

Research & Reviews: Journal of Medical and Health Sciences

Trend in Age at Menarche in Relation to Body Mass Index among Children and Adolescent Girls in Saudi Arabia

Abdulmoein E Al-Agha¹, Bara'ah O Tatwany²

¹Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia

²Department of Pediatrics, Faculty of Medicine, King Abdulaziz University, Jeddah, Saudi Arabia

³Faculty of Medicine, Ibn Nafis University, Jeddah, Saudi Arabia

Trend in Age at
Menarche in
Relation to Body
Mass Index
among
Children and
Adolescent Girls

Research Article

Received date: 27/06/2016

Accepted date: 15/07/2016

Published date: 22/07/2016

*For Correspondence

Abdulmoein E Al-Agha, Faculty of Medicine, King Abdulaziz University, Jeddah- 21589, P.O. Box: 80215, Kingdom of Saudi Arabia, Tel: +966-505590459.

E-mail: aagha@kau.edu.sa

Keywords: Menarche, Menstrual, Body mass index, Overweight, Saudi Arabia.

ABSTRACT

Objective: It has been evaluated that the process of menarche occurs at a specified age, which enables a girl for reproduction. However, age of menarche is getting reduced on a constant basis in different western and eastern countries. Thus, this study has developed its objective to assess the decreased trend of menarcheal age, and its relationship with the body mass index of female individuals in the population of Saudi Arabia.

Methods: A cross sectional study has been conducted among Saudi girls who were aged between 8-17 years old. Participants were randomly selected from six shopping centers of Jeddah, Saudi Arabia over the course of one month. Personal interviews were carried out for collecting data on the menarche related age and other pubertal signs including thelarche and pubarche. Age of menarche was subsequently categorized as early (<11 years old) and normal/late (>11 years old). Weight and height were measured for BMI calculation and participants were then classified as being obese/overweight (BMI>2SD) and normal or underweight (BMI<2SD).

Results: A total of 637 girls were recruited, of which, 25.4% only were experiencing the process of menarche at the time of study. Mean age of the study population was 11.2 ± 12.2 . Mean BMI was 19.5 ± 4.6 . Mean age at menarche was 11.9 ± 1.4 (95% CI: 11.6, 12.1), the minimum age was 8 and the maximum age was 16. Early menarche (<11years of age) was found among 27 (16.7%) girls (95% CI: 9.2, 9.8). Normal/late menarche (≥ 11 years of age) was observed among 135 (83.3%) girls (95% CI: 12.2, 12.5). The mean menarcheal age among obese/overweight group was 11.2 ± 1.4 (95% CI 10.4, 12), while that of the normal/underweight group was 12 ± 1.4 (95% CI 11.7, 12.2). No significant difference was found between the two groups (P=0.668).

Conclusion: it has been concluded that extremely feeble relationship was present between the body mass index and menstrual age of the selected population. Advanced research studies are required for deriving out excessive outcomes related to the menarcheal age and BMI index.

INTRODUCTION

Age of menarche is a major characteristic that has a close relationship with the maturity and initiation of reproductive life. Menarcheal age is also considered as an important factor that reflects the population health due to the major public health implications that can be caused by changes in the age at menarche. Therefore, several studies have been conducted in the professional settings for the identification of menstrual age. Various studies showed that the menarcheal age can be influenced by many factors such as obesity, socioeconomic status, ethnicity, and different environmental conditions [1-5].

Recent studies reported that there is a secular trend towards earlier age at menarche particularly among the industrialized countries due to the improvement in lifestyle and increase in the prevalence of obesity [6,7]. Occurrence of menarche at the earlier age has been attributed to a significant number of adverse health outcomes during childhood and adulthood. Depression [8], eating disorders [9], metabolic syndrome [10], and Type II diabetes mellitus have been identified as the major adverse health related issues [11-14]. It's been also linked to cardiovascular and stroke related mortality [15-18]. Furthermore, early age at menarche has been identified as a risk factor for breast and endometrial cancer due to the increased exposure to estrogen [19]. Early closure of the epiphyseal plates is considered as another major health complication that occurs due to earlier menarche [20].

Increased body weight or obesity has been also identified as a correlated factor with the menarcheal age. Some of the research bases have clearly described that a strong relationship is always present among the increased BMI and earlier menstrual age [21-26]. On the contrary, a study has also declined this association with the help of their findings [27]. However, some studies argue that obesity cannot be solely attributed to this advance in age at menarche and that other factors might be inter-related [28]. Some others argue that causality is difficult to be established based on the present studies because most of them are mainly cross sectional [29]. BMI has been also linked to other signs of puberty such as breast and pubic hair development [30].

PURPOSE OF THE STUDY

This study has aimed to assess the average age at menarche and to determine its relationship with BMI among girls in Jeddah, Saudi Arabia.

MATERIALS AND METHODS

Study subjects and data collection tools

This study used a cross sectional approach for the collection of data. The study has selected girls who were aged between 8-17 years old. Participants were randomly selected from six shopping centers of Jeddah, Saudi Arabia over the course of one month (July, 2014).

Participants, who were younger than 8 or older than 17 years old, were excluded from the analysis. Personal interviews were carried out for collecting data on the age of menarche and other pubertal signs including thelarche and pubarche. Participants, who could not remember their age, reported the school grade at which they experienced menarche. Participants were subsequently categorized as having early menarche (<11 years old) and normal/late (>11years old). Tanner stages were used for determining pubarche and thelarche. Written description with illustrative pictures of Tanner stages was used for the assistance of participants to determine their stage. Weight and height were measured for the purpose of BMI calculation. The BMI calculation was done instantly for all patients using the following formula:

$$\text{Weight (kg)} / (\text{Height (m)} \times \text{Height (m)})$$

Charts of Centers for Disease Control and Prevention (CDC) were used for plotting. Participants were classified according to their BMI into two groups, which include obese/overweight group (BMI>2SD above the mean) and normal/underweight group (BMI<2SD above the mean). All of the participants signed the informed consent form before participation in the study.

Statistical analysis

Data was entered, coded, and analyzed using statistical package for social science (SPSS), version 16. Continuous data are reported as mean \pm standard deviation. Differences in means were tested using independent samples t test. Chi square test was used to calculate the statistical significance between age at menarche categories (early, normal/late) and BMI categories (obese/overweight and normal/underweight). The statistical significance between age at thelarche and age at pubarche in relation to BMI categories were also calculated. The researchers has placed p values of <0.05 as significant.

RESULTS

A total of 637 participants were recruited to the study. However, only 162 (25.4%) had attained their menarche by the time of the study. The majority 345 (60.6%) of participants were belonged to Saudi Arabia. The mean age of the study population was 11.2 ± 12.2 years old. The mean age among those, who had their menarche, was 13.2 ± 2 years old.

The mean age at menarche was 11.9 ± 1.4 (95% CI: 11.6, 12.1) years old, the minimum age was 8 years and the maximum age was 16 years. Early menarche (<11 years of age) was found among 27 (16.7%) girls (95% CI: 9.2, 9.8). Normal/late menarche (≥ 11 years of age) was observed among 135 (83.3%) girls (95% CI: 12.2, 12.5). The mean menarcheal age among obese/overweight group was 11.2 ± 1.4 years (95% CI 10.4, 12), while that of the normal/underweight group was 12 ± 1.4 years (95% CI 11.7, 12.2) (**Figure 1**) (P 0.048) (t=1.996) (95% CI of the difference: 0.008, 1.51). However, on cross-tabulating BMI categories (normal/underweight and obese/overweight) with the menarche categories (early and normal/late), the study did not find any difference between the two values (p=0.668). **Table 1** is presenting the distribution of age at menarche among the normal/underweight and obese/overweight categories. The mean age at thelarche was 9 ± 1.7 years (95% CI: 9.4, 9.6), while the mean age at pubarche was 10.1 ± 1.6 years (95% CI: 10, 10.3). There was no association between age at pubarche and BMI (p=0.476) nor thelarche and BMI (p=0.967).

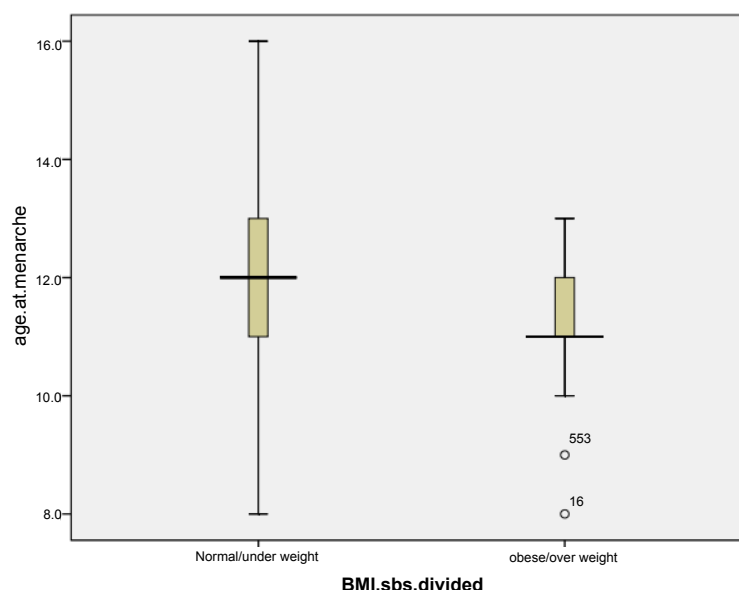


Figure 1. Mean age at menarche among normal/underweight and obese/overweight groups.

Table 1. Age of menarche among normal/underweight and obese/overweight groups.

	Normal/underweight	Obese/overweight (N=50)	P value
Age	11.3 ± 2.2	10.8 ± 2.2	0.106 ¹
Menarche			
Yes	141 (26.9%)	15 (30%)	0.639 ²
No	383 (73.1%)	35 (70%)	
Age at menarche	12 ± 1.41	11.2 ± 1.4	0.048 ¹
Status of menarche			
Early (<11 years)	22 (15.6%)	3 (20%)	0.668 ²
Normal/late (≥ 11 years)	119 (84.4%)	12 (80%)	
8	1 (0.7%)	1 (6.7%)	0.401 ²
9	7 (5%)	1 (6.7%)	
10	14 (9.9%)	1 (6.7%)	
11	24 (17%)	5 (33.3%)	
12	41 (29.1%)	5 (33.3%)	
13	37 (26.2%)	2 (13.3%)	
14	14 (9.9%)	0	
15	1 (0.7%)	0	
16	1 (0.7%)	0	

Continues data are expressed as mean ± standard deviation

Categorical data are expressed as number (%)

¹calculated using independent sample t test

²calculated using chi square test

The mean BMI was 19.5 ± 4.6% (95% CI: 19.2, 19.9). The prevalence of obesity among the whole study population was 3.1% (95% CI: 28.2, 33.2), while that of overweight was 5.6% (95% CI: 24.9, 27). The majority of the study population (91.3%) (95% CI: 18.8, 19.4) had normal weight. Obesity or overweight was found among 15 (30%) of those who had their menarche (95% CI: 10.4, 12). The trend of overweight or obesity was 12%, 10.4% and 0% among those who had early menarche (<11 years), normal menarche (11-13 years), and late menarche (>13 years) respectively. **Table 2** is providing information about the comparison of weight, height and BMI between the early menarcheal group and the normal/late menarcheal group (**Figure 2**).

DISCUSSION

There are certain specified past studies, which have solely focused on the menstrual age of girls in the countries of gulf region. However, most of such studies have been conducted in the era of late 90s. These studies have represented the average age at menarche for those, who were born in the 1990s. The mean menarcheal age among girls, who were born between the years of 1932-1990, was reported to be 13.05 ± 1.32 years (range, 9-18 years) in Saudi Arabia [31]. However, age at menarche among girls, born between 1977 and 1973, was 12.7 ± 1.6 years in the territories of Kuwait (range 9-18) [32]. A past study has been conducted in the population of Emirates, which have shown that the mean menarcheal age among those born between 1987 and 1983 was 12.68 ± 1.27 [33]. The data of current study confirms that there is a marked reduction in the menarcheal age from 13.05 to 11.9 years among the population of Saudi Arabia. The rate of reduced age was noticeably higher as compared to other countries. It has been evaluated that the mean age at menarche have gotten reduced from 12.53 years by the year

1988-1994 to 12.34 years by the year 1999-2002 in the population of USA ^[34]. Moreover, the mean age has been dropped from 12.82 years by the year 1990 to 12.31 years by the year 2010 within Croatia ^[35]. In Ireland, the average age has been decreased from 13.52 years by the year 1986 to 12.53 years by the year 2006 ^[36]. Similarly, the mean age has been reduced from 12.8 during 1950s to 12.2 during 1980s in Japan ^[37]. This trend related to the age at menarche was also associated with enhanced improvements in the socioeconomic status and increased prevalence of obesity among the population of Saudi Arabia ^[38]. It has been stated that the changes in the daily routines, dietary habits, and obesity are strongly associated with the occurrence of menarche at an earlier ages.

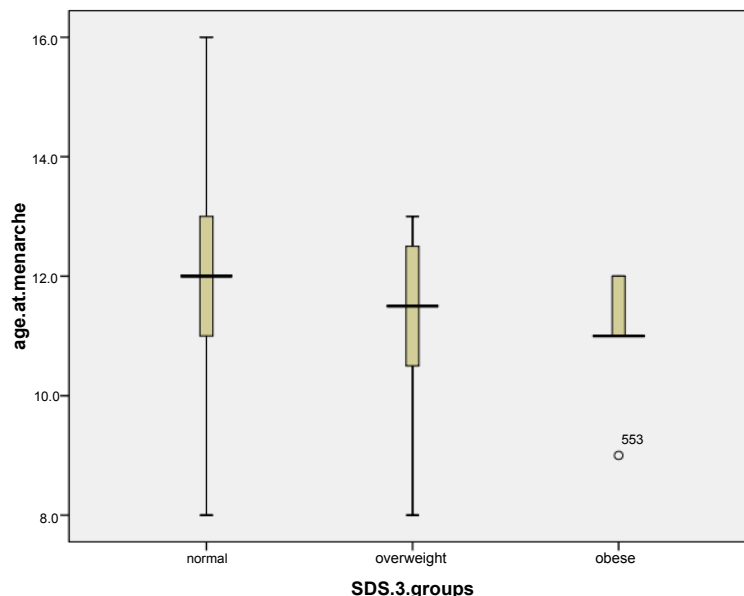


Figure 2. Mean age at menarche among normal, overweight and obese groups.

Table 2. Characteristics of the menarchal population.

	Early menarche	Normal/late menarche	P value
Age	11.31 ± 2.4	14 ± 2	0.0001 ¹
BMI	22.4 ± 5.2	22 ± 5	0.724 ¹
BMI in SDS	?	?	0.000
BMI in SDS BMI<2SD BMI>2SD	22 (88%) 3 (12%)	119 (90.8%) 12 (9.8%)	0.668 ²
Height 8 Y/O 9 Y/O 10 Y/O 11 Y/O 12 Y/O 13 Y/O 14 Y/O 15 Y/O 16 Y/O 17 Y/O	127.0 ± 15.5 131.9 ± 7.5 150.4 ± 4.5 149.5 ± 2.1 159.0 ± 9.8 144.3 ± 10.3 149.2 ± 13.1 N/A N/A 159.5 ± 0.0	N/A N/A N/A 146.9 ± 4.7 149.4 ± 6.6 152.1 ± 6.9 152.4 ± 6.9 155.8 ± 5.4 151.6 ± 6.2 155.6 ± 7.0	0.475 ¹ 0.088 ¹ 0.132 ¹ 0.356 ¹ 0.613 ¹
Weight 8 years old 9 years old 10 years old 11 years old 12 years old 13 years old 14 years old 15 years old 16 years old 17 years old	31 ± 18.4 35.1 ± 8.9 41.2 ± 4.5 51.5 ± 3.5 55.5 ± 9.2 42.3 ± 10.3 60.7 ± 22.9 N/A N/A 78.5 ± 0.0	N/A N/A N/A 49.2 ± 11.7 51.4 ± 14.5 49.4 ± 12.1 49.6 ± 11.8 53.9 ± 13.5 53.1 ± 16.2 54.3 ± 15.3	0.788 ¹ 0.706 ¹ 0.420 ¹ 0.069 ¹ 0.180 ¹

N/A no subjects in the study group

SDS standard deviations

¹calculated using independent sample t test

It is a fact that most of the western countries have increased rates of earlier menarcheal ages as compared to the population

of Saudi Arabia. This statement has been justified by different studies, which include United States of America (12.6 years among white girls and 12.3 years among black girls) ^[39], Argentina (12.84 years), United Kingdom (12.5 years) ^[40], Italy (12.4 years) ^[41]. Similarly, the average age at menarche is lower among Saudi Arabia as compared to Eastern Asian countries, which include Korea (12.7 years) ^[42]. It is also lower than the other Arabic counties within the gulf region as in Kuwait ^[43] (12.41 years) and outside the gulf region as in Egypt (12.44 years old) ^[44]. This can be explained by racial or ethnic differences in sexual maturation ^[45]. It can be due to environmental factors and earlier exposure to synthetic estrogen, which accelerates the maturation process. It has been estimated that the average age of menstrual cycle among the normal/underweight group was almost similar to the above defined values.

The prevalence of obesity has risen significantly among Saudi population which was found to be correlated mainly with eating restaurants foods and sedentary lifestyle ^[46]. In our current study, weak correlation was found between earlier age of menarche and overweight/obesity. The findings showed that the prevalence of overweight and obesity were 5.6% and 3.1%, respectively. Obesity and overweight are now being studied as potential risk factors for earlier age at menarche ^[42]. This study has found statistically insignificant difference between BMI in categories (normal/underweight and obese/overweight) and age at menarche in categories (early and normal/late). However, significant difference in means among the different BMI categories can be observed although the association is weak ($P = 0.048$). Most of the overweight/obese group (66.6%) had their menarche process between 11 and 12 years old. However, the highest proportion of the normal/underweight group (55.3%) had their menarche between 12 and 13 years old. No late menarche (>13 years) was found among the overweight/obese group.

The findings of the study have evaluated height and weight as two different measures, which were not directly associated with the issue of early menarche. Whether increase in BMI predisposes to early menarche or early menarche predisposes to obesity later in life is still controversial. A past study has shown that earlier menarcheal process is related to the deposition of fats which subsequently increases the risk of obesity ^[47].

A Korean study has shown that the increased BMI at the age of 7 to 8 years is connected with the early occurrence of menarche ^[42]. Another prospective cohort concluded that the advance in age at menarche is reflected in the concurrent increased in BMI, waist circumference, and body fat in early childhood ^[48]. Additionally, another study have found higher BMI z-score at 36 months of age and an increased rate of change in BMI between the age of 36 months and grade 1 at a school, a period well before the occurrence of puberty, to be associated with earlier puberty ^[49]. Different explanations have been stated to identify the relationship between BMI and menarcheal age. Adiposity is associated with increased levels of leptin, a hormone that acts directly on the hypothalamus to stimulate the secretion of gonadotropin releasing hormone (GnRH); hence, starting the sexual maturation process ^[50]. Another explanation is that higher BMI in the pre-pubertal period with high fat percentage can increase the peripheral conversion to estrogen menarche ensues ^[51]. On the contrary, it has been evaluated that earlier menarcheal process is directly associated with higher estrogen, which can increase peripheral fat deposition ^[52]. Based upon the facts, BMI and menarche have been identified as independent factors that can be precipitated through genetic factors.

LIMITATIONS OF THE STUDY

Small proportion of menarcheal girls was the leading limitation of this study. Therefore, the findings of the study cannot be considered as the generalized outcomes. The association between BMI and menarcheal age is needed to be validated through testing from other confounders, which may include dietary habits and socio-economic status. Despite all of these limitations, it is a fact that a very low number of studies related to this topic have been conducted in Saudi Arabia. Therefore, the findings of this study have a great importance.

CONCLUSION

This study concludes that the mean age of menarche has dropped significantly among girls in Saudi Arabia in comparison to the old data. It also concludes that there's no significant relationship between the body mass index of the participants and menarcheal age. BMI and age of menarche are independent factors that can be precipitated by genetic factors.

REFERENCES

1. Talma H, et al. Trends in menarcheal age between 1955 and 2009 in the Netherlands. *PloS one*. 2013;8:60056.
2. Deardorff J, et al. Socioeconomic status and age at menarche: An examination of multiple indicators in an ethnically diverse cohort. *Annals of epidemiology*. 2014;24:727-733.
3. Mpora BO, et al. Age at menarche in relation to nutritional status and critical life events among rural and urban secondary school girls in post-conflict Northern Uganda. *BMC Women's Health*. 2014;14:66.
4. Kaplowitz, et al. Earlier onset of puberty in girls: relation to increased body mass index and race. *Pediatrics*. 2001;108:347-353.
5. Wronka I, and Pawlinska-Chmara R. Menarcheal age and socio-economic factors in Poland. *Annals of Human Biology*. 2005;32:630-638.

6. Kaplowitz, P. Pubertal development in girls: Secular trends. *Current opinion in Obstetrics and Gynecology*. 2006;18:487-491.
7. Harris MA, et al. Age at menarche in the Canadian population: Secular trends and relationship to adulthood BMI. *Journal of Adolescent Health*. 2008;43:548-554.
8. Kaltiala-Heino R, et al. Pubertal timing, sexual behavior and self-reported depression in middle adolescence. *Journal of Adolescence*. 2003;26:531-545.
9. Striegel-Moore RH, et al. Exploring the relationship between timing of menarche and eating disorder symptoms in black and white adolescent girls. *International Journal of Eating Disorders*. 2001;30:421-433.
10. Stockl D, et al. Age at menarche is associated with pre-diabetes and diabetes in women (aged 32–81 years) from the general population: The KORA F4 Study. *Diabetologia*. 2012;55:681-688.
11. Dreyfus JG, et al. Age at menarche and risk of type 2 diabetes among African-American and white women in the atherosclerosis risk in communities (ARIC) study. *Diabetologia*. 2012;55:2371-2380.
12. Stöckl D, et al. Age at menarche is associated with pre-diabetes and diabetes in women (aged 32–81 years) from the general population: The KORA F4 Study. *Diabetologia*. 2012;55:681-688.
13. He C, et al. (2009). Age at menarche and risk of type 2 diabetes: Results from 2 large prospective cohort studies. *American journal of epidemiology*, kwp372.
14. Lakshman R, et al. Association between age at menarche and risk of diabetes in adults: results from the EPIC-Norfolk cohort study. *Diabetologia*. 2008;51:781-786.
15. Conway BN, et al. Age at menarche, the leg length to sitting height ratio, and risk of diabetes in middle-aged and elderly Chinese men and women. *PloS one*. 2012;7:e30625.
16. Jacobsen BK, et al. Age at menarche, total mortality and mortality from ischemic heart disease and stroke: the Adventist Health Study, 1976–1988. *International journal of epidemiology*. 2009;38:245-252.
17. Lakshman R, et al. Early age at menarche associated with cardiovascular disease and mortality. *The Journal of Clinical Endocrinology & Metabolism*. 2009;94:4953-4960.
18. Jacobsen BK, et al. Age at menarche, total mortality and mortality from ischemic heart disease and stroke: The Adventist Health Study, 1976–88. *International Journal of Epidemiology*. 2009;38:245-252.
19. Ritte R, et al. Height, age at menarche and risk of hormone receptor-positive and -negative breast cancer: A cohort study. *International Journal of Cancer*. 2013;132:2619-2629.
20. Onland-Moret NC, et al. Age at menarche in relation to adult height The EPIC study. *American Journal of Epidemiology*. 2005;162:623-632.
21. Biro FM, et al. Puberty in girls of the 21st century. *Journal of Pediatric and Adolescent Gynecology*. 2012;25:289-294.
22. Kaplowitz PB, et al. Earlier onset of puberty in girls: Relation to increased body mass index and race. *Pediatrics*. 2001;108:347-353.
23. Mandel D, et al. Age at menarche and body mass index: A population study. *Journal of Pediatric Endocrinology and Metabolism*. 2004;17:1507-1510.
24. Vitale MS, et al. Body mass index, pubertal development and their relationship with menarche. *Revista da Associação Médica Brasileira*. 2003;49:429-433.
25. Hernandez MI, et al. Age of menarche and its relationship with body mass index and socioeconomic status. *Revista Medica de Chile*. 2007;135:1429-1436.
26. Oh CM, et al. Relationship between body mass index and early menarche of adolescent girls in Seoul. *Journal of Preventive Medicine and Public Health*. 2012;45:227-234.
27. Bazrafshan H, et al. Association between puberty and weight, height and body mass index in a developing community. *JPMA- Journal of the Pakistan Medical Association*. 2012;62:454.
28. Castilho SD, et al. Secular trends in age at menarche in relation to body mass index. *Arquivos Brasileiros de Endocrinologia & Metabologia*. 2012;56:195-200.
29. Rosenfield RL, et al. Thelarche, pubarche and menarche attainment in children with normal and elevated body mass index. *Pediatrics*. 2009;123:84-88.
30. Jasik CB and Lustig RH. Adolescent obesity and puberty: The “perfect storm”. *Annals of the New York Academy of Sciences*. 2008;1135:265-279.
31. Babay Z. Age at menarche and the reproductive performance of Saudi women. *Age*. 2004;15:14-1.
32. Jackson RT and Al-Mousa Z. Iron deficiency is a more important cause of anemia than hemoglobinopathies in Kuwaiti adolescent girls. *The Journal of nutrition*. 2000;130:1212-1216.

33. Badrinath P, et al. Cultural and ethnic barriers in conducting research. Factors influencing menarche in the United Arab Emirates. *Saudi Medical Journal*. 2004;25:1626-1630.
34. Anderson SE and Must A. Interpreting the continued decline in the average age at menarche: Results from two nationally representative surveys of US girls studied 10 years apart. *The Journal of pediatrics*. 2005;147:753-760.
35. Vecek N, et al. Secular trend of menarche in Zagreb (Croatia) adolescents. *European Journal of Obstetrics & Gynecology and Reproductive Biology*. 2012;160:51-54.
36. O'Connell A, et al. The mean age at menarche of Irish girls in 2006. *Irish Medical Journal*. 2009;102:76-79.
37. Hosokawa M, et al. Secular trends in age at menarche and time to establish regular menstrual cycling in Japanese women born between 1930 and 1985. *BMC women's health*. 2012;12:19.
38. Lee JM, et al. Weight status in young girls and the onset of puberty. *Pediatrics*. 2007;119:e624-e630.
39. Freedman DS, et al. Relation of age at menarche to race, time period and anthropometric dimensions: The Bogalusa heart study. *Pediatrics*. 2002;110:43-43.
40. Joinson C, et al. Timing of menarche and depressive symptoms in adolescent girls from a UK cohort. *The British Journal of Psychiatry*. 2001;198:17-23.
41. Rigon F, et al. Update on age at menarche in Italy: toward the leveling off of the secular trend. *Journal of Adolescent Health*. 2010;46:238-244.
42. Cho GJ, et al. Age at menarche in a Korean population: Secular trends and influencing factors. *European journal of pediatrics*. 2010;169:89-94.
43. Al-Awadhi N, et al. Age at menarche and its relationship to body mass index among adolescent girls in Kuwait. *BMC Public Health*. 2013;13:29.
44. Ghaly I, et al. Optimal age of sexual maturation in Egyptian children. *East Mediterr Health J*. 2008;14:1391-1399.
45. Freedman DS, et al. Relation of age at menarche to race, time period and anthropometric dimensions: The Bogalusa Heart Study. *Pediatrics*. 2002;110:e43.
46. Al-Muhaimeed AA, et al. Prevalence and correlates of overweight status among Saudi school children. *Journal of Annals of Saudi Medicine*. 2015;35:275-281.
47. Pierce MB and Leon DA. Age at menarche and adult BMI in the Aberdeen children of the 1950s cohort study. *The American Journal of Clinical Nutrition*. 2005;82:733-739.
48. Davison KK, et al. Percent body fat at age 5 predicts earlier pubertal development among girls at age 9. *Pediatrics*. 2003;111:815-821.
49. Lee JM, et al. Weight status in young girls and the onset of puberty. *Pediatrics*. 2007;119:624-630.
50. Shalitin S and Phillip M. Role of obesity and leptin in the pubertal process and pubertal growth: A review. *International journal of obesity and related metabolic disorders*. *Journal of the International Association for the Study of Obesity*. 2003;27:869-874.
51. Cheng G, et al. Beyond overweight: Nutrition as an important lifestyle factor influencing timing of puberty. *Nutrition reviews*. 2012;70:133-152.
52. Gaudineau A, et al. Factors associated with early menarche: Results from the French health behavior in school-aged children (HBSC) study. *BMC public health*. 2010;10:175.