Factors Influencing Age at Menarche: An Indian Scenario

Devaki Gokhale

Abstract

Menarche, an important marker of puberty and a milestone in a girl’s reproductive life is studied in this review. There are global as well as national studies reporting the overall factors contributing to this important phenomenon. As we look at the overall determinants of age at menarche, following factors are prominently reported: dietary intake, body composition, physical activity, psychosocial stress, etc. Most of them share a relationship with each other and influence the process of menarche. Studies show that higher intake of proteins and fats in the diet in peri pubertal period results in earlier menarche. Higher body fat percentage which is an important component of body composition and reduced physical activity may also have a contributory role in an early onset of menarche. Girls growing up in homes without their biological fathers undergoing a considerable amount of psychological stress tend to go through puberty earlier than their peers. Thus various factors influencing the process of menarche display the complexity of it. Determinants of age at menarche is extensively studied in developed countries whereas there are less reported studies in India and thus there is a lot of scope for the researchers to further explore this area.

Keywords: Menarche, Diet, Body composition, Physical activity, Psychosocial.

Introduction

Puberty is the process of physical changes by which a child’s body becomes an adult body capable of reproduction. Menarche is the culmination of a series of physiological and anatomic processes of puberty. Menarche which is the appearance of first menstrual period is an important landmark in a woman’s reproductive career.

The age of onset of menarche is a very important factor for future health of a girl since early or late onset of menarche has many health implications like metabolic syndrome, CVD, Cancers, PCOS, amenorrhea, dysmenorrhea, anemia as well as infertility. Early-maturing girls have been found to exhibit significantly more behavior problems than their peers who menstruate on time. There is a change in body composition pre and post menarche leading to over all shifts in the outlook of a girl. Thus for a girl it is very important to have optimum menarcheal age. According to a western researcher, the average age at which the onset of puberty occurs has dropped significantly since the 1840s.

Indian data suggests that in the past, the age for onset of menarche was 12-14 years however now there has been a steady decline in the age of onset of menarche to up to 9-10 years. A review of study on mean menarcheal age of Maharashtrian girls from 1960s onwards and a study conducted a decade later in the year 2000 by Bagga and Kulkarni showed that there is a consistent lowering of age at menarche on an average, by about six months per decade.

Dietary intake, body composition, physical activity and psychological aspects seem to be very important determinants which strongly are correlated with the age of onset of menarche. If observed closely, there is an interrelationship between these factors, for example, body composition is modulated through dietary intake as well as physical activity and psychological stress.

Dietary Intake

Developing countries like India are undergoing nutritional transition due to globalization and industrial revolution which seems to affect our food consumption. In India presently we see a paradox of under nutrition and over nutrition. There are studies reporting that under nutrition and over nutrition have their own effects on age at

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menarche. Under-nutrition among girls is associated with reduced lean body mass, lack of muscular strength and decreased work capacity. Studies report that delayed menarche is a sign of malnutrition and as nutritional status improves, the age at menarche is lowered drastically whereas fussy eating habits and under nutrition subsequently leading to poor health have been considered as reason for the late onset of menarche as well. To evaluate effect of early-life nutritional status on age at menarche, a study was conducted by Dahiya and Rathi on a cohort of 100 girls aged ≤14 years recruited in 2006 and were followed up in 2009 in NCR Delhi, India.

The findings revealed that age at menarche was not strongly influenced by birth size or childhood stunting caused by malnutrition but there was significant contribution of nutritional status in adolescence.

Effect of diet on onset of menarche has been studied extensively. Under nutrition and low body fat, or an altered ratio of lean mass to body fat seem to delay the adolescent spur and to retard the onset of menarche whereas obesity and high body fat% is positively correlated to early attainment of puberty.

The quality of food intake also influences puberty. Fat, vegetable and animal protein intakes have shown to greatly influence age of onset of menarche. It is a topic of interest for the researchers whether animal or vegetable protein and similarly animal or vegetable fat has the same effects on the menarcheal age through a change in the body composition.

Observational studies suggested a role of dietary intakes during pre pubertal period. High intake of proteins, low intake of fat, high fiber, high isoflavones and calorie restricted diet shows a delay in menarche whereas diet high in fats and animal proteins were associated with early menarche. A study conducted by Chandra Prakash reported that the girls having non vegetarian diet had significantly earlier onset of menarche and thereby showed a positive correlation of age of menarche and non vegetarian diet. Opposing effects of animal protein and vegetable proteins have also been studied to show that children with higher animal protein intake experience early menarche as compared to those on higher vegetable protein intake. This finding was established 6 decades ago by an Indian researcher in a study on Maharashtrian girls which reported that girls having non-vegetarian diet would menstruate about six months earlier than those on a vegetarian diet. This is supported by Bagga and Kulkarni (2000) who found out that early menarche in Maharashtrian girls is associated with a change in food habits from vegetarian to eggetarian and non-vegetarian diets. Recent worldwide increased consumption of animal protein and other changes in nutrition have increased childhood obesity and resulted in falling ages of puberty, mainly in those populations with the higher previous ages.

### Body Composition

Human body is composed of lean body mass, fat mass and water that account for body weight of an individual.

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean Age at Menarche (years)</th>
<th>Place</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>13.80</td>
<td>All over India</td>
<td>[4]</td>
</tr>
<tr>
<td>1978</td>
<td>13.94±0.9 (poor) 13.50±0.03 (non poor)</td>
<td>Andhra Pradesh</td>
<td>[5]</td>
</tr>
<tr>
<td>1990</td>
<td>13.20±1.09</td>
<td>Punjab</td>
<td>[7]</td>
</tr>
<tr>
<td>1998</td>
<td>12</td>
<td>Mumbai</td>
<td>[8]</td>
</tr>
<tr>
<td>1999</td>
<td>13.6±0.83</td>
<td>Haryana</td>
<td>[9]</td>
</tr>
<tr>
<td>2000</td>
<td>12.58±1.03</td>
<td>Pune</td>
<td>[2]</td>
</tr>
<tr>
<td>2001</td>
<td>13.50</td>
<td>Delhi</td>
<td>[10]</td>
</tr>
<tr>
<td>2009</td>
<td>12.45±0.02</td>
<td>Assam</td>
<td>[12]</td>
</tr>
<tr>
<td>2011</td>
<td>12.62±1.05</td>
<td>Pune</td>
<td>[13]</td>
</tr>
<tr>
<td>2011</td>
<td>12.43±1.49</td>
<td>Uttar Pradesh</td>
<td>[14]</td>
</tr>
<tr>
<td>2011</td>
<td>13.22±0.88</td>
<td>Meghalaya</td>
<td>[15]</td>
</tr>
<tr>
<td>2012</td>
<td>13.51±1.04 (urban) 13.67±0.8 (rural)</td>
<td>Central India (Wardha)</td>
<td>[16]</td>
</tr>
<tr>
<td>2014</td>
<td>12.38</td>
<td>Punjab</td>
<td>[17]</td>
</tr>
<tr>
<td>2015</td>
<td>13.7</td>
<td>Western India (Nashik)</td>
<td>[18]</td>
</tr>
</tbody>
</table>

Table 1: Studies on menarcheal age in different parts of India
Body composition collectively describes the distribution of these different body components into compartments.

Studies show that body composition during puberty is a marker of metabolic changes that occur during this period of growth and maturation, and, thus, holds key information regarding current and future health. During puberty, the main components of body composition such as total body fat, lean body mass, and bone mineral content increase. Furthermore, these components of body composition and their changes during puberty are risk factors for a variety of common, multi-factorial adult diseases, including cardiovascular disease, diabetes mellitus, obesity and osteoporosis.26

Frisch and Revelle in their classic study done decades ago27 have opined that acquiring an optimum amount of body fat is essential for the sexual maturation of the individual which is an important factor for onset of menses.

Lassek and Gaulin have given a different dimension to the traditional thinking expressed by Frisch.19 They suggest that menarche may be related to fat distribution rather than total fat, and in particular to the relative amount of lower-body fat (gluteofemoral) vs. upper-body fat.

One of the key components of body composition during puberty is adipose tissue and adipocytokines are molecules derived from adipose tissue. These include leptin, adiponectin and resistin. Leptin functions as a regulator of energy balance by interacting with several neuropeptides to inhibit food intake, and affecting the expenditure of energy. Leptin is primarily synthesized in adipose tissue along with stomach, placenta, mammary glands and ovarian follicles. It provides a pathway to communicate the size of fat stores to the GnRH secreting neurons in the hypothalamus via Leptin receptors in KiSS-1 neurons and is required for puberty.28 Age at menarche in young women is inversely related to leptin levels. If young women with relatively more gluteofemoral fat produce more total and free leptin, this may increase GnRH pulse frequency and the likelihood of early menarche.19 Leptin also appears to be involved in mediating various endocrine mechanisms like onset of puberty or insulin secretion and is related to disorders including obesity and polycystic ovarian syndrome.1

The significance of body composition for onset and maintenance of regular menstrual cycles is well accepted worldwide. According to Frisch, a minimum level of fatness (17% of body weight) is associated with menarche; however, a heavier minimum weight for height, representing an increased amount of body fat (22%), appears necessary for its onset.

Even though the significance of body fat is well understood whether increased body fat predisposes girls to earlier puberty or earlier puberty in some girl’s leads to an estrogen-mediated increase in body fat is not very clear. A review of the effects of gonadal steroids on body composition in adults concluded that estrogens and possibly progesterone largely account for the greater degree of body fatness in women as opposed to men, because these hormones seem to work together to favor the storage of excess calories as fat, with estrogens promoting deposition of fat in peripheral adipose tissue depots.29

Physical Activity

Physical activity is considered to be one of the determinants which also influences the age at which the girl attains her menarche. This might be through the changes brought about in body composition through exercise. Too less physical activity leads to increased fat percent in the body that results in early menarche, whereas it appears later in excessive activity.

Trentham-Dietz et al.30 have reported that increased participation in sports or any kind of physical activity is associated with delayed menarche, while increased physical inactivity, such as television watching, is associated with earlier menarche. The probable cause of this early menarche in physically inactive girls is increase in body mass and body fat percentage.

According to Rokade et al.,31 percentage of girls attaining early menarche is more in those undergoing occasional/ no exercise than those with regular exercise, the difference being statistically significant. The age of menarche for the girls having regular exercise and/or those participating in outdoor games was found to be higher than those with no/ occasional exercise. The small study conducted by us on a population of school girls (11 to 15 years) from Mumbai and Pune city have also shown same results with means of age at menarche of physically active and inactive girls statistically significant (p=0.000).

It has been observed that menarche is delayed significantly in those sportswomen who embark on physical training activities before the onset of menstruation. The age at menarche differs in athletes and non-athletes, mean age at menarche for athletes was significantly higher (13.58 years) as compared to that of a control group (12.23 years) in a study conducted by
Malina et al.\textsuperscript{32} It was also observed that college athletes, various groups of national and Olympic athletes attained menarche significantly later than non-athletes. Sidhu and Grewal\textsuperscript{18} observed a significant difference between the mean age at menarche (15.21 v/s 14.05 years) in 264 Indian sportswomen and 108 girls of control group.

A recent study suggests that the most probable explanation for delay in menarcheal age of swimmers is that the normal body fat composition of swimmers balances the negative hypothalamic effect on GnRH pulsatile exerted by intensive exercise.\textsuperscript{33}

Thus various studies reviewed have shown that physical activity has a definite role to play in the onset of age at menarche. Whether this effect is through modulation of body composition or through increase in energy expenditure is for us to debate.

\textbf{Psychosocial Aspect}

Life history theory suggests that in risky and uncertain environments the optimal reproductive strategy is to reproduce early in order to maximize the probability of leaving any descendants at all. The fact that early menarche facilitates early reproduction provides a rationale for our first two hypotheses: that women who experience more risky and uncertain environments early in life would have (1) earlier menarche and (2) earlier first births than women who experience less stress at an early age.\textsuperscript{34} Since 1991, when the evolutionary theory of socialization was published, the psychosocial factors, which can influence female sexual maturation, have gained a lot of importance. Family disruption, childhood adversity, and continuous stress may accelerate sexual and reproductive development of girls. Risky behavior, adolescent pregnancy, drug addiction, and early first sexual intercourse may be consequences of family disharmony, especially if it happens during the first 5-7 years of life. Single parenting and stressful situation in a family may speed up reproductive maturity of the girl. Absence of the biological father in early childhood has been linked to depressive symptoms in mid-adolescent girls. Earlier studies have linked father absence to early timing of menarche, and early menarche as a risk factor for increased depressive symptoms in adolescence.\textsuperscript{35}

Numerous prospective studies have indicated that girls who experience menarche earlier than their peers have higher levels of depressive symptoms in adolescence.\textsuperscript{36} Father absence occurs in the context of multiple socioeconomic and familial adversities (e.g., financial hardship, maternal depression) that precede family dissolution and are associated with both earlier menarche\textsuperscript{37,38} and adolescent psychopathology\textsuperscript{39}.

The resilience of pubertal development among girls who have been subjected to stressful life events would be better understood by studies of socio-nutritional factors as they interact with or via endocrine mechanisms in generating signals that affect menarche age.\textsuperscript{40}

Indian girls if not all as compared to western counterparts do experience emotional and psychological distress which in turn may explain the early onset of menarche or rapid sexual maturation in girls from families suffering from varied adversities.

\textbf{Conclusion}

The uniqueness of each child in her given genetic background and current environment serve as the best for her reproductive fitness and that there are various determinants for age at menarche, the important ones being diet, body composition, physical activity and psychosocial factors of the girl. There is interrelationship found between these factors wherein all affect each other directly. Substantial data in this field is available globally but in comparison there are less Indian studies reported.

\textbf{Conflict of Interest}

The author declares that there is no conflict of interest regarding the publication of this article.

\textbf{References}


