Body mass index influences the age at menarche and duration of menstrual cycle

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Abstract: The changing trends in the prevalence of childhood obesity, early puberty and menarche, and ethnoracial differences in the effect of BMI on the reproductive characteristics of young females around the world, warrants continuous evaluation. Hence, this study aims to investigate possible variations in the influence of BMI on the age at menarche as well as duration of menstrual cycle and menses in young girls in two urban areas in southern Nigeria. Participants (n = 52; median age = 20 years) were classified into 3 groups: normal, NM (n = 27; BMI = 21.0 ± 2.0 Kg/m^2), overweight, OW (n = 14; BMI = 28.1 ± 1.2 Kg/m^2) and obese, OB (n = 11; BMI = 31.5 ± 0.6 Kg/m^2). BMI was calculated from the equation; BMI = weight, kg/height, m^2. Cross-sectional data on menarche and menstrual cycle patterns were obtained through self-administered questionnaires. Data analysis showed a statistically significant difference in the BMI ($p < 0.0001$). Though the mean($\pm$ SD) ages at menarche were similar (NM = 13.0 ± 1.2 years; OW = 12.9 ± 0.9 years; OB = 13.7 ± 0.9 years)($p > 0.05$), the average duration of the menstrual cycle (NM = 27.3 ± 1.4 days; OW = 27.9 ± 0.6 days; OB = 29.4 ± 1.4 days) and menstrual bleeding (NM = 4.4 ± 0.6 days; OW = 4.4 ± 0.8 days; OB = 5.4 ± 0.9 days) differed significantly according to the BMI ($p < 0.0001$ and $p < 0.05$ respectively). There was an increase in the average length of the menstrual cycle and menses with increased BMI (r = 0.52, 95% CI = 0.28 – 0.69, $p < 0.0001$) and (r = 0.38, 95% CI = 0.12 – 0.59, $p < 0.05$) respectively. However, the correlation between BMI and age at menarche was weak (r = 0.25, 95% CI = -0.02 – 0.49, $p > 0.05$); and the average duration of the menstrual cycle tend to decrease with older menarcheal age, though this was not statistically significant (r = -0.02, 95% CI = -0.29 – 0.26, $p > 0.05$). Girls with higher BMI experience longer menstrual cycle and menses compared to their normal weight counterparts. The effect of BMI on age at menarche and the relationship between early onset of menarche and the duration of menstrual cycles and menses later in life may not be causal. Further investigations may resolve these differences in relation to the reproductive characteristics of young females.

Keywords: Body Mass Index, Menarche, Menstrual Cycle, Menses

1. Introduction

Menarche refers to the first menstruation in a female human. It is indeed the most symbolic and easily recalled event in the entire pubertal period [1-2]. The average age at menarche ranges from 12 – 15 years among different populations [3-7] and is a sensitive marker of various population indices including diet patterns, socioeconomic status, geographical location and environmental conditions [8-9].

High BMI (obesity) in childhood has been linked to the risk of early onset of puberty and menarche [10]. This has been identified as the prime factor in the decline in the onset of puberty and eventually menarche in industrialized nations [11-13] and other regions with improving nutritional and socioeconomic statuses [7].

Earlier than average age at menarche has been associated with certain adverse health effects in childhood and adolescent. These include eating disorders, depression, substance abuse, sexual exploits and teenage pregnancy [14-15]. Early onset of menstruation in girls is also linked to increased risk of breast, ovarian and endometrial cancers [16], type 2 diabetes, metabolic syndrome [17-18], hypertension and cardiovascular disease [19].

The menstrual cycle, with a mean length of 28 days, is an indication of a woman's reproductive health. The

duration and regularity of the cycle are associated to ovarian steroid production levels. These are influenced by several factors including psychosocial stress, strenuous physical exercise, body weight and percentage fat distribution and hormonal abnormalities [20]. Other factors such as ethnicity, alcohol and caffeine consumption and smoking can also affect the menstrual cycle [21-22]. Menstrual cycle length has also been used as a predictive tool in certain cancers [23-24] and cardiovascular disease risk factors [25].

The changing trends in the prevalence of childhood obesity, early puberty and menarche, and ethnoracial differences in the effect of BMI on the reproductive characteristics of young females around the world, warrants continuous evaluation. Hence, we aim to investigate possible variations in the influence of BMI on the age at menarche as well as duration of menstrual cycle and menses in young girls in two urban areas in southern Nigeria.

2. Materials and Methods

2.1. Participants

The study participants were drawn from the final grade of three high schools in Benin City and second year medical students of the Niger Delta University, Wilberforce Island, Bayelsa State both of the South-South geopolitical zone of Nigeria. They comprised of 52 young girls within the ages of 18 – 25 years (median age = 20 years). We obtained permission and consent from the authorities of the schools and the participants before commencement of the study.

2.2. Data Collection

Using the WHO criteria [26], the participants were classified in to three groups according to their BMI: normal (NM), overweight (OW), and obese (OB) (Table 1). The BMI of each participant was calculated from her weight and height using the formula: weight, kg/height, m^2.

Table 1. *Classification of study participants (n = 52).*

	Normal	Overweight	Obese
Age, years	20.6 ± 2.1	20.6 ± 1.9	20.7 ± 1.9
BMI, kg/m^2	21.0 ± 2.0	28.1 ± 1.2	31.5 ± 0.6*
Number of participants	27	14	11

Data are presented as mean ± 1SD. * BMI – Body Mass Index (*p< 0.0001*).

Cross-sectional data on menarche and menstrual cycle patterns were obtained via self-administered questionnaires. Menarche was identified as the age at which the girl's first menstrual bleeding was observed. This was easily recalled and was mostly reported with the school grade the event occurred. Menstrual cycle history was assessed based on the normal duration of the cycle (the time from onset of one menstrual bleeding (menstruation) to the first day of the next bleeding), normal duration of menstruation (time from

the onset of one menstrual bleeding to the end of the period) and the regularity/frequency of the cycle. Information on the severity of the menstrual pain and amount of blood loss observed during menstruation were inconsistent and unreliable. The questionnaire also included use of pain relief drugs during the menstrual cycle, mother's menstrual cycle pattern (if known), marital status, ethnicity, religion etc.

2.3. Statistical Analysis

Analysis of variance (ANOVA) was carried out to compare the differences between the group means. Relationships between the variables were ascertained by correlation and linear regression plots. Error bars in figures represented ±1 standard deviation (SD) of the mean where indicated and *p*-values of ≤ 0.05 were deemed statistically significant. Data were analyzed using the GraphPad Prism 6 statistical software.

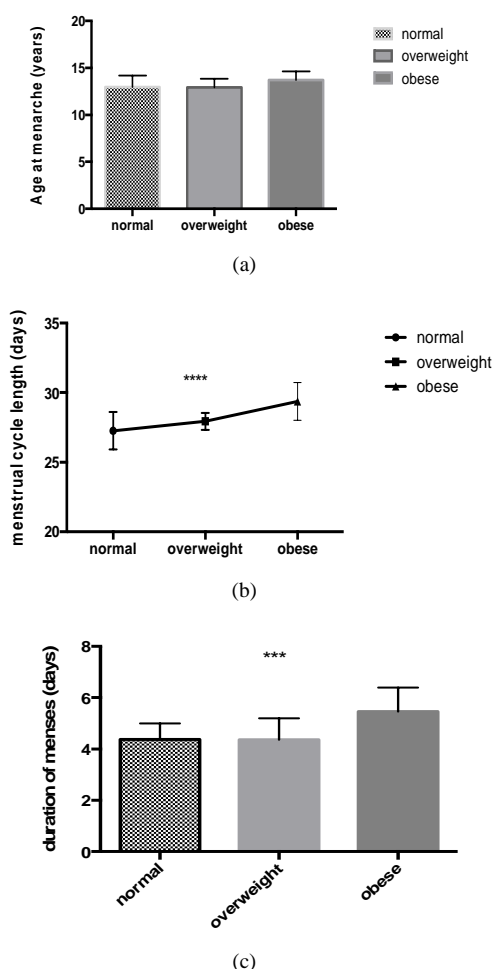## 3. Results

(a)

(b)

(c)

Figure 1. *Age at menarche, duration of menstrual cycle and menses according to Body Mass Index, BMI (normal, overweight and obese).(a) Age at menarche, (b) Menstrual cycle length and (c) Duration of menses. Girls with higher BMI experience significantly longer menstrual cycle and menstruation compared to their normal weight counterparts. Error bars represent Standard deviation (SD). **** p< 0.0001, *** p < 0.05.*

The participants' age and BMI are represented in Table 1. Though they were within the same age range, data analysis showed a statistically significant difference in their BMI (F (2, 49) = 204.6, $p< 0.0001$). This was crucial for classification into the various groups.

Though the mean (± SD) ages at menarche did not differ significantly (F (2, 49) = 2.2, $p> 0.05$), the average duration of the menstrual cycle and menses (menstrual bleeding) differed significantly according to the BMI (F (2, 49) = 12.01, $p< 0.0001$ and F (2, 49) = 8.9, $p< 0.05$ respectively) (Fig 1). The length of the menstrual cycle and menses increase significantly according to the BMI.

To determine the degree of association between BMI and age at menarche as well as menstrual cycle length, linear regression plots and correlation were computed. The results indicate an increase in the average length of the menstrual cycle and menses with increase in BMI (Fig. 2b and 2c). However, the correlation between BMI and age at menarche was not statistically significant (Fig. 2a).
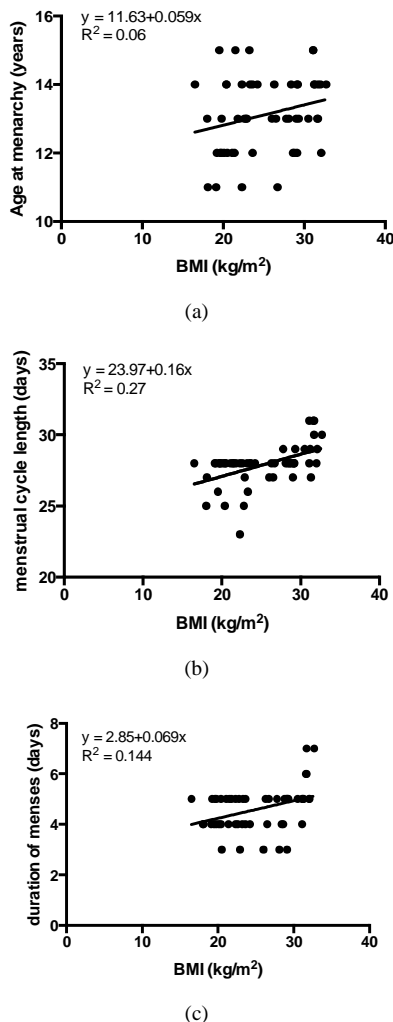
Because older age at menarche has been linked with prolonged and irregular cycles in other climes [27], we opted to resolve the association between age at menarche and menstrual cycle in the current study. It was observed that older age at menarche was negatively related to the length of the menstrual cycle. The average duration of the menstrual cycle tends to decrease with older menarcheal age, though this was not statistically significant (Fig. 3).
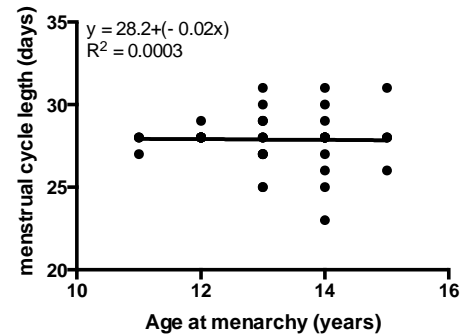

Figure 3. *Association between age at menarche and menstrual cycle length (r = - 0.02, 95% CI = - 0.29 – 0.26, p> 0.05). An inverse correlation existed between the menarcheal age and duration of menstrual cycle.*

4. Discussion

In this study, we investigated the influence of BMI on the age at menarche as well as the duration of menstrual cycle and menses in young girls in two urban areas in southern Nigeria. No significant difference in the age at menarche between the normal, overweight and obese participants was observed. There was a linear correlation between BMI and age at menarche, although this was not statistically significant. However, the association between high BMI, average duration of menstrual cycle and menses was statistically significant.

Worldwide the median age at menarche is 14 years (11 – 18 years) [28]. Previous studies have shown a clear inverse association between early pubertal development, age at menarche and BMI. Girls with higher BMI at childhood attain menarche earlier than their normal weight counterparts [11-13, 29]. In contrast to these observations, we observed a linear relationship between BMI and age at menarche, although this was not statistically significant. We also observed no significant difference in the mean ages at menarche between the normal, overweight and obese participants. These mean values were similar to those observed in other studies conducted in the same geographical location as ours [6], and even other countries [4, 20], but dissimilar to that observed among school girls in the Northern region of the same country as ours [5]. These disparities could be attributed to several factors such as genetic [30], environmental, socioeconomic, nutritional and hormonal factors [31-33]. "Children and adolescents differ in their rate of development, and adolescents of the same chronological age may differ greatly in their stage of maturity" [34]. It has also been reported that there is no

(a)

(b)

(c)

Figure 2. *Association between Body mass index, BMI and (a) age at menarche (r = 0.25, 95% CI = - 0.02 – 0.49, p> 0.05) and (b) menstrual cycle length (r = 0.52, 95% CI = 0.28 – 0.69, p< 0.0001), (c) duration of menses (r = 0.38, 95% CI = 0.12 – 0.59, p< 0.05). Though BMI did not significantly affect the age at menarche, the duration of the menstrual cycle and menses increased significantly in proportion to the BMI.*

significant correlation between postmenarcheal height and age at menarche, but BMI, premenarcheal weight and mean age at menarche are significantly correlated [31]. This could explain the reason for our observation as the participants reported their age at menarche retrospectively.

In concordance with our findings, early puberty and age at menarche have been implicated as indicators of overweight and obesity in later life rather than consequences of early childhood obesity [35-36]. This is supported by a cohort study on children born in the 1950s which reported that independent of childhood BMI, age at menarche is a predictor of adult BMI [37]. However, adjustments for childhood and adolescent BMI enervated the relationship between age at menarche and adult BMI [38] and the effects of menarcheal status on BMI assessments of overweight and obesity are usually of little clinical significance [39].

The effect of BMI on menstrual cycle characteristics is well documented [40-41]. Body fat and obesity influence the menstrual cycle leading to cycle irregularities [42]. Overweight and obese young females are at a greater risk of experiencing longer and infrequent periods [43-44]. Women with low or high BMI related to obesity experience more prolonged menstrual cycles [45]. High BMI and sedentary behaviours may influence the level and equilibrium of endogenous hormones required for optimal menstrual function, thus resulting in irregular menstrual patterns [46]. Hormonal factors such as insulin and sex hormone binding globulin (SHBG) may affect the association between obesity and irregular menstrual cycle [47]. Our findings are consistent with the above reports. The overweight and obese participants in this study had a significantly longer average duration of menstrual cycle and menses. BMI significantly correlated with prolong menstrual cycle and menses. The girls with higher BMI experienced significantly longer menstrual cycle and in addition longer menstruation compared to their normal weight counterparts. These groups of participants also reported infrequent cycles and more severe premenstrual symptoms. Information on the severity of the menstrual pain and amount of blood loss observed during menstruation were inconsistent and unreliable.

Although not statistically significant, we observed an inverse correlation between age at menarche and duration of menstrual cycle. Girls who had an early menarcheal age tend to experience longer menstrual cycles. This is in contrast to the findings of Rowland *et al.* [27], who stated that late menarche (greater than 14 years) is a risk factor for longer and more variable cycles. However, it still supports part of the observation that early menarche (less than 12 years) could be a risk factor for either short or long cycles [43]. Mean menarcheal age has been found to be significantly higher in a group of college females with irregular menstrual cycle compared to a regular cycle group [48]. These contrasting findings may indicate that the relationship between early onset of menarche and the duration of menstrual cycles and menstruation later in life may not be causal.

These findings are promising; however, the relatively few number of participants in each group and the cross-sectional method of data collection could be limitations to the study. A longitudinal study with larger amount of participants and possible measurement of certain sex hormones such as estrogen, progesterone, androgens and SHBG may further elucidate the associations of these parameters in relation to the reproductive health of young females.

5. Conclusion

Girls with higher BMI experience significantly longer menstrual cycle and menses compared to their normal weight counterparts. The effect of BMI on age at menarche and the relationship between early onset of menarche and the duration of menstrual cycles and menses later in life may not be causal. These associations may be modified by ethnoracial differences. Further investigations may resolve these differences in relation to the reproductive characteristics of young females.

Acknowledgments

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