whose BMI was below 5th percentile, i.e. underweight. Majority of the underweight (75%) and healthy (50%) girls experienced heavy discharge during their menstrual days. Disorders like premenstrual syndrome (PMS) (78.8%) and dysmenorrhea (85.5%) were the major prevalent menstrual problems among these girls and occurrence of the symptoms of these disorders significantly varied based on their BMI. A highly significant difference ($p<0.01$) was found among underweight, healthy and overweight girls in terms of duration of menstrual bleeding, mean number of days of peak discharge and occurrences of PMS. Result of linear regression and step wise logistic regression (backward elimination) shows that various socio-economic and anthropometric variables are the influential predictors of menstrual characteristics like duration of menstrual discharge, cycle length, days of peak discharge as well as menstrual problems like cycle irregularity and heavy flow ($p<0.05$). Therefore, the present study unwraps a podium to focus on the menstrual health issues of the adolescent girls and enforce health education as well as instigates nutritional intervention programme to fortify the existing menstrual health status.

KEY WORDS: menstrual characteristics, nutritional status, adolescent girls, urban slum, West Bengal

Abbreviations used in this paper: AM – Age at menarche, ANOVA – Analysis of variance, BAI – Body adiposity index, BMI – Body mass index, BSF – Biceps skin fold, CI – Conicity index, CL – Cycle length,

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DB – Duration of bleeding, DLHS – District level household survey, FFM – Fat-free mass, FFMI – Fat-free mass index, FM – Fat mass, FMI – Fat mass index, FP – Frankfurt plane, HC – Hip circumference, LR – Likelihood ratios, MUAC – Mid upper-arm circumference, NDPD – Number of days of peak discharge, NGO – Non-governmental organisation, PBF – Percent body fat, PMS – Premenstrual syndrome, SISF – Supra-iliac, SPSS – Statistical package for social sciences, SSF – Subscapular skinfold, TSF – Triceps skinfold, WC – Waist circumference, WHO – World Health Organization, WHR – Waist-to-hip ratio.

Introduction

Adolescence is the transitional phase of physical and mental development between childhood and adulthood and is characterised by immense hormonal changes. The word adolescent derived from of the Latin word, *adolescere* meaning "growing to maturity" (Dictionary by Merriam-Webster). This period is very crucial since these are the formative years in the life of an individual when major physical, endocrinal and physiological development took place in terms of attainment of menarche, the onset of menstruation (Kaczmarek 2011; Kanotra et al. 2013). Menstrual cycle is normal physiological process that is characterized by periodic and cyclic shedding of progestational endometrium accompanied by loss of blood. This is an additional vital sign which adds as a powerful tool to the assessment of normal development and the exclusion of pathological conditions among the adolescent and young girls (Diaz et al. 2006).

Generally, adolescence is considered as a healthy phase of life, however, menstrual problems are very common especially in the late adolescence (Ziv et al. 1999). Menstrual health is one of the major areas of concern in reproductive health, and affects a large number of women throughout their reproductive life from adolescence (Omidvar et al. 2018). The list of menstrual disorders may range from hypomenorrhea (light menstruation), menorrhagia (heavy menstrual bleeding), oligomenorrhea (infrequent menstrual cycle), amenorrhea (menstrual cycle occurring more than 35 days apart) to dysmenorrhoea (painful menstruation) and premenstrual syndrome (PMS) (Campbell and McGrath 1997). Studies worldwide show that several factors such as socio-economic status, ethnicity, place of residence, nutritional status, life style habits, and genetics are responsible behind these menstrual disorders (Munster et al. 1992; Harlow and Park 1996; Rowland et al. 2002; Rahman et al. 2004; Sanyal and Ray 2008) and out of these nutrition and body weight play a very crucial role in determining pubertal development (Karlberg 2002).

There appears to be a relationship between body weight and the onset of menarche and maintaining a healthy menstrual cycle (World Health Organization 1986).It is estimated that a minimum body fat of 17% is necessary for menarche and 22% body fat is necessary for maintaining normal menses (Lacroix and Whitten 2018). It is reported that having a high or low Body Mass Index (BMI) may cause to experience an absence of menstruation, irregular menstruation and painful menstruation (Yu et al. 2015). Women without much fat on their bodies may lead to lack of estrogen, and the lack of fat doesn't allow cells to convert cholesterol into extra estrogen which may stop ovulation (Fujiwara and Nakata 2004). On the other hand, extra estrogen can cause bleeding or menstrual disorders because overweight women carrying extra fat cells have "little estrone-making factories", which have an estrogenic effect on glands. Therefore, it is required to keep BMI within the normal range to promote regular and healthy menstrual cycles (Fujiwara 2005; Nagata et al. 2005).

Body mass index (BMI) is widely used in assessing the nutritional status, but it cannot describe the distribution of abdominal adipose tissue (Wang et al. 2017). Therefore, additional anthropometric indices are required to assess abdominal adipose accumulation. Elevated waist circumference (WC) and waist-to-hip ratio (WHR) were reported to be strongly associated with central fat distribution (Bao et al. 2008), in addition with other indices like conicity index (CI) and body adiposity index (BAI) that have often been used in epidemiological research (Shidfaret al. 2012; Bergman et al. 2013).

Adolescence, is a period which prepare an individual nutritionally for a healthy adult life .In a developing country like India adolescence constitutes around 1/5th of the total country's population (Hanson and Gluckman 2006), and are the worst sufferers of the ravages of various forms of malnutrition because of their increased nutritional needs and low social power (Kaur et al. 2007; Choudhary et al. 2009). Moreover, due to poverty, poor standard of living, malnutrition, low level of education, poor knowledge of health and diseases and poor access to health care services, urban slum area are more susceptible to various diseases and morbidity tends to be high predominantly among the women of the reproductive age group (Vasanthi et al. 1994; Chaturvedi et al. 1996). Under this circumstance the present study is an envisage to study the association between the various anthropometric indices with the menstrual characteristics among the-urban slum adolescent girls of North 24 Paraganas of West Bengal.

Materials and Methods

Study design and participants

The present study was carried out in a peri-urban area of Duttabad, a slum in North 24 Paragana district at West Bengal, India. Duttabad, one of the first established slums located in Salt Lake City under Bidhannagar Municipal Corporation and out of the 21 slums in Salt Lake area Duttabad occupies the largest space (Mitra and Banerji 2016). From this selected slum area, data has been collected from total 90 adolescent girls covering the ages 16, 17 and 18. All the study participants were Hindu, Bengali speaking girls and were from the same ethnic group. Prior to data collection, the purpose and nature of study were explained to the participants as well as to their either or both parents and a verbal consent was taken from them. No proper sampling technique was adopted in selecting the subjects. The whole data were collected from the participants in person, by one of the authors (AS) during the months of March to May, 2017.

The study participants were selected based on the certain criteria these are, presently not in wedlock, aged between 10–19 years (following WHO criteria for being an adolescent), and experienced menarche at least two years prior to the interview date. All the participants were free from any previous histories related to medical and surgical episodes, physical deformity and were not suffering from any diseases at the time of interview. The subjects who volunteered to participate in the study and also corresponded with the study criteria were incorporated in the study.

Data regarding socio-economic status, menstrual characteristics and menstrual disorders, were collected by using a pre-tested structured schedule. Socio-demographic status was ascertained through the data like subjects' age, educational status, educational and occupational status of their parents, number of family members and monthly family expenditure.

Data related to menstruation included date of first menstruation (menarche) which was collected by asking the exact date, if couldn't recall, then the nearest month of any events or festivals around the time of menarche; menstrual discharge which was considered by scanty, moderate and heavy amount of menstrual bleeding (self-assessed); days of peak discharge was considered as the number of days during which maximum amount of menstrual blood is discharged (self-assessed); duration of bleeding was considered as the number of days during which menstrual blood is discharged from the body and cycle length was considered as the period between the first day of menstrual bleeding and the day immediately prior to the next menstrual bleeding. Menstrual disorders like 'irregular periods' was considered as menstruation that took place on a monthly basis but at a nonspecific interval of time and 'skipping of cycle', as the skipping of menstrual cycle during a particular month or for some months on the basis of last one-year history. Menstrual disorders were also determined by Premenstrual syndrome and dysmenorrhea. Premenstrual problems were defined as symptoms like irritability, anxiety, mood swing, insomnia, breast tenderness, changes in appetite, nausea, abdominal bloating, lower abdominal pain, lower back pain and joint pain that they have experienced just a few days before the menstruation started. Dysmenorrhea was described as painful cramping, abdominal pain accompanying menstruation in association with few other symptoms like lower back pain, pain in thigh, pain during or after passing urine, pain with full bladder, abdominal blotting, nausea or vomiting, frequent urination and fatigue.

Anthropometric measurements

All the measurements were carried out by a well-trained student, the first author (AS). Care was taken to avoid any possible systematic errors (instrumental or definition of landmarks) in the course of recording the anthropometric measurements as outlined by Lohman et al. (1988). Height was measured to the nearest 0.1 centimetre by using an anthropometric rod by asking the subject to stand erect looking straight on a levelled surface with heels together and toes apart, without her shoes, with head oriented in the Frankfurt plane (FP). FP is defined as the anatomical position of the human skull, based on a plane passing through the inferior margin of the left orbit and the upper margin of each ear. Weight was recorded measured in kilograms under basal conditions with participant in bare feet and wearing minimum clothing. Mid Upper-Arm Circumference (MUAC) was measured in centimetre with non-stretched measuring tape by asking the participant to flex the bicep muscle while the tape was wrapped around the flexed bicep gently but firmly avoiding compression of soft tissues in the midway between the tip of acromion and olecranon process. Waist circumference (WC) was measured in centimetre at a point midway between the lower border of the ribs and the highest point of iliac crest using a non-stretchable flexible tape in horizontal position, with the subject standing erect and looking straight forward. Hip circumference (HC) was also measured in centimetre by applying the tape at the point yielding the maximum circumference or the widest part over the buttocks, between the greater trochanter (top of the thigh bone) and the lower buttock level, with the participant's legs together. Biceps skin fold (BSF) was measures by hanging the subject's arm in a relaxed position at the side and measurements was taken by pinching the fold running parallel just above a marked point on the midline of the front of the arm between the elbow and the acromion process. The triceps skinfold (TSF) was measured on the back of the same arm by pinching the fold slightly above over the triceps muscle, midway between the elbow and the acromion process of the scapula by keeping the skinfold site in a vertical position. Subscapular skinfold (SSF) was taken just below the inferior angle (lower tip) of the scapula (shoulder blade). The subscapular skinfold measurement was on a line from the inferior angle of the scapula in a direction that is obliquely downwards and laterally at 45 degrees. Supra-iliac (SISF) was measured through locating first the anterior superior iliac spine. The tip of the calliper was gently touched at the point where the superior iliac spine is downward and dropped off, while the left hand was on the axillary border. Raised the fold 5–7 cm (depending on the size of the subject) above the anterior superior iliac spine and measurements was taken. All the skinfold measurements were taken in mm by using Harpenden skinfold calliper.

Various anthropometric indices

1. Body mass index (BMI) was calculated in the standard way as:

$$\text{BMI (kg/m}^2\text{)} = \text{Weight (kg)/Height}^2 \text{ (m)}$$

BMI was classified for age, according to the WHO (2007) classification criteria, where a BMI less than 5th percentile is classified as underweight, 5th to <85th percentile as healthy, 85th to <95th percentile as overweight and ≥95th percentile as obese.

2. Waist-hip ratio (WHR) was calculated) by the formula (WHO 2000)

$$\text{WHR} = \text{WC (cm)/HC (cm)}$$

3. The following equations of Slaughter et al. (1988) were used to estimate Percent Body Fat (PBF):

$$\text{PBF} = 1.33\ (\text{TSF} + \text{SSF}) - 0.013(\text{TSF} + \text{SSF})^2 - 2.5$$

4. The following equations of VanItallie et al. (1990) were utilized to assess the proportion of Fat mass (FM), Fat-free mass (FFM), Fat mass index (FMI) and Fat-free mass index (FFMI):

$$\text{FM (kg)} = (\text{PBF}/100) \times \text{weight (kg)}$$
$$\text{FFM (kg)} = \text{Weight (kg)} - \text{FM (kg)}$$
$$\text{FMI (kg/m}^2\text{)} = \text{FM (kg) /Height}^2 \text{ (m}^2\text{)}$$
$$\text{FFMI (kg/m}^2\text{)} = \text{FFM (kg) /Height}^2 \text{ (m}^2\text{)}$$

5. Body Adiposity Index was calculated according to the following equation (Bergman et al. 2011):

$$\text{BAI} = [\text{HC (m)/Height}^{2/3} \text{ (m)}] - 18$$

6. Conicity Index (CI) was determined according to the following equation (Taylor et al. 2000):

$$CI = WC\ (m)/\sqrt{0.109} \times Weight\ (kg)/Height\ (m).$$

Statistical analysis

Descriptive statistics were used to understand the variation in the menstrual profile of the adolescent girls according to their nutritional status. One-way ANOVA was analyzed for comparing menstrual characteristics and anthropometric variables among the three BMI groups (underweight, health and overweight/obese). Pearson's correlation coefficient (r) was used to determine the relationship between different anthropometric parameters and menstrual characteristics.

Linear regression was applied to understand the impact of socio-economic, menstrual characteristics as well as anthropometric variables on dependent variables like cycle length, duration of menstrual bleeding and number of days of peak discharge. For all dependent variables, socio-demographic parameters like participants' age and education, parental education, total number of family members and family's monthly expenditure; menstrual characteristics like age at menarche, menstrual years, duration of bleeding, number of days of peak discharge cycle length, irregularity of periods and heavy menstrual discharge; and anthropometric variables like MUAC, BMI, FMI, WHR, BAI and PBF were considered as the independent predictors but only significant indicators were mentioned in the final table.

Stepwise logistic regression (backward elimination) analysis was performed for identifying the most influential variables (Kutner et al. 2005; Chatterjee and Hadi 2006) on irregular menstrual cycles and heavy menstrual flow. Backward elimination (Likelihood Ratio) method started (step 1) with the full model (including all the possible explanatory variables like socio-economic status, menstrual characteristics and anthropometric variables) and in each step it removed insignificant variables from the model using the probability of the likelihood ratio statistic based on the maximum partial likelihood estimates (Midi et al. 2010), until all of the remaining stepwise terms have a statistically significant contribution to the model. The contribution of individual variable for each step was checked by the Wald statistic and if all the Wald test values are significant, the full set of variables was retained in the final step. Prior to carrying out the any regression analyses, menstrual characteristics and anthropometric variables that tend to co-occur were identified using chi-square tests and co-occurring variables were not considered together as independent variables at the time of regression analyses.

The analyses of the data were done using the Statistical Package for Social Sciences version18.0 (SPSS Inc., Chicago IL, USA). And *p*-values less than equal to 0.05 (two-tailed) were considered statistically significant.

Results

Table 1 shows the association of menstrual characteristics between underweight, healthy and overweight and obese adolescent girls. The result revealed that only duration of menstrual bleeding ($p<0.001$), 'mean number of days of peak discharge' ($p<0.001$) and occurrences of PMS ($p<0.01$) differ significantly between these three groups. Underweight girls attained menarche comparatively in later age (12.67±1.23) than that of healthy and overweight girls. Mean length of the menstrual cycle, mean duration of menstrual bleeding and mean number of days of peak discharge was maximum in percentage among those girls whose BMI was below 5th percentile (underweight). Nevertheless, majority of the underweight (75%) experienced heavy discharge during their menstrual days. It is interesting to note that majority of the girls in all the three categories did not skip their monthly cycle in last one year and also experienced monthly periods on a regular basis but, menstrual disorders like PMS and Dysmenorrhoea was predominant among all the three groups.

Table 2 represents s that majority of the underweight girls experienced PMS like mood swing (66.7%), insomnia (58. 3%), pain in lower abdomen (75%) and lower back pain (50%). Lower abdominal pain (53.2%) and back pain (44.7%) were the most frequently reported PMS among the healthy girls while girls with higher BMI reported less PMS related problems except lower back pain (41.7%). A significant difference ($p\leq0.05$) was observed between the three BMI based categorized girls for problems like irritation, mood swing, insomnia, breast tenderness, nausea, lower abdominal pain and joint pain.

Maximum girls in all the three groups, underweight (91.8%), healthy (79.3%)

Table 1. Distribution of the menstrual characteristics stratified by weight status

Variables		Body weight status			*F*-value and χ^2 *p*-value
		Underweight n=12	Normal weight n=66	Overweight and Obese n=12	
Age at menarche (years)[a]		12.67±1.23	12.48±1.27	12.58±0.79	F=0.13 p=0.88
Length of menstrual cycle (days)[a]		32.00±4.86	31.52±4.12	30.17±2.10	F=0.70 p=0.23
Duration of menstrual bleeding (days)[a]		7.00±1.60	4.85±1.34	4.92±1.38	F=12.56 $p<0.001$
Number of days of peak discharge[a]		3.08±1.31	1.73±1.03	1.50±0.91	F=9.26 $p<0.001$
Menstrual flow during peak discharge day	Light	1 (8.3)	16 (24.2)	6 (50.0)	χ^2= 8.78 $^{¥}p$ = 0.07
	Med	2 (16.7)	17 (25.8)		
	Heavy	9 (75)	33 (50.0)	6 (50.0)	
Nature of discharge	With clot	8 (66.7)	33 (50.0)	10 (83.3)	χ^2= 5.16
	Without	4 (33.3)	33 (50.0)	2 (16.7)	$^{£}p$ = 0.07
Skipping of cycle	Yes	2 (16.7)	14 (21.2)	3 (25.0)	χ^2 = 2.50
	No	10 (83.3)	52 (78.8)	9 (75.0)	$^{¥}p$ = 0.92
Regularity of cycle	Regular	7 (58.3)	53 (80.3)	9 (75.0)	χ^2= 2.76
	Irregular	5 (41.7)	13 (19.7)	3 (25.0)	$^{¥}p$ = 0.23
Premenstrual syndrome	Yes	12 (100)	47 (71.2)	12 (100)	χ^2= 8.76
	No		19 (28.8)		$^{¥}p<0.01$
Dysmenorrhoea	Yes	12 (100)	53 (80.3)	12 (100)	χ^2= 5.53
	No		13 (19.7)		$^{¥}p$ = 0.07

[a]Mean±standard deviation; Figures in parenthesis indicates percentage; [¥]Fisher's exact test; [£]Chi square test.

Table 2. Distribution of the premenstrual and dysmenorrhoea problems stratified by weight status

Symptoms	Body weight status			*p*-value
	Underweight n=12	Normal weight n=66	Overweight and Obese n=12	
Premenstrual syndromes, Yes n=71 (78.9%)				
Irritation	4 (33.3)	3 (6.48)	2 (16.7)	¥0.03
Anxiety	1 (8.3)	8 (17.2)	2 (16.7)	¥0.89
Mood swing	8 (66.7)	11 (23.4)	2 (16.7)	¥0.01
Insomnia	7 (58.3)	9 (19.2)		¥0.002
Breast tenderness	2 (16.7)			¥0.05
Changes in appetite	3 (25.0)	14 (29.8)	2 (16.7)	¥0.79
Nausea		10 (21.3)		¥0.04
Abdominal bloating	1 (8.3)	9 (19.1)		¥0.28
Pain in lower abdomen	9 (75.0)	25 (53.2)	3 (25.0)	£0.05
Lower back pain	6 (50.0)	21 (44.7)	5 (41.7)	£0.88
Dysmenorrhoea, Yes n=77 (85.6%)				
Pain in lower abdomen	11 (91.7)	42 (79.3)	10 (83.3)	¥0.75
Lower back pain	9 (75.0)	22 (41.5)	6 (50.0)	£0.12
Pain in thighs	5 (41.7)	15 (28.3)	2 (16.7)	¥0.40
Pain during or after passing urine	2 (16.7)	11 (20.8)		¥0.25
Pain when bladder is full		21 (39.6)	4 (33.3)	¥0.02
Abdominal bloating	4 (33.3)	6 (11.3)	4 (33.3)	
Nausea/Vomiting	3 (25.0)	12 (22.6)		¥0.21
Frequent urination	4 (33.33)	32 (60.4)	2 (16.7)	¥0.01
Fatigue	3 (25.0)	16 (30.2)	6 (50.0)	¥0.41

Figures in parenthesis indicates percentage; ¥Fisher's exact test; £Chi square test.

and overweight (83.3%) reported lower abdominal pain as the main dysmenorrhoeal problem, followed by lower back pain and pain in thighs among the underweight girls; frequent urination, lower back pain and pain with full bladder among the healthy girls; and fatigue and lower back pain among the overweight girls (Table 2). Significant differences ($p<0.05$) were found between the three groups in the problems like pain with full bladder, abdominal bloating and frequent urination.

Table 3 reflects the anthropometric measures of the participants in the three categorised groups (based on BMI). Except height and conicity index, mean values of all anthropometric variables gradually increased with BMI. There was a significant difference ($p<0.05$) in the mean values of height, triceps skinfold, sub-scapular skinfold, PBF, FM, FMI and BAI among the underweight, healthy and overweight girls.

Correlation of menstrual characteristics with anthropometric measures was represented in Table 4. No statistical significant association was found between age at menarche and rest of the other variables. An inverse statistically significant ($p<0.01$) correlation ($r = -0.25$) was found between cycle length and number of days of peak discharge. Duration of bleeding shows a statistically significant ($p<0.001$) positive correlation ($r= 0.57$) with number of days of peak

Table 3. Distribution of the mean anthropometric measures stratified by weight status

Variables	Body weight status			*F*-value and *p*-value
	Underweight n=12	Normal weight n=66	Overweight and Obese n=12	
Height (cm)	157.26±5.93	153.22±5.84	154.06±6.83	F=6.19, p=0.003
Weight (kg)	39.61±4.24	48.07±5.42	67.41±11.19	F=1.46, p=0.24
MUAC (cm)	39.61±4.24	48.07±5.42	67.41±11.19	F=0.91, p=0.41
WC (cm)	62.58±4.54	68.72±6.10	89.68±6.70	F=0.73, p=0.48
HC (cm)	83.76±5.55	88.36±5.25	102.81±8.40	F=2.84, p=0.06
Biceps skinfold (mm)	13.43±2.98	19.64±6.46	23.93±9.14	F=2.60, p=0.08
Triceps skinfold (mm)	14.08±2.63	16.64±4.45	20.68±7.26	F=4.82, p=0.01
Sub-scapular skinfold (mm)	13.73±3.28	22.22±6.14	29.57±12.20	F=5.14, p=0.008
Supra-illiac skinfold (mm)	10.59±3.60	19.57±6.67	22.42±7.69	F=1.53, p=0.22
PBF (%)	24.33±1.87	28.34±3.11	27.36±3.85	F=7.97, p=0.001
FM (kg)	9.67±1.50	13.7±2.54	18.57±4.58	F=5.46, p=0.006
FFM (kg)	29.94±2.98	34.37±3.47	48.84±7.79	F=0.32, p=0.73
FMI (kg/m^2)	3.9±0.46	5.83±0.99	7.7±1.39	F=3.17, p=0.04
FFMI (kg/m^2)	12.11±0.74	14.65±1.13	20.42±2.29	F=0.35, p=0.71
WHR	0.75±0.05	0.78±0.05	0.88±0.02	F=0.83, p=0.44
BAI (%)	24.54±1.88	28.72±3.33	35.61±3.06	F=3.26, p=0.04
Conicity Index	1.15±0.07	1.13±0.07	1.25±0.03	F=1.72, p=0.19

[a]Mean±standard deviation.
MUAC – Mid-upper arm circumference; WC – Waist circumference; HC – Hip circumference; PBF – Percent body fat; FM – Fat mass; FFM – Fat free mass; FMI – Fat mass index; FFMI – Fat Free mass index; WHR – Waist-hip ratio; BAI – Body adiposity index.

Table 4. Correlation matrix between menstrual characteristics and anthropometric measures

	AM	CL	DB	NDPD	MUAC	WHR	BMI	FMI	FFMI	BAI	PBF	CI
AM	–											
CL	−0.08	–										
DB	−0.19	0.17	–									
NDPD	−0.09	−0.25[b]	0.57[c]	–								
MUAC	0.08	−0.17	−0.32[b]	−0.29[b]	–							
WHR	0.06	0.04	−0.05	−0.29[b]	0.57[c]	–						
BMI	0.03	−0.09	−0.34[c]	−0.29[b]	0.87[c]	0.69[c]	–					
FMI	0.06	−0.06	−0.36[c]	−0.26[b]	0.81[c]	0.53[c]	0.87[c]	–				
FFMI	0.01	−0.09	−0.30[b]	−0.28[b]	0.81[c]	0.69[c]	0.97[c]	0.71[c]	–			
BAI	−0.10	0.15	−0.26[b]	−0.30[b]	0.65[c]	0.57[c]	0.82[c]	0.72[c]	0.79[c]	–		
PBF	0.04	0.00	−0.27[b]	−0.09	0.37[c]	00.06	0.30[b]	0.73[c]	00.04	0.27[b]	–	
CI	−0.03	0.19	0.05	−0.22[b]	0.49[c]	0.82[c]	0.55[c]	0.44[c]	0.55[c]	0.66[c]	0.07[c]	–

[a] Correlation is significant at $p<0.05$ level, [b] Correlation is significant at $p<0.01$ level, [c] Correlation is significant at $p<0.001$ level.
AM – age at menarche; CL – cycle length; DB – duration of bleeding; NDPD – number of days of peak discharge.

Table 5. Results of linear regression for selected menstrual characteristics

Dependent variables	Significant Indicator(s)	β	SE	*p*-value	R^2
Cycle length	Participants' education	−0.24	0.23	0.015	0.482
	Irregularity of periods	0.26	1.02	0.034	
	Number of days of peak discharge	−0.36	0.46	0.007	
	BMI	2.00	0.99	0.016	
	BAI	0.49	0.17	0.006	
	PBF	2.04	0.84	0.003	
	FMI	−3.58	3.86	0.003	
Duration of discharge	Father's educational status	−0.30	0.04	0.009	0.582
	Number of days of peak discharge	0.65	0.12	0.001	
	WHR	0.41	3.42	0.002	
	BMI	−1.61	0.32	0.032	
Number of days of peak discharge	Mother's educational status	−0.26	0.04	0.031	0.569
	Father's educational status	0.33	0.03	0.004	
	Duration of Bleeding	0.67	0.08	0.001	
	Cycle length	−0.30	0.03	0.007	
	WHR	−0.34	2.80	0.013	

Table 6. Stepwise (backward elimination) logistic regression : predictors of irregular menstrual cycle

Step	Independent indicators	β	SE	Wald	*p*-value	OR	95% CI for OR		Change in −2LR
							Lower	Upper	
Step 1	Participants' age	−0.12	0.63	0.04	0.845	0.88	0.26	3.06	0.04
	Participants' education	0.22	0.46	0.24	0.628	1.25	0.51	3.05	0.25
	Mothers' education	0.45	0.25	3.23	0.072	1.56	0.96	2.55	4.46
	Fathers' education	−0.11	0.2	0.29	0.59	0.9	0.61	1.32	0.3
	Monthly Expenditure	0.00	0.00	0.84	0.358	1.00	1.00	1.00	0.94
	Age at menarche	−0.83	0.59	1.99	0.158	0.43	0.14	1.38	2.58
	Cycle length	0.6	0.31	3.89	0.049	1.83	1.00	3.33	8.61
	Duration of Bleeding	0.59	0.52	1.30	0.254	1.81	0.65	5.03	1.23
	Menstrual flow								
	Heavy			Reference group					
	Moderate	−0.25	1.47	0.03	0.864	0.78	0.04	13.8	0.18
	Scanty	−0.66	1.6	0.17	0.677	0.52	0.02	11.73	
Step 8	BMI	1.89	0.86	4.78	0.029	6.6	1.22	35.83	7.83
	BAI	−0.07	0.31	0.06	0.813	0.93	0.5	1.72	0.05
	MUAC	−1.82	1.05	2.99	0.084	0.16	0.02	1.27	4.72
	WHR	−42.42	20.72	4.19	0.041	0.00	0.00	0.17	6.21
	PBF	−0.45	0.33	1.90	0.168	0.64	0.34	1.21	2.67
	Mothers' education	0.34	0.13	6.92	0.009	1.40	1.09	1.8	9.33
	Age at menarche	−0.84	0.44	3.68	0.05	0.43	0.18	1.02	4.29
	Cycle length	0.53	0.2	7.39	0.007	1.70	1.16	2.49	18.68
	BMI	1.67	0.63	7.07	0.008	5.29	1.55	18.08	13.34
	MUAC	−2.16	0.86	6.32	0.012	0.12	0.02	0.62	12.04
	WHR	−29.86	13.94	4.59	0.032	0.00	0.00	0.08	5.95

discharge, and a negative significant correlation with MUAC, BMI, FMI, BAI, and PBF. Number of days of peak discharge showed a negative significant ($p<0.01$) correlation with MUAC, WHR, BMI, FMI, FFMI, BAI and conicity index.

Table 5 represents the results of linear regression for outcome variables like cycle length, duration of menstrual discharge and 'number of days of peak discharge'. A combination of socio-economic, menstrual characteristics and anthropometric variables viz. participants age and education, parental education, total number of family members, family's monthly expenditure, age at menarche, menstrual years, duration of bleeding, cycle length, irregularity of periods, heavy flow, MUAC, WHR, BMI, FMI, BAI and PBF were included as independent predictors for outcome variables. Only the significant predictors of the outcome variables are presented in the table. The result highlights that 'number of days of peak discharge', BAI, PBF and FMI were found to be the significant ($p<0.01$) predictors of length of the menstrual cycle. Similarly, 'number of days of peak discharge' ($p<0.001$) as well as fathers' educational status and WHR ($p<0.01$) were significantly predicting the outcome variable 'duration of the menstrual discharge'.

The stepwise logistic regression (backward elimination) was performed (Table 6) to find out the most influential factors for irregular menstrual cycle. In the first step, socio-economic characteristics, menstrual characteristics and anthropometric variables were included and out of that participants age was found to be the least significant indicators, and its corresponding change in the −2LR was also insignificant. So it was

Table 7. Stepwise (backward elimination) logistic regression: predictors of heavy menstrual discharge

Step	Independent indicators	β	SE	Wald	*p*-value	OR	95% CI for OR		Change in −2LR
							Lower	Upper	
Step 1	Participants' age	0.10	0.37	0.08	0.783	1.11	0.54	2.28	0.08
	Participants' education	−0.47	0.21	4.96	0.026	0.62	0.41	0.95	5.61
	Mothers' education	0.18	0.14	1.87	0.172	1.20	0.92	1.57	2.04
	Fathers' education	−0.23	0.11	4.25	0.039	0.79	0.64	0.99	5.11
	Monthly Expenditure	0.00	0.00	5.36	0.021	1.00	1.00	1.00	7.90
	Age at menarche	0.58	0.30	3.72	0.054	1.79	0.99	3.25	4.24
	Cycle length	−0.26	0.12	4.47	0.035	0.77	0.61	0.98	4.89
	Duration of Bleeding	0.40	0.26	2.39	0.122	1.49	0.9	2.48	2.54
	Regularity of cycle								
	Regular				Reference group				
	Irregular	−0.75	0.89	0.71	0.401	0.47	0.08	2.70	0.72
Step 12	BMI	0.19	0.30	0.40	0.526	1.21	0.67	2.19	0.39
	BAI	0.22	0.18	1.53	0.216	1.25	0.88	1.79	1.63
	MUAC	0.36	0.28	1.59	0.207	1.43	0.82	2.49	1.95
	WHR	−38.37	11.3	11.53	0.001	0.00	0.00	0.00	18.57
	PBF	−0.11	0.10	1.24	0.265	0.90	0.74	1.09	1.33
	Expenditure	0	0	4.34	0.037	1	1	1	5.73
	MUAC	0.34	0.13	7.20	0.007	1.41	1.10	1.81	8.33
	WHR	−19.58	6.08	10.37	<0.001	<0.001	<0.001	<0.001	12.80

removed in the second step. Similarly in the second step participants' age had least effect on the dependent variable therefore, this variable was excluded from the third step. The same procedure was followed in the consecutive steps and except mothers' education, age at menarche, cycle length, BMI, MUAC and WHR, all the variables were removed one by one in the previous steps. In the final step, the six influential indicators, were statistically significant which included mothers' education, cycle length, BMI, MUAC ($p<0.001$) and WHR and age at menarche ($p<0.05$). The corresponding changes in −2LR for all independent indicators were also found to be statistically significant.

Likewise, in Table 7, stepwise backward elimination logistic was carried out to find the most influential predictors of outcome variable heavy menstrual flow. After the elimination of the least effective indicators like participants' age and education, parental education, age at menarche, cycle length, duration of menstrual bleeding, BMI, BAI and PBF only family's monthly expenditure, MUAC and WHR were found to be the significant predictors of the heavy flow in the final step, which is substantiated by the significant corresponding change in −2LR.

Discussion

In India, almost a quarter of the population comprises of girls below 20 years (Agarwal and Agarwal 2010). Menstrual problems like dysmenorrhoea, pre-menstrual syndrome, irregular menses, excessive bleeding during menstruation etc. are common in adolescence because they are closely related to the processes involved in the pubertal development (Houston et al. 2006; Meenal et al. 2012; Sheetu et al. 2014). Nutrition plays a crucial role determining a healthy reproductive outcome (Joshi et.al. 2014). Report of District Level Household Survey (DLHS-4, 2015–16) shown that in Kolkata 7.3% women are underweight and 40.6% women are overweight. The present study indicates a different result where majority (73.3%) of the adolescents were healthy than the undernourished or overweight girls (each 13.3% respectively). This finding is similar to the many findings viz. Deshpande et al. (2013); Dars et al. (2014); Thapa and Shrestha (2015) and Jena et al. (2017). This is may be due to the bearing of certain good amount of monthly expenditure (Median value – Rs. 8,000/-) which could provide a healthy nutritional care of the adolescent girls.

The mean age at menarche was found to be 12.52 ± 1.20, which is in close agreement with menarcheal ages studied in slum areas of Rajasthan (Khanna et al. 2005), West Bengal (Dasgupta et al. 2008; Bhattacherjee2013) and Karad slum area of western Maharashtra (Mohite and Mohite 2013). The present findings also suggested that underweight girls attained menarche comparatively in later age (12.67 ± 1.23) than that of the healthy or overweight girls. This is in agreement with the biological phenomenon that a critical fat mass (~17% of body weight) is required for the onset of menarche (Frisch 1987).

The finding of the present study also shows that menarche age is positively correlated with BMI and body fat (Wronka 2010; Tienboon and Wahlqvist 2002, Sandhu et al. 2006). The present study revealed that majority of the girls had regular cycle. The incidents of irregular cycle with normal BMI was very less, but the percentage of having cycle irregularity among the undernourished girls was more than 40%. This is because, it has been widely accepted that irregular menstruation in young adolescent is partially caused by an inadequate nutritional state indicating that BMI is an important factor affecting menstrual regularities (Teixeira et al.2013). On the other hand, 1/4th of the participants of the present study who were overweight reported irregular cycle which was also corroborated with an Australian based study (Wei et al. 2009). But no significant association was found with BMI, menstrual irregularity, skipping of cycle and length of the menstrual cycle in the present study. This is in congruence with some other previous Studies (Samir et al. 2015; Khodakarami et al. 2015; Thapa and Shrestha 2015. Various studies including Kulkarni and Durga (2011); Kumbhar et al. (2011); Chauhan and Kodnani (2016) conducted among the slum adolescent girls and also the present study deciphered the high prevalence of dysmenorrhoea and PMS, and its association with BMI. Similar observation was also reported by Mohite et al. (2013) among the adolescent girls residing in a slum area of western Maharashtra where a significant association has been found between BMI and both of the menstrual disorders.

It has been found that most of the symptoms of PMS and dysmenorrhoea are higher among undernourished girls. This result corroborates with the findings of Seedhom et al. (2013) and Ju et al. (2015). Though the underlying mechanisms of the association between BMI and PMS or dysmenorrhea are not well understood, there is complex interaction between body fat and steroid hormones (Scott and Johnston 1982) i.e. both, too much and too little fat are being associated with the disruption of healthy menstrual cycle (Frisch and McArthur 1974). Body weight influences the direction of oestrogen metabolism with very thin women making less potent and obese women more potent forms of oestrogen (Frisch 1994).

The present findings suggested that the mean value of almost all the anthropometric indices increased with the ascending BMI categories. A strong significant correlation was found between the various anthropometric indices and the menstrual characteristics. This finding is in consistent with the findings of (Gharakhanlou et al. 2011; Katzmarzyk et al. 2015; Nwankwo et al. 2018).

Although, majority of the study revealed a significant correlation between age of puberty and BMI (Mamun et al. 2009; Pejhan et al. 2013; Indira and Kantha 2017) but the present study found no such correlation between age at menarche and either BMI or any other body fat indices. This is in accordance with the findings of García (2010) and Gopalakrishnan et al. (2015). This may be due to the fact that other than BMI, factors like heredity, gene, ecology, lifestyle, endocrine functions and other medical issues also have an acute role on the age of puberty (Towne et al. 2005; Hossain et al. 2010) as well a son menstrual profile(Samir et al. 2010). These could also be the reason behind the present inverse correlation between menstrual duration and almost all other anthropometric indices. This is in concordance with the study of Peter and Ocholi (2017) where a negative correlation has been found between BMI and menorrhagia (monthly menstrual blood loss in excess of 80ml – Warner 2004),but in the same study, a positive correlation with other indices like height, weight, waist circumference, hip circumference and waist hip ratio was found. The present study contradicts with the idea that girls having higher BMI show a tendency towards heavy flow or longer duration (Lu 2006; Samir 2010).

Body fat is an important predictor of a normal ovulatory cycle or menstrual cycle; it regulates the activity of steroid hormones and thus the endocrine control of menstruation (Hong et al., 2015) but too much or too little fat being associated with the disruption of their reproductive health (Frisch and McArthur 1974; Frisch 1990). Though the present study is based on small sample size but it is interesting to note that the linear regression results represents that BMI was a significant predictor of menstrual cycle length and similar findings has also been reported by Wei and colleagues (2009) and Tayebi and colleagues (2018). Other than BMI, various anthropometric indices like PBF, BAI, FMI and WHR were also significant predictor of cycle length, menstrual duration and number of days of peak discharge. Symons et al. (1997) in his study found a significant positive association of cycle length with each body composition measure i.e. longest mean cycle lengths occurred with greater BMI, body fat mass or body lean mass .It has been reported in various studies that centrally distributed body fat may be more strongly associated with menstrual characteristics than measures of peripheral body fat or overall adiposity such as BMI (Hartz et al. 1979; Hartz et al. 1984; Douche et al. 2002).

In the logistic regression analysis of stepwise backward elimination (step 8) the odds ratio values demonstrated that the chance of likely to have irregular menstrual cycle is more with the girls having higher BMI, longer cycle length and mothers' higher educational status. This finding is similar with the findings of Wei et al. (2009) among the Australian women, where both overall BMI and obesity were significantly associated with irregular menstrual cycles. Hossain et al. (2011), also reported a positive association ($p<0.05$) between BMI and irregular menstrual cycle. The present study shows a significant ($p<0.05$) negative association between age at menarche and menstrual irregularities, indicating that girls who reached menarche earlier had a higher probability of experiencing irregular menstrual cycles. This is in converse with the findings of Hossain et al. (2011). The coefficient of multiple logistic regression shows that MUAC and WHR have a significant negative association with menstrual irregularities. This demonstrated that the chance of having irregular periods was high among the girls with less mean value of these anthropometric measures. Similar results have been demonstrated by West et al. (2014) and Mukherjee et al. (2014) showing a negative impact of WHR and MUAC on menstrual irregularities. Furthermore, the result of multiple logistic regression where heavy menstrual bleeding is a response variable reveals that monthly expenditure and MUAC was a positive and WHR was a negative predictor of heavy menstrual bleeding.

The findings of this study should be viewed under certain limitations such as the inadequate sample size. This study also lacks the data of dietary habits which along with the anthropometric measures could have provided a better comprehensive dimension towards nutritional status of the adolescent girls. In association with that, other factors like ethnicity and cultural background, lifestyle, genetics as well as endocrine function also play a very important role in determining menstrual characteristics; therefore, further research is required to determine the impact of these factors to suggest a better insight of menstrual health. But still, this study is a good attempt for the situation assessment of slum adolescent girls who are the future mother in some consecutive years but still face several menstrual health related problems, so that government with the help NGO's or other community-based organisations could take an active initiation through effective menstrual health programme, for the better improvement of these future mothers.

Authors' contributions

AS carried out the data acquisition and dataset tabulation; JT carried out statistical analysis and drafted the manuscript; MG conceived and designed the study, analyzed the data and helped to draft the manuscript.

Conflict of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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