THE PERIMENARCHEAL WEIGHT GAIN PATTERNS/ BODY COMPOSITION, DIETARY INTAKE AND ITS CORRELATION TO AGE AT MENARCHE.

A Major Research Project (UGC)

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ABSTRACT

Through this major research project an endeavour has been made to study the effect of various factors such as anthropometry, body composition, dietary intake and physical activity of girls on their age at menarche. Baseline data was collected from 3000 school girls from Mumbai and Pune city. Based on willingness of participation, time availability and consent from parents' 2500 girls from 5^{th} to 9^{th} standard were recruited and finally 2,017 completed the study. Data was collected using General Questionnaire, Anthropometric measurements, Body Composition Analysis and 24 hr dietary record. Out of the total sample, 370 students had attained menarche (A) in the recent period of their recruitment whereas 1,646 girls had not attained menarche meaning they were perimenarcheal (PM) at the recruitment. The mean age of the study population was 11.59 yrs ± 1.114. Totally 370 girls had attained menarche with mean age 12.35 yr ±1.009 whereas 1647 girls were in the perimenarcheal group with mean age 11.42 yr ±1.065. A fact of lot of concern establish by us was that 10% of the girls had attained menarche when they were just 11 yrs and 52.18% girls had attained menarche before they were 12 yrs of age. In our study population positive effect of various factors such as anthropometry, body composition, dietary intake and physical activity was observed which was proved with appropriate statistical tests resulting in high statistical significance. Our findings are suggesting that girls who mature early, who are well nourished and who do not indulge into heavy physical activity attain their menarche earlier. Effect of heredity which was assessed through correlating maternal menarcheal age with daughters' menarcheal age could not be substantiated due to lack of statistical significance in these two variables.

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INTRODUCTION

Menarche is an important event in girl's reproductive career; it is the first appearance of menstrual period in girls and is accompanied with numerous changes in the hormonal secretions and body composition. 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 as well as infertility (Apter, 1989; Remsberg 2002).

There is lot of research on age at menarche which in other words means woman's age at her first menstruation and it has been estimated that during most of the 20th century age at menarche has fallen by about 3 months per decade (Olga, 2010). Early onset of menarche is associated with teen age pregnancy, childhood obesity, hormonal imbalance and polycystic ovarian syndrome. In later stages of life it can give rise to multiple problems like complications during pregnancy, infertility, breast or ovarian cancers etc (Karapanou and Papadimitriou, 2010). Many studies indicate that menarcheal age has also been found to adversely affect cardiovascular disease risk factor changes. Girls with early menarche exhibit elevated blood pressure and metabolic syndrome compared with later maturing girls, independent of body composition (Frontini et al 2003).

Age at menarche may be determined in part by factors as nutrition, body composition, genetics, altitude of residence, sleep patterns, family size and health status (Warren, 1983; Golub, 1992; Murata and Araki, 1993) Various studies show, anthropometry, body composition and diet to be correlated strongly with the age of onset of menarche (Koprowski, 1999; Chumlea, 2003 and Lassek and Gaulin, 2006).

Anthropometry has been shown to have an impact on age of menarche. Studies done over the past 100 years show that age at menarche has declined and the adolescent growth spurt has

occurred at younger age and peak height growth velocity has increased as well (Prokopec, 1989; Wieringen,1986). The tallest girls (height > 148.6 cm) at the time of first assessment reached menarche at an earlier age than the shortest girls (height < 135.9 cm) (Koprowski, 1999).

Body Mass Index is another contributing factor for onset of menarche; changes in body composition are reflected by changes in BMI of girls. Evidence from several different epidemiologic studies in the past years indicates a relationship between earlier puberty in girls and increased BMI, which is the most common indirect measure of obesity and body fat stores. Studies show that girls who reach menarche at a younger age have higher BMI (Kaplowitzs, 2001; Koprowski, 1999) and increased body fatness and obesity (Karen, 2002).

Body composition is yet another direct contributing factor for onset of menarche. Body composition collectively describes the different body compartments which constitute the human body; lean body mass, fat mass and water. 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 (Frisch and Revelle 1970). Body composition during puberty is thereby a marker of metabolic changes that occur during this period of growth and maturation, and, thus, holds key information regarding current and future health.

Diet on other hand acts as an important key factor regulating body composition and BMI of an individual, therefore diet is thought to have an effect on the age of menarche and thereby the menstrual pattern. 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 spurt and to retard the onset of menarche whereas obesity and high body fat percentage is positively correlated to early attainment of puberty (Begum, 2000). The quality

of food intake also influences puberty for example fat, vegetable and animal protein intakes have shown to greatly influence age of onset of menarche.

Along with energy intake, the energy expenditure is an essential factor influencing the age at menarche. The physical activity helps in maintaining the body composition as well as the hormonal balance. Too less physical activity leads to increased fat percent in the body that result in early menarche. Higher levels of physical activity in girls have been found to be associated with delayed menarche. It has been observed that participation in dance, ballet, gymnastic, skating; synchronized swimming and diving competition generally delays menarche (Moison et al, 1991). Increased sport activity is also associated with delay in the age at menarche (Merzenish et al, 1993).

The factors related to heredity comprise of the genetic composition and the maternal age at menarche. The factors related to heredity comprise of the genetic composition and the maternal age at menarche. Study done by Ong et al (2007) have found that mother's age at menarche in turn predicts her offspring's infancy growth rate and daughter's menarche provide some important insights into the trans generational influences on childhood growth.

All the factors influencing age at menarche are interrelated and hence the onset of menarche cannot be attributed to a single factor. Menarche in general appears to be a complex phenomenon having strong interrelated effect of diet, body composition and physical activity.

A number of western studies have been conducted in the past and present times to understand the complexity of this phenomenon; however studies in India have been limited. Since menstrual health is of utmost importance in a female's reproductive career and future health, it was considered to be a worthwhile effort to conduct a study on this topic.

The mean age at menarche in India was last estimated long ago, and a number of biological, social and ecological factors have likely changed since then. Considering the numerous negative consequences of early age at menarche, it is opportune to re-assess the onset of menarche and its association with various factors, particularly diet composition, body composition, socio economic status etc. Thus this research is socially relevant.

Through this study if certain correlation is established it will help us in educating the community at large about the role of diet in the maintenance of proper body composition. This may further help them in acquiring menarche at an appropriate age to avoid the occurrence of above mentioned health problems. With findings of this study it may become possible to draw attention of researchers and policy makers to adapt measures to combat problem of over nutrition.

Knowledge of the age at menarche will help the government to design and implement programmes about reproductive health of women, and to decide the appropriate age at which the topics like the sex education, contraception and sanitary practices can be in schools.

The study was undertaken with the following objectives,

- To record age of menarche in the given population
- To correlate height, weight and BMI of girls in the age group of 10 – 14 years with age of menarche
- To observe weight gain pattern in the perimenarcheal period and note down weight gain after onset of menarche and correlate it with menarcheal age
- To correlate body composition with age of menarche
- To collect information on dietary habits of the students with special importance to fat and protein intake and establish correlation with age of menarche
- To correlate maternal anthropometric profile with age of menarche

REVIEW OF LITERATURE

Puberty is a dynamic period of development marked by rapid changes in body size, shape, and composition, all of which are sexually dimorphic. It is characterized by the greatest sexual differentiation since fetal life. The onset of menarche is a vital maturational event of puberty in female adolescents marking an important milestone in a women's life. Puberty is defined as the period of onset of sexual maturity in which the reproductive organs become functional, and is the time when a child becomes an adult capable of reproduction. In girls, puberty is manifested between 8 and 14 years of age, by growth of the breasts and initiation of menstruation and by the development of pubic and axillary hair (Krik J., Bandhakavi M., 2008). The physical changes that occur in the female body during puberty probably are more dramatic than those associated with a boy progressing into manhood.

During puberty, the transition is made from having the physical appearance of a child to appearing as an adult (Petersen & Taylor, 1980; Tanner, 1962). In boys, puberty usually begins with the testicles and penis getting bigger. Then hair grows in the pubic area and armpits. Muscles grow, the voice deepens, and acne and facial hair develop as puberty continues, whereas the first sign of puberty in girls is the breast bud formation, the onset of breast development followed by the appearance between the ages of 8.5 to 13 years in 95% of girls and the breasts reach the mature stage between 11.8 and 18.9 years and then finally menarche (Marshall W.A., Tanner J.M. 1969). The adolescent growth spurt, the development of the breasts, and the growth of the pubic hair occur more or less concurrently, and take, on the average, about 3 years from beginning to completion, with menarche occurring usually in the latter half of this period (Tanner, 1962). The Tanner scale also known as the Tanner stages is a scale of physical development in children, adolescents and adults. This scale defines physical measurements of development based on external primary

and secondary sex characteristics, such as the size of the breasts, genitalia, and development of pubic hair, and was first identified by James Tanner, a British pediatrician and thus bears his name (Marshall, 1969). This scale is commonly used as a marker of female puberty at thelarche and menarche.

Table 1: Tanner Stages of Female Pubertal Development

Age (Years)	**Stages of breast development**	**Stages of pubic hair development in females.**
10 and younger	*B-1*: pre-pubertal	*Ph-1*: pre-pubertal
10-11.5 yrs	*B-2*: breast bud	*Ph-2*: sparse growth of long slightly pigmented hair usually slightly curly mainly along the labia
11.5-13 yrs	*B-3*: enlargement of beast and areola with no separation of the contours	*Ph-3*: the hair is darker, coarser and curlier and spreads over the junction of the pubes
13-15 yrs	*B-4*: projection of areola and papilla to form a secondary mound above the level of the breast	*Ph-4*: the hair spreads covering the mons pubis
15 + yrs	*B-5*: recession of the areola to the general contour of the breast with projection of the papilla only.	*Ph-5* the hair extends to the medial surface of the thighs and is distributed as an inverse triangle.

Puberty is mainly controlled by neuro-endocrine mechanisms. The onset of puberty is based on many factors but one portion of the body that is crucial is the hypothalamic-pituitary-gonadal (HPG) axis. In girls the last attainment of puberty is menarche. The menstrual cycle is therefore a repetitive phenomenon caused by the interaction of the hypothalamic-pituitary-

ovarian system and can be divided into three stages: the follicular phase- recruitment and growth of a new follicle; the ovulatory period- at which time an oocyte is released into the peritoneal cavity; the luteal phase- at which time a newly formed corpus luteum produces progesterone. The cycle is mainly regulated by the hypothalamus, in which gonadotropin-releasing hormone (Gn-RH) is released in pulses to stimulate pituitary gonadotropes to secrete follicle-stimulating hormone (FSH) and luteinizing hormone (LH). These gonadotropins in turn promote follicular development with ovulation and corpus luteum formation in the ovary, inducing steroid hormone production (Tomoko Fujiwara, Natsuyo Sato, Hiroyo Awaji, 2007). Menstrual health thereby holds a key to the well being of present and future life of a female. Menstrual health is one of the major areas of concern in reproductive health, affecting a large number of women throughout their reproductive life beginning from adolescence. Moreover, menstrual disorders and improper hygienic care have direct consequences in fertility and reproductive tract infections, respectively (Ray, 2008).

Age at menarche and Secular Trend:

Tanner (1962) described the secular trend in age at menarche. According to Tanner, the average age of menarche dropped from about 17 to 12.8 during the period 1830-1962. The rate of decline was 4 months per decade. Tanner has also noticed a decline in the age of initiation of the growth spurt. The trend seems to have stopped, with the age of menarche levelling off at 12.6 years.

Sanchez-Andres (1997) studied genetic and environmental factors affecting menarcheal age of daughters and mothers. The mean age at menarche of mothers was significantly greater than in 12 daughters. Year of birth and family size accounted of the variation in age at menarche. They concluded that genetic and environmental factors affects age at menarche, even though the influence of environmental variables may change over time. Graham et al.

(1999) studied the secular trend in age at menarche in rural parts of China. The study showed that the mean age at menarche decreased by 2.8 years from 16.5 to 13.7 over an approximate 90 years time interval. They found association between age at menarche and a number of covariates like country, physical labour, general health status, exposure to pesticides before menarche. Various studies carried out to record the age of menarche, records from several northern European countries, particularly Norway, Denmark, and Finland, document that the age of menarche, a convenient marker for the timing of puberty in girls, has decreased from 16 to 17 years during the 19th century to ~13 years by the middle of the 20th century, (Wyshak, 1982). The average menarcheal age in Western Europe varied between 12.0 yr in Italy (Borneman, 1995) and 13.5 yr in the eastern part of Germany (Engelhardt, 1995).

In the United States, a decline from 14.75 years in 1877 to just under 13 years by the period of 1950 to 1970 has been reported (Wyshak, 1982). Findings by Chumlea et al (2003) indicate that 10% of US girls start to menstruate before 11 years, and 90% are menstruating by 13.75 years of age. This distribution of ages indicated that 80% of all US girls start to menstruate between 11.00 and 13.75 years of age with a mean age of 12.43 years. In Thailand and South-American countries such as Chile and Venezuela, the average menarcheal age was reported to be12.5 yr (Chompootaweep, 1997; Ruiz, 2000, Macias-Tomei, 2000).

Table 2: Age at menarche in various countries around the world

Country	Year	Age (Years)
Switzerland	1983	13.4
Belgium	1985	13.1
South Africa	1990	13.2
Japan	1992	12.6

Finland	1993	13.0
UK	1993	13.0
Italy	1995	12.0
Sweden	1996	13.2
Germany	1996	13.5
Hong Kong	1997	12.4
Thailand	1997	12.5
India	1998	12.1
Denmark	1998	13.0
Cameroon	1999	13.2
Greece	1999	12.3
Venezuela	2000	12.6
Netherlands	2000	13.2
USA	2001	12.5
Spain	2002	12.6
France	2006	12.6

Source: Parent A.S. et al, (2003)

It has been widely assumed that improved health and nutrition associated with the coming of the Industrial Revolution were responsible for most if not all of that decline in the mean age of menarche (Paul, 2008). The declining age of puberty has also been attributed to improved standards of living such as adequate nutrition and health care (Tomoko Fujiwara, Natsuyo Sato, Hiroyo Awaji, 2007).

Indian data suggests that in the past the age for onset of menarche was 12-14years. The study conducted by Rakshit. S (1962) reported mean menarcheal age as 14 years and 4 months

among Maharashtrian Brahmin women of Nagpur. Similarly the Indian Council of Medical Research (ICMR 1972) reported the mean menarcheal age for Maharashtrian girls as 13 years and 9 months. Kundalkar (1981) reported it to be 13 years and 2 months. However, now there has been a steady decline in the age of onset of menarche to up to 9-10years, thereby making it a topic of interest amongst the researchers. Study by Bagga & Kulkarni (2000) has reported that there is a consistent lowering of the menarcheal age up to 12 years and 6 months. Overall global studies have reported that during most of the 20th century, age at menarche has been falling by about 3 months per decade (Olga, 2010). Thus, historical data suggests that the timing of puberty has been consistently decreasing and that it is influenced by genetic as well as epigenetic factors.

Significance of Age of Onset of Menstruation:

Age of menarche is very vital because early or late onset of menarche has many health implications like metabolic syndrome, CVD, Cancers, PCOS as well as infertility making the age of onset of menarche a very important factor for future health of a girl. Early puberty has been associated with increased insulin resistance, total number of metabolic syndrome components and hence increased risk of cardiovascular diseases (Feng, 2007; Apter, 1989; Remsberg, 2002). Age at menarche thereby reflects numerous health aspects of a population including the timing of sexual maturation, growth nutritional status, and environmental conditions (Wartman, 1970). Numerous studies have been conducted to identify the possible consequences of an early age at menarche (Karapanou O., Papadimitriou A., 2010; Posner B.R., 2006; Frontini M.G. et al, 2003; Magnusson C.M. et al, 1999; Wyatt G. et al, 1999). Other cancers like the cervical (Fujita M. et al, 2008) ovarian and the endometrial (Henderson et al., 1981) are associated with early menarcheal age.

Cooper et al (1998) have shown the association between early menarche and the increased risk of ischemic heart disease. The sample comprising 44,899 subjects with years of follow-up and 45 cases of myocardial infarction, angioplasty heart bypass surgery, or ischemic heart disease-related mortality were observed. Early menarche has also been associated with overweight (Wattigney W.A. et al, 1999) and metabolic syndrome (Frontini M. G. et al, 2003). Associations of early menarche are seen with higher adult body mass index (BMI), and obesity (Harris M.N.et al, 2008). This study observed that a one year increase in age at menarche was associated with a decrease in mean BMI of approximately 0.5 kg/m. Also the trend toward earlier menarche could be an indicator of a change in insulin-related metabolism.

Indirectly, it also poses a public health concern as it may result in earlier onset of sexual activity (Wyatt G et al 1999). Depression, eating disorders and poor school performance are among the other teenage problems that have been associated with early menarche (Posner BR, 2006).

On the other hand late menarche is associated with Alzheimer's disease (Parent et al 2003) and skeletal problems such as osteoporosis. Since amenorrheic young women may have reduced bone mineral density at forearm, spine and proximal femur (Cann et al., 1984; Drinkwater et al., 1984), their ultimate risk of fractures and osteoporosis may increased. A recent study by Chevalley T. et al (2009) suggest that in girls experiencing menarche later, report a deficit of peak bone mineral density with very mild increment during the whole period of pubertal maturation. This observation indicates that estrogen exposure is not the only one key factor responsible for the influence of menarcheal age on peak bone mineral density and that other genetic determinants could also be involved.

Factors Influencing Age at Menarche:

It is generally accepted that the development of sexual maturity is influenced by both the heredity as well as the environmental factors (Parent A.S. et al, 2003; Wehkalampi K.et al, 2008; Kaprio J. et al, 1995). The factors related to heredity comprise genetic composition and the maternal age at menarche, while environmental factors include nutrition, physical activity, stress and ethnic and racial differences along with geographical conditions.

Other than these factors many minor factors seem to be affecting the age at menarche. Girls from families with a high socioeconomic status experience menarche at an earlier age than girls from families with lower socioeconomic status. Also, parental educational status has been associated with earlier timing of puberty (Wronka I, 2005). The geographical differences might involve altitude, temperature, humidity, and lighting which signals the hypothalamus-pituitary-gonadal axis mediated through melatonin circuit. This might be the probable cause of menarche being more frequent in winter than in summer, which points to an inhibitory effect of photostimulation. Stress factors like acute/ chronic illness or war conditions suppress the hypothalamic-pituitary-gonadal axis and delay pubertal onset. Studies performed, in U.S.A. have shown that, black girls experienced menarche, on an average, three months earlier than white girls (Karapanou O. & Papadimitriou A., 2010). Body Composition is another factor influenced by both- the heredity as well as environment. Along with the other factors; nutrition, physical activity and the maternal age at menarche influence the girls' age at menarche. Menarche therefore is regulated by factors such as an appropriate body composition and adequate nutritional status and alteration seen in any of these two components can influence the onset of menarche. Various studies show, anthropometry, body composition and diet seem to be correlated strongly with the age of onset of menarche (Koprowski, 1999; Lassek and Gaulin, 2006; Chumlea2003).

Age at Menarche and Anthropometric Profile:

Height, Weight and BMI:

The onset of puberty corresponds to a skeletal (biological) age of approximately 11 years in girls and 13 years in boys (Tanner, J M; et al 1975). On an average, girls enter and complete each stage of puberty earlier than boys, but there is significant intraindividual variation in the timing and tempo of puberty, even among children of the same gender and ethnic background. One of the hallmarks of puberty is the adolescent growth spurt. As puberty approaches, the growth velocity slows to a nadir ("preadolescent dip") before its sudden acceleration during mid-puberty. The timing of the pubertal growth spurt occurs earlier in girls, typically at Tanner breast stage 3, and does not reach the magnitude of that of boys. Girls average a peak height velocity of 9 cm/year at age 12 and a total gain in height of 25 cm during the pubertal growth period (Marshall WA, Tanner JM, 1975). Boys attain a peak height velocity of 10.3 cm/year, on average, 2 years later than girls, during Tanner genital stage 4, and gain 28 cm in height (Marshall WA, Tanner JM, 1970). The longer duration of prepubertal growth in combination with a greater peak height velocity results in the average adult height difference of 13 cm between men and women (Tanner, J M, 1989).

***Table 3*:** Changes in height of pubertal girls (Source: Tanner, 1985)

Tanner Stages	Age (years)	Increase in Height(cm)
I	10 and younger	Height increases at basal rate: 5-6 cm/year
II	10-11.5	Height increases at accelerated rate: 7-8 cm/year
III	11.5-13	Height increases at peak rate: 8 cm/year
IV	13-15	Height increases at 7 cm/year
V	15 +	No further height increase

Tanner (1985) suggests that there is an increase in height throughout puberty and that Peak height velocity occurs at 11.5 years (9.7-13.3 years) whereas the Basal growth occurs until Tanner Stage 2 further he suggests that girls with an increase in height by about 9.0 (7.0-11.0) cm/yr mature early as compared to girls who mature late with an increase in height of 7.5 (5.4-9.6) cm/yr.

Other authors have also reported that postmenarcheal girls were taller than their premenarcheal counterparts of the same age (Bauer, 2007: Kirchengast, 2007). The tallest girls (height > 148.6 cm) at the time of first assessment reached menarche at an earlier age than the shortest girls (height < 135.9 cm); the RH was 2.9 (95% CI 2.1–4.1) according to Koprowski (1999). Similarly, it was observed that girls with the largest body mass (QI > 20.7) reached menarche sooner than girls with the smallest body mass (QI < 16.1, RH = 2.2, 95% CI 1.7–2.9).

Studies on relationships between body size (height and QI) and menarche have consistently reported that taller girls attain menarche earlier than their shorter counterparts with those (Moisan et al, 1990*a*, 1990*b*; Maclure et al, 1991; Merzenich et al, 1993). It has also been demonstrated that skeletal development, as measured by height, is related to menarche. And that taller girls were more likely to experience menarche at an earlier age also in the past a number of investigators have proposed that age at menarche is closely related to skeletal maturity (Ellison, 1982; Elizondo, 1992; Koprowski,1999) recent study showed similar results that the menarcheal girls were taller than non-menarcheal ones (Ji-Yeong Kim, 2010).

Body weight has also shown an effect on age of menarche. Kirchengast (2007) reported that postmenarcheal girls exhibited a higher weight status, a higher absolute and relative amount of fat mass and a higher amount of lean body mass than their premenarcheal counterparts of the same age. Studies carried out in the past by Shuttle worth (1937), (1938); Simmons and

Greulich (1943); Simmons (1944); Marshall (1974) showed that there is a close association between menarcheal age and skeletal maturation.

However, Frisch and Revelle (1970) suggest that menarcheal age is related to attainment of appropriate weight for reproduction rather than appropriate skeletal status. 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 the onset and maintenance of regular menstrual cycles. Body weight also has shown an impact on the age of menarche, the girls who achieved menarche earlier (between 9-11 years) showed the maximum mean body weight (46 kg) being 5 kg more than the mean weight of the girls in ideal age group. The late menarche group of girls showed the least mean body weight (37 kg)which was about 4.5 kg less than that of the ideal group (Bagga & Kulkarni, 2000) recent study showed similar results that the menarcheal girls were heavier than non-menarcheal ones (Ji-Yeong Kim, 2010).

Body mass index (BMI) is a commonly used index of body composition (adiposity). It is defined as weight in kilograms divided by the square of stature (standing height) in meters. BMI is proportional to weight and inversely proportional to the square of the height. BMI is often used to determine overweight and obesity in the clinical environment, usually by comparison of an individual to age- and sex-specific percentiles from a reference population (Flegal, 2000).

Bock (1994) analysed BMI in two cohorts, cohort 1 (born 1929–1954) and Cohort 2 (born 1955–1982) wherein girls were followed longitudinally from 6 years before menarche to 6 years after menarche and it was reported that there was a large and significant difference between the two cohorts in BMI suggesting that onset of menarche can be governed with an increase in BMI also evidence from several different epidemiologic studies in the past 30

years indicates a relationship between earlier puberty in girls and increased BMI, which is the most commonly available indirect measure of obesity and body fat stores.

Edward (2007) investigated that the BMI of the girls was related to the age of onset of menarche as the BMI increased the age of menarche decreased and this study was consistent with findings which reported that BMI is a contributing factor in the age of onset of puberty [Palmert,(2001), Fredricks (2005), Kaplowitz (2001), Janssens (2003)]. A recent study also reported of higher BMI and greater waist circumference in menarcheal girls as against the non menarcheal ones (Ji-Yeong Kim, 2010). However, a study by John (2008) pointed out that the average effects of menarcheal status on BMI assessments of overweight and obesity are small.

Body weight, height, BMI and body composition of a subject are therefore very important parameters reported in literature to influence the age at menarche (Awadhi et al, 2013; Banerjee et al, 2007; Deo and Gattorgi, 2004 Lin-Su et al, 2002 and Mohammad et al, 2013). A recent longitudinal study provides further evidence for a link between body weight and onset of puberty, as those girls that had a higher body weight or body mass index earlier in childhood were more likely to initiate reproductive development at nine years of age than their peers (Davison et al. 2000).

The findings from the studies of Moisan et al 1990a and 1990b demonstrated that skeletal development, as measured by height is related to menarche. A close relation between skeletal maturity and the age at menarche showing that taller girls are more likely to attain menarche at an earlier age was observed by various investigators (Ellison T, 1882; Elizondo et al 1992; Koprowski et al 1999). A study done in California showed that taller girls (148.60 cm) experience menstruation earlier than shorter ones (135 cm) (Kaplowitz and Kaplowitz, 2011).

Similar results were seen in a recent study that the menarcheal girl were taller than the non-menarcheal ones (Kim J.Y. et al 2010).

Waist, hip circumference and Waist-Hip Ratio:

Waist circumference is a more accurate measure of the distribution of body fat. BMI and waist circumference are primary tools for assessing adiposity. During adolescent development, secretion of oestrogen promotes storage of fat in the gluteofemoral region and breasts of girls (Merzenich et al., 1993; Boot et al., 1997). This gynoid distribution of body fat can be measured using the waist-to-hip ratio (WHR), which is calculated by dividing the circumference of the waist by the distance around the hips and buttocks. Some researchers found an association between body composition and waist to hip ratio. Lassek and Gaulin, (2006) suggested 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. A low WHR, characterized by a slimmer waist in relation to wider hips, fuller thighs and larger buttocks, is linked to the onset of menarche in girls (Lassek and Gaulin, 2007), and the maintenance of regular, ovulatory cycles in adulthood (Moran et al., 1999; Van Hooff et al., 2000). Female waist-hip ratio (WHR) declines during childhood from 1.03 at 4 months of age to 0.78 at the time of menarche (Fredriks et al., 2005). Women with larger breasts and low WHRs have been shown to have higher circulating levels of oestradiol and progesterone (Jasienska et al., 2004), β17 which are predictors of the probability of conception (Lipson and Ellison, 1996). Women's WHRs increase as they age, possibly due to reduction in estrogen production (Kirschner and Samojlik, 1991). Women with lower WHRs have been found to have a younger age of first coitus and report having had more sexual partners than women with high WHRs (Hughes et al., 2004).

Age at menarche and Body Composition:

The human body is composed of fat mass as well as fat free mass, thus it is found that anthropometric parameters, such as weight, height and BMI are strongly correlated with age at menarche. To start menstruation, girls need to achieve a minimum weight of 47.8 kg; and more importantly, their body fat should amount to 23.7%. It may also occur when enough gonadotropin hormones are released from the pituitary and hypothalamus (Frisch, 1974). 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 (total body fat, lean body mass, bone mineral content) all increase (Siervogel, 2003). Monitoring body composition during puberty is important because many aspects of body composition during this period are predictive of subsequent measures of these traits in adulthood (i.e. body composition 'tracks', (Guo, 2002, 2000). Furthermore, certain aspects 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 (Chumlea, 2002; Siervogel, 2000).

Considering the effect of body composition on menarche acquiring an optimum amount of body fat and body weight is essential for the sexual maturation of the individual which is an important factor for onset of menses (Matkovick, 1997). There have also been studies to suggest that obese girls tend to mature earlier than normal and that "thin" girls tend to mature later. For example, a significant delay in puberty and menarche is seen in girls who are very physically active and have markedly diminished body fat (Warren, 1983). Higher subcutaneous fat levels and BMI at prepubertal ages (5-9 yrs) were associated with increased likelihood of early (<11years) menarche (Bagga and Kulkarni, 2000; Freedman et al, 2002). Study conducted by Ajita and Jiwanjot (2014) states that the body mass index and body fat

percentages were significantly correlated and an inverse correlation was found. The higher body mass index, the lower was the age at menarche (Bralic et al, 2012; Currie C et al, 2012; Oh CM et al, 2012 & Wronka, 2010).

Another important aspect of body composition during puberty is the adipose tissue which is an active endocrine organ and adipocyte-secreted proteins which are produced in response to a variety of changes in metabolic status (Holst, 2002). Adipocytokines (adipose tissue-derived molecules) 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 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 ovary syndrome (Remsberg, 2002). Leptin is primarily synthesized in adipose tissue, but is also synthesized in the stomach, placenta, mammary glands and ovarian follicles, as well as other organs. Leptin is strongly related to TBF, This hormone , produced by fat cells, 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 (Smith et al., 2006) and is required for puberty (Chehab et al., 1996, 1997; Clement et al., 2007; Ozato et al., 1999; Farooqi et al., 1999), several studies also show that age at menarche in young women is inversely related to leptin levels (Matkovic et al., 1997) if young women with relatively more gluteofemoral fat produce more total and free leptin, this may increase GnRH pulse frequency and the likelihood of menarche, (Lassek, 2006). It is anticipated, therefore, that leptin deficiency is a primary reason for delayed puberty and menarche in individuals and in populations accustomed to absolute or relative dietary energy deficiency. In menstruating women, a negative energy balance caused by either fasting and/or exercise could cause secondary amenorrhea , presumably due to low levels of circulating leptin (De Souza,1991).

Elevation of the serum leptin level, which precedes puberty, is thought to play an important role in the onset of puberty.

All of the studies that show a relationship between early puberty and obesity in girls do not answer the question of whether increased body fat predisposes girls to earlier puberty or earlier puberty in some girls leads to an estrogen-mediated increase in body fat. 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 (Rosenbaum, 1999).

Age at Menarche and Nutritional Status:

Nutritional status and dietary composition have an important bearing on age at menarche i.e. the quantity as well as quality of food intake influences puberty. Adolescents gain 50% of adult weight and more than 20% of their adult height during this period (Berkey et al, 2000; Bharti, 1998). Studies report that delayed menarche may be a sign of malnutrition and as nutritional status improves, the age at menarche is lowered drastically (Abioye-Kuteyi, 1997; Acharya., 2006).

Studies suggest that there is a strong correlation between body composition and menarcheal pattern influenced by the dietary pattern of adolescent population. It has also been suggested that decreases in age at menarche until the mid-1960s resulted from "positive" changes, such as better nutrition, whereas decreases since that time are related to "negative" changes, such as overeating and decreased physical activity (Paula, 2008). It has been suggested that girls need to reach a critical weight or height for menarche to occur and that changes in dietary

habits as observed in children may cause this critical weight to be reached at an earlier age. Up to now it is unclear, however, whether energy intake or specific nutritional components play a role, or whether Nutrition affects menarche through its effect on accumulation of adipose tissue (Onland-Moret, 2005).

Dieting behaviours and nutrition can have an enormous impact on the gynaecologic health of adolescents. A strong secular trend has been observed; in all developed countries girls have shown a preponed menarche. Some authors consider that chronic malnutrition as seen in many developing countries is the main determinant of delayed puberty (Driezen et al. 1967, Kulin et al. 1982, Eveleth and Tanner 1990). Kulin H.E. et al (1982) compared between 342 privileged, urban children and 347 impoverished rural adolescents in Kenya and found that chronic malnutrition leads to a delay in menarche of girls by 2.1 years. This could be attributed to the effects of chronic malnutrition in the first decade of life leading to stunting as the mean height differences of 7.4 cms was found in both the groups in their pre pubertal stages in spite of catch up growth in early years. Similar studies in the American population have shown a delay of 2 years in menarche (Dreizen S, Spirakis C.N., Stone R.E. 1987) and a delay of 1½ year in Indian girls (Satyanarayan K., Naidu N., 1970). The oldest age of menarche was noted when the protein, iron and caloric intake was less than 80% of the RDAs (Mounir, 2007). Observational studies suggested a role of dietary intakes during prepuberty; high intake of proteins, low intake of fat, high fiber, high isoflavones and calorie restricted diet shows a delay in menarche. Fussy eating habits and under nutrition subsequently leading to poor health have been considered as a reason for late menarche as well (John C, 2008).

On the other hand, a diet high in fats and animal proteins has been associated with early menarche. A study conducted by Prakash C (2010) 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.

Animal protein and vegetable proteins have been shown to have different effects on the age at menarche. Children with higher animal protein intake experience early menarche as compared to those on higher vegetable protein intake (Buyken, 2010). Bagga and Kulkarni (2000) have also demonstrated that early menarche is associated with a change in food habits from vegetarian to eggetarian and non-vegetarian diets. Similarly some studies suggest that greater intake of milk or milk-derived nutrients such as calcium, protein, or fat contributed to earlier menarche (Chevalley, 2005; Berky, 2000) whereas another study stated that only greater total calcium and milk intake contributed to a higher risk of early menarche (Andrea S.W,2011). Meyer et al. (1990) found that higher dietary energy intake was associated with earlier menarche and dietary composition was not however many other studies report that not only dietary intake but individual intake of nutrients also play an important role.

A plethora of other dietary factors seem to be influencing the age of onset of menstruation (early or late onset) such as a higher fiber intake (Koo, 2002: Thijssen, 1991) or higher intakes of carbohydrate and micronutrients (Kissinger, 1997), lower intakes of vitamin C, vitamin E, β-carotene and higher leptin concentrations (Aeberli, 2006; Foster, 1999) indicating probable associations between diet quality in the prepubertal period with the timing of puberty onset. Nutrient intake and storage during childhood may influence the timing of menarche through hormones such as leptin and insulin, and growth factors such as Insulin-like Growth Factor I (IGF-I), all of which are involved in the regulation of growth and maturation (Parent, 2003). Therefore there is substantial evidence that the timing of onset of menarche has numerous health implications, and that adolescent growth and development factors are somehow causally associated with risks of adult diseases. Therefore their associations with earlier, potentially modifiable childhood factors are relevant to disease prevention.

Age at menarche and Physical Activity:

Physical Activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. It has been identified as fourth leading risk factor for global mortality causing estimated 3.2million deaths globally. Regular moderate intensity physical activity- such as walking, cycling or participating in sports-has significant benefits for health. For instance, it can reduce the risk of cardiovascular diseases, colon and breast cancer, and depression (WHO).

Physical activity helps in maintaining the body composition which modulates the age at menarche as well as the hormonal balance. Physical activity and menarche are as much connected as the other factors. Too less physical activity leads to increased fat percent in the body that result in early menarche, where as it appears later in excessive activity. Vigorous physical training causes amenorrhea and is found to be associated with delayed menarche (Frisch R.E., 1984; Bernstein L et al, 1987).

A cross sectional study performed in a group of Colombian university women demonstrated that age at menarche was positively associated with the practice of at least 2 hours daily physical activity (Chavarro J, 2004).

Moison et al (1991) observed that participation in dance, ballet, gymnastic figure skating, synchronized swimming and diving competition had lower risk of reaching menarche at an early age. Menarche on an average occurs later in athletes, including ballet dancers, than in general population, with the exceptions of swimmers, suggesting that intense exercise delays puberty (Warren, 1980; Frisch et al., 1981). 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 (Karapanou O. & Papadimitriou A., 2010).

The delay in menarche is observed as secondary amenorrhoea may continue throughout the teenage years as long as strenuous physical activity continuous (Frisch et al., 1980; Warren 1980; Frisch et al., 1981; Wakat et al., 1982). Rigorous physical activity delays the age at menarche and therefore lowers the risk of breast cancer and of reproductive cancer (Frisch et al., 1985). However such rigorous activity also increases susceptibility to reduced bone density (Cann et al., 1984; Drinkwater et al., 1984).

Merzenish et al (1993) noted that the increased sport activity is associated with delay in the age at menarche. It may be the vigorous exercise, intense physical and mental stress which delays the menarche. Girls who undergo regular daily training before and after menarche come to lose the balance in the ratio of body weight to fat, and that the excessive physical and mental stress from regular training in female athletes tends to cause delayed menarche (Malina, 1983).

The age at menarche differs in athletes and non-athletes. Malina et al (1973) found that mean age at menarche for athletes was significantly higher (13.58 years) as compared to that of controlled group (12.23 years). Also Malina et al (1978) noted that college athlete's attained menarche significantly later than non-athletes and various groups' of national and Olympic athlete's attained menarche significantly later than high school and college athletes.

Sidhu and Grewal (1980) observed a significant difference between the mean age at menarche in Indian sports women (n=264) (15.21 years) and control samples (n=108) (14.05 years). These studies substantiate the findings of Malina et al (1978) that there is a possibility of different maturity relationships for different sports and competitive levels among women athletes of different countries.

Girls who indulge in moderate physical activity, averaging more than 600 kcal of energy expenditure in activity per week through participation in two or more hours per week in

activities like aerobic exercise classes, swimming, jogging or tennis, are significantly more likely than less active girls to have a normal menarcheal age and less risk for breast cancer (Bernstein L et al.1987).

Age at Menarche and Heredity:

Menarche or first menstrual period is a landmark in reproductive life span and it is the most prominent change of puberty which shows successful reactivation of hypothalamic-pituitary-gonadal axis, leading to sexual maturation (Ebling FJ, 2005). It is generally accepted that the development of sexual maturity is influenced by both the heredity as well as the environmental factors (Parent et al, 2003; Wehkalampi et al, 2008; Kaprio et al, 1995). The factors related to heredity comprise of the genetic composition and the maternal age at menarche. Study done by Ong et al (2007) have found that mother's age at menarche in turn predicts her offspring's infancy growth rate and daughter's menarche provide some important insights into the trans generational influences on childhood growth. Several studies have indicated that the time of menarche can be under the influence of genes as well as individual environmental factors interacting with genetic factors (Loesch DZ et al, 1995; Palmert MR, Hirschhorn JN, 2003; Meyer JM et al, 1991).

Mother's age of menarche seems to be a better predictor of daughter's age of menarche than socioeconomic, contextual stressors such as mother's education, age at first marriage, and employment status of mother and/or current husband (Campbell & Udry, 1995). Because early menarche is associated with early sexual intercourse and consequent single motherhood, it may be that mothers predisposed to raise children without a biological father in the home genetically transmit an early menarcheal age to their daughters (Caspi, 1998; Surbey, 1990).

The developmental event of a daughter's menarche (first menstrual period) is an early adolescent transition that is most commonly addressed by mothers in families where mothers are present (Carlson & Wilson, 1994; Costos, Ackerman & Paradis, 2002; Kalman, 2003).

METHODOLOGY

The present study was an action research which was a combination of the retrospective and prospective methods. It was conducted with an aim to determine the age at menarche, diet pattern and body composition. The subjects for the study were school girls in the age group of 10-14 years (5^{th}-8^{th} standard) from various schools from two important metro cities in Maharashtra namely Mumbai, Pune. This study was approved by Inter System Biomedica Ethics Committee, Kasturba Health Society, Vile Parle (W) (Approval letter Appendix-A).

The school principals were first approached with an official letter to seek permission for the study (Appendix B). On obtaining approval from the school authorities, girl students from class 5 through class 9 were given a preparatory talk in different sessions as arranged by the school authorities. In this preparatory talk session the girls were introduced to physiological and anatomical changes taking place during puberty, the onset of menarche and the menstrual cycle. Following this talk, a pre questionnaire (Appendix C) was administered to identify the girls who had recently attained menarche, for inclusion in the sample group as defined by the inclusion and exclusion criteria. A consent letter was sent along with the selected girls to be signed by the parents indicating their agreement to participate in the study (Appendix D). Mothers of these girls were later invited for a meeting (Appendix E) to obtain information regarding their demographic profile, family medical history, menstrual details and pattern of physical activity using a closed ended general questionnaire (Appendix F) along with 24-hour Diet Recall (Appendix G) and Food Frequency Questionnaire (Appendix H). Based on the willingness of girls and their mothers to participate in the study, 2017 subjects who had were enrolled for the study.

TOOLS OF DATA COLLECTION:

General Questionnaire:

In the first interaction, general questionnaire was used to find out Information regarding Name, Date of birth, Age of the subjects, their medical history, Family history, Parents Occupation, maternal menarcheal history etc; was obtained through the questionnaire. It was also used to gather information concerning the subject's physical activity and its types like - Walking, Jogging, Dance, Swimming, Athletics, tennis, aerobics, football etc., the duration of activity such as 30 mins, 45 mins, 1 hr, 1½ hr etc. and its frequency i.e. daily, alternate days, twice/week, weekly etc. The intensity scores were devised on the basis of calories expended per hour for that activity as given by Mudambi S.R. and Rajagopal M.V. (2007) and Oxford Food and Fitness Dictionary (2012) (Appendix I). Thus the calorie expended per hour in moderate walking is 139, cycling 165, basketball 240, moderate swimming 242, moderate dancing 183 etc. Hence, intensity scores for walking were allotted as 1, cycling as 2, dancing as 3, swimming as 4, basketball as 4 etc. Duration of the activity along with its frequency was also allotted scores which are given below:

Table 4: Duration of the activity along with its frequency was with allotted scores

Duration		**Frequency**	
Time	**Score**	**Frequency**	**Score**
Less than 30 minutes	1	Twice/ day	6
30 minutes	2	Daily	5
45 minutes	3	Alternate days	4
1 hour	4	Twice/week	3
1 ½ hour	5	Weekly	2
More than 2 hours	6	Once in 15 days	1

The intensity scores along with duration of physical activity and frequency together were used to calculate the physical activity index for each sample. The formula is given as follows:

Physical Activity Index= (Intensity Factor)* (Duration)* (Frequency)

For example:

1) If a girl indulges in walking for 30 mins daily; her physical activity index is calculated as:

   1(Intensity score)* 2(Duration)*5 (Daily) =10 (Physical activity index)

2) If a girl is involved in dancing for 1 ½ hr twice/week Her physical activity index is calculated as:

   3(Intensity score)*5(Duration)*3(Frequency) = 45 (Physical activity index)

Food Frequency Questionnaire:

Food frequency questionnaire (FFQ) was designed in order to find out daily consumption of various foods throughout the day. It contained 100 foods from various food groups such as breakfast items, sweet preparation, milk based recipes, protein supplements, fried snacks, chat items, fast food, and non vegetarian foodstuff etc. Keeping the objectives of the study in mind more emphasis was given to protein rich foods from animal and vegetable groups as well as foods rich in fats. Food frequency questionnaire was filled by an interview method in which parents were given assistance regarding the portion sizes and actual quantities consumed by their daughters. For this, paper cut models of chapatti, puri, phulka, were prepared and standard cups, table spoon sets other serving spoons and plates were carried and shown to them.

24 Hour Diet Record:

24 hr diet record is a useful tool to validate the data filled in the Food Frequency Questionnaire. To gain information on the girls' dietary pattern 24hr diet record form was

given to them along with directions to fill the record sheet. Also they were instructed to enter the recipes consumed in a day including their meals and tiffins along with its quantities and ingredients as far as possible. However, the amounts mentioned were based on approximation and not accurate.

Anthropometric Measurements:

The anthropometric measurements were collected.

- **Weight (kg)** was measured using an electronic weighing scale (Nova BGS-1204). The accuracy of the scale was ± 100g. The subjects were asked to stand, bare feet on the center of the weighing scale without moving, tilting or holding anyone else. Weight was recorded nearest to 100g.

- **Height (cm)** was measured using a fiber optic non stretchable measuring tape against the wall. The subjects were asked to stand parallel to the wall bare feet, with mandibular plane parallel to the floor. A mark was made on the wall at the tip of the head using a wooden foot rule.

- **Body Mass Index (Kg/m^2)** was calculated as weight in kilograms divided by the square of height in meters.

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

- **Waist Circumference (cm)** was also measured with a non-stretchable measuring tape. It was placed half way between hip bone and lowest rib of a subject. This was about 5 cm (2 inch) above belly button. The measuring tape was wrapped around the waist and the measurement where the two ends of the tape meet was noted.

- **Hip Circumference (cm)** was also measured with a non-stretchable measuring tape. It is measured at its widest portion of the buttocks. The measuring tape was wrapped around the hip and the measurement where the two ends of the tape meet was noted.

- **Waist to Hip Ratio (WHR):** One of the simplest ways of measuring body fatness is calculating waist-to-hip ratio, a relationship between waist circumference and hip circumference.

$$\text{WHR} = \frac{\text{Waist (cm)}}{\text{Hip (cm)}}$$

Body composition analysis was conducted using a Body composition analyzer (Tanita model no. BC 420 P MA) which works on the principle of Bio Electrical Impedance. The general principle behind BIA: two conductors are attached to a person's body and a small electric current is sent through the body. The resistance between the conductors will provide a measure of body fat, since the resistance to electricity varies between adipose, muscular and skeletal tissue. Fat-free mass (muscles) is a good conductor as it contains a large amount of water (approximately 73%) and electrolytes, while fat is anhydrous and a poor conductor of electric current. The girls were asked to stand on the machine bare feet wearing their uniforms, the age (years) and height (cms), were entered manually. The values and measurements for the following parameters Weight (kg), BMI (Kg/m^2), Skeletal Muscle Mass (Kg), Fat Mass (kg), Fat Percentage, Total Protein (kg), Total Body Water (kg), WHR were automatically obtained on the analyzer and were printed as a graph.

Body Composition Measurement:

Body composition analyzer -Tanita (model no. MA- 420) was used to analyze the following constituents of the body composition:-

- ***Total Body Fat%-*** Body fat percentage is the amount of body fat as a proportion of your body weight. Percentage Body Fat indicates the percentage of body fat to body weight.

  Percentage Body Fat (%) = Body Fat Mass / Body Weight× 100.

- ***FM (Fat Mass)* -** Body Fat Mass can be stored under the skin, as well as in the abdomen. When a person's body fat mass is higher than the standard range, then they are clinically obese. By knowing the percentage of body fat, multiplying Body fat % by weight gives exact weight of fat in present in the body.

  Body Fat Mass = Body Weight – Fat Free Mass (FFM).

- ***FFM (Fat Free Mass)* -** Fat free mass is, everything that is not fat: muscle, water, bone, connective tissue, etc.

- ***Muscle mass-*** This indicates the weight of muscle in our body. It includes the skeletal muscles, smooth muscles (such as cardiac and digestive muscles) and the water contained in these muscles.

- **Total Body Water Percentage**: Total body water percentage (TBW%) is the total amount of fluid in the body expressed as a percentage of total body weight.

Statistical Analysis:

The data from the General questionnaire, FFQ, and BCA was coded on a code sheet using Microsoft Excel-2007 spreadsheet. All entries were double checked for any possible keyboard error. This data was analyzed with the help of statistical package SPSS Version-17.Stastical analysis was done by using frequency, mean and standard deviation for the general questionnaire.

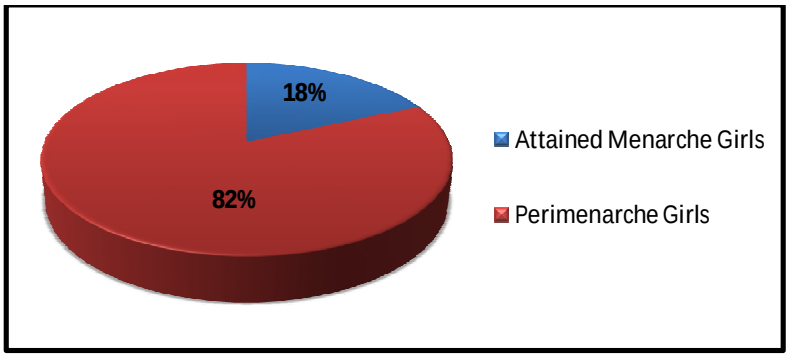
The techniques used for analysis were:

- Frequency, mean and standard deviation for the general questionnaire
- Correlations using Karl Pearsons' Coefficient of Correlation for determining the relationships between:
    - ✓ Age at menarche and anthropometry,
    - ✓ Age at Menarche and Body Composition,
    - ✓ Age at Menarche and Dietary-intake,
    - ✓ Age at menarche and physical activity,
    - ✓ Age at menarche and heredity factor.
- Regression and Discriminant analysis to predict the age at menarche from anthropometry, body composition and dietary intake

RESULTS AND DISCUSSION

In the present study an endeavour has been made to study the effect of various factors such as anthropometry, body composition, dietary intake and physical activity of girls on their age at menarche. The study started with 2500 school girls from Mumbai and Pune city who were selected for the preparatory talk as an initial part. Based on their willingness to participate in the study, availability in the school on the day when data collection was done and consent from parents' finally 2,017 students actually participated in the study. Out of the total number, 370 students had attained menarche (AM) in the recent period when they were recruited for this study whereas 1,647 girls had not attained their menarche meaning they were perimenarcheal (PM) at the recruitment (Refer to Figure 1).

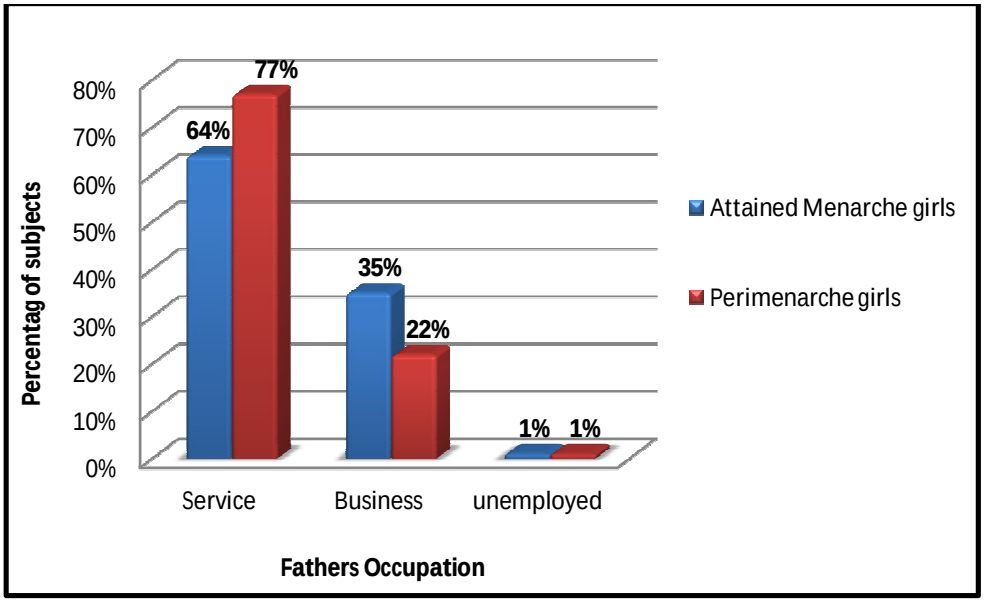
***Figure 1*:** Overall study population



The study samples belonged to standard 5th to 9th and majority of the population belonged to the age group of 10-14 yrs. Only 3 girls were of 8 yrs age and 13 girls were of 9 yrs age. Maximum girls were of 12-13 yrs age and minimum girls were in the category of below 10 and above 40 yrs of age. The mean age of the study population was 11.59 yrs ± 1.114.

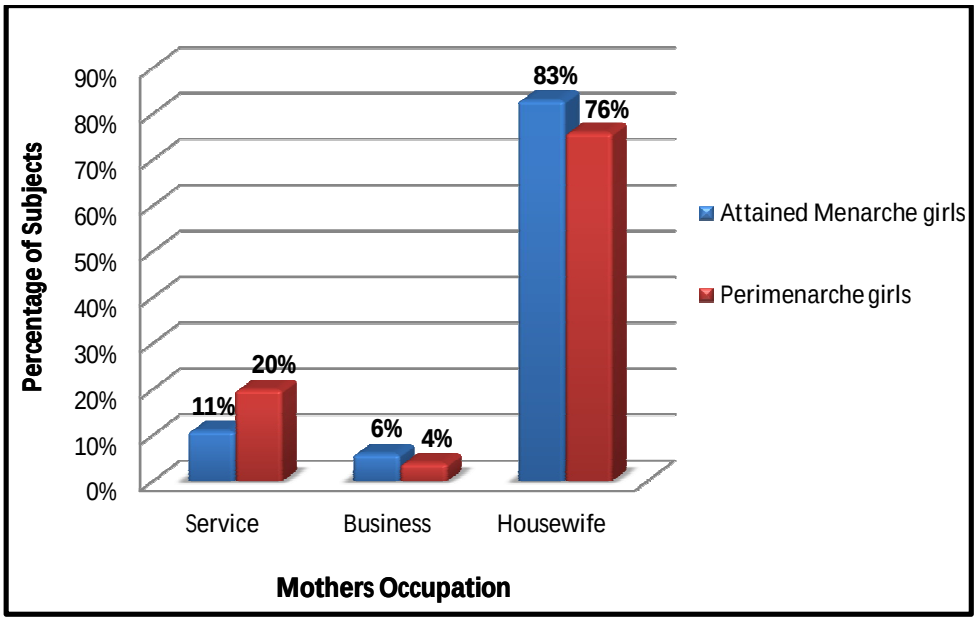
So far as fathers occupation was concerned majority of the fathers were in service and less number of fathers were in business. The number of unemployed fathers was very negligible. This finding was true for both the AM and PM groups with minor difference in percentage (Refer to Figure 2).

***Figure 2*:** Occupation of Father of selected samples



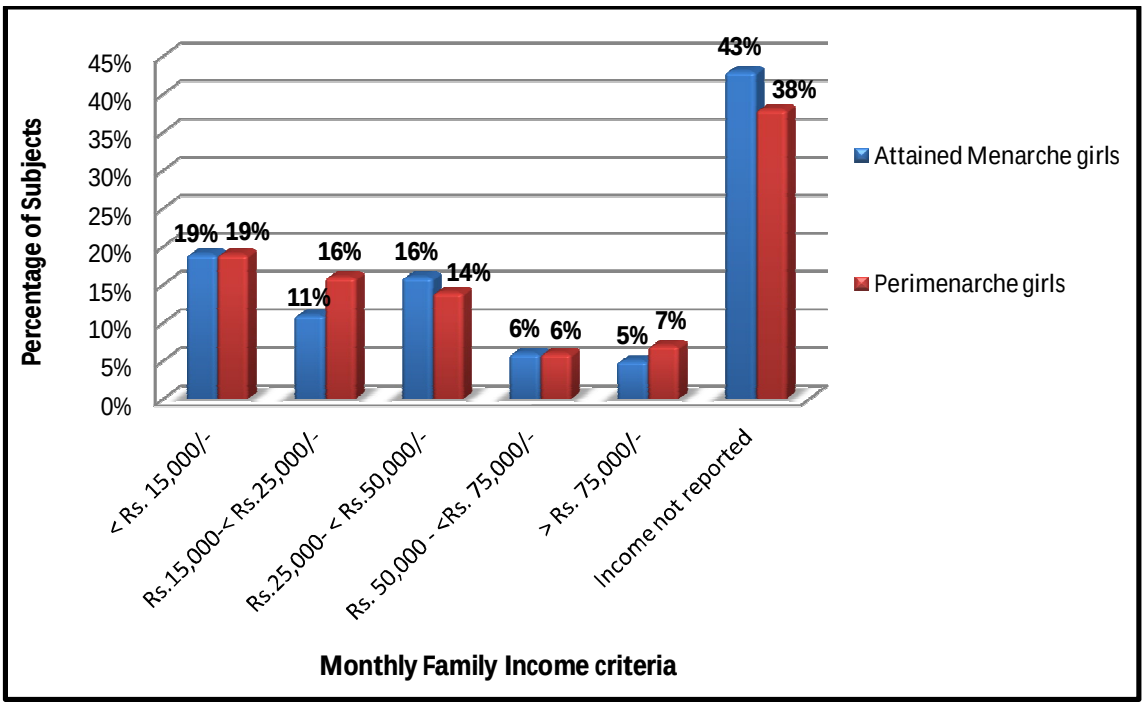
Percent wise most of mothers were housewife and less percentage of mothers were in service and business in both the groups (Refer to Figure 3).

***Figure 3*:** Occupation of mother of selected samples



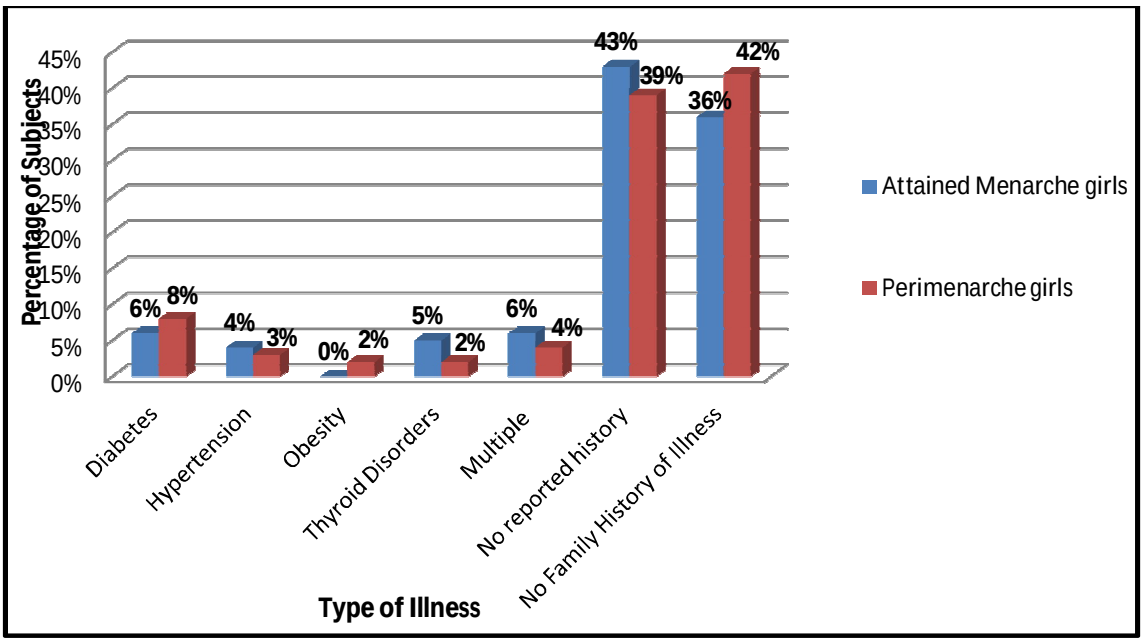
When monthly family income of both the groups was compared there was no measurable difference found over all the income categories (Refer to Figure 4) 43% of girls from AM group and 38% of girls from PM group did not report their monthly family income. From the remaining income categories higher percentage (19%) of girls were in low income category from both the groups while percentage of girls in high income category from both the groups was less.

Figure 4: Monthly Family Income of the Parents



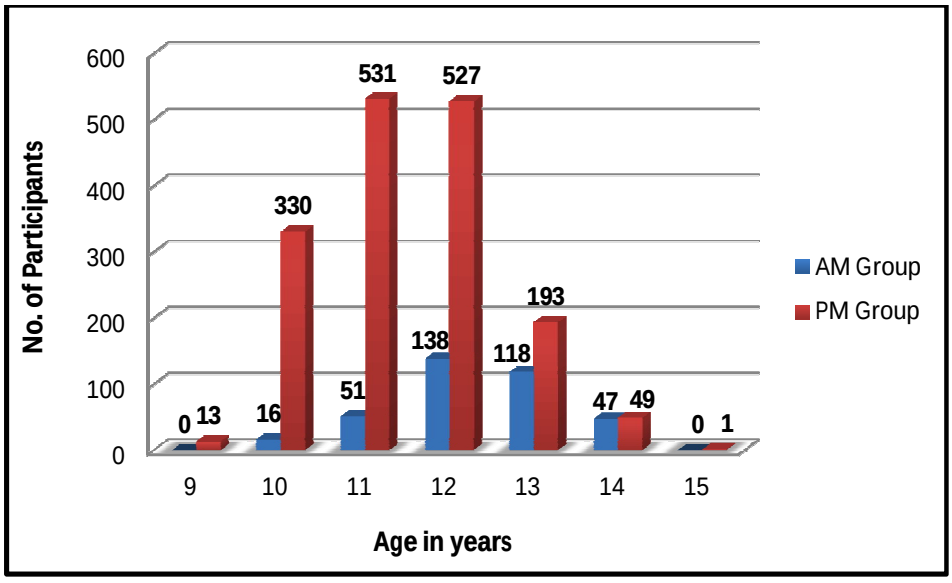
While reporting family history of illness almost 40% of girls in both groups did not respond, whereas close to 40% girls reported of having no family history of illness. Negligible percentage of girls reported of having history of some major illness like diabetes or obesity etc. (Refer to Figure 5)

Figure 5: Family History of illness among study population



Age of the Sample: The total number of girls in the AM group was 370 with the mean age 12.35 yr ±1.009 whereas the total number of girls in the PM group was 1647 with the mean age 11.42 yr ±1.065. The age distribution within the sample is as shown in the figure 6.

Figure 6: Age wise distribution of the total number of participants



Age at Menarche: The mean age at menarche of the sample (n=274) was 12.16 yrs ±1.132. Almost 50% students had age of menarche between 11-12yr, 36.5% of students were between 12-13 yrs and 12% of the girls had age at menarche above 13 yrs of age.

Table 5: Age wise distribution of Mean Menarcheal Age

Age (years)	N	Mean ± SD
10 yr	8	10.18 yrs ± .139
11 yr	27	11.07 yrs ± .698
12 yr	108	11.61 yrs ± .872
13 yr	100	12.79 yrs ± .697
14 yr	31	13.55 yrs ± 648
Total	274	12.16 yrs ± 1.132

From the above table it is evident that 143 out of 274 (52.18%) girls had attained their menarche before they were 12 yrs of age. This is a significant finding which substantiates the changing trend in today's Indian society so far as lowering of menarche is concerned. Out of the total population 10% of the girls had attained menarche at age 11 which is very concerning.

Observation on Menstrual details:

Out of the overall participants 43% did not report on any aspect of menstrual details. From the remaining ones those who reported menstrual details, following results were obtained: (Figures 7, 8 & 9)

1. 82% girls had regular menstruation whereas 18% girls had irregular menstruation.
2. More than 50% (57%) of the girls had 4-5 days of menstrual flow whereas less percentage (4%) of girls had < 4 days of menstrual flow and 29% of the girls had > 6 days of menstrual flow.

3. Maximum percentage of girls (51%) had 28-30 days of interval between two menstrual cycles while 27% had >30 days of interval and 22% had <28 days of interval between two menstrual cycle.

Figure 7: Regularity of Menstrual cycle

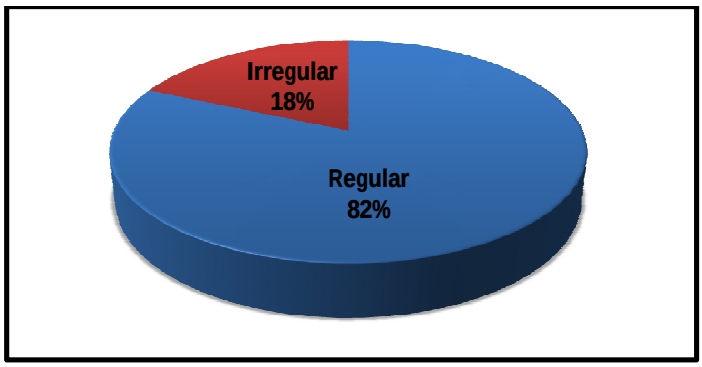


Figure 8: Number of Days of Menstruation

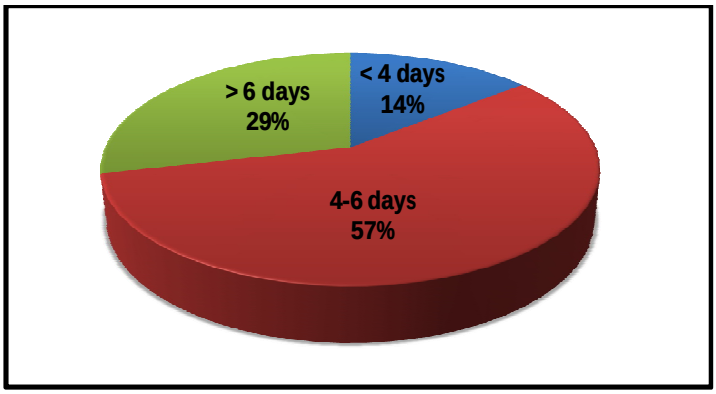
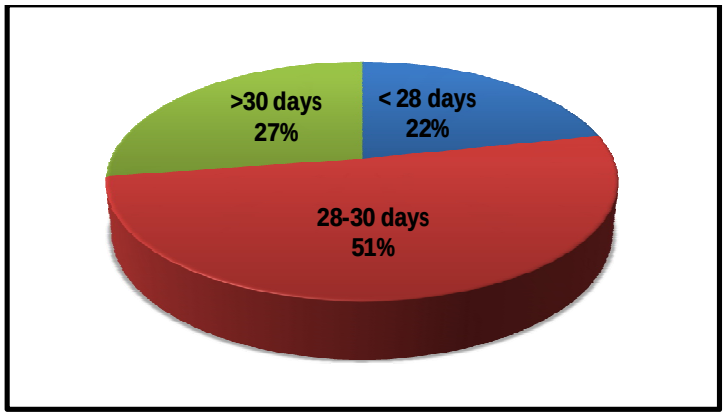


Figure 9: Interval between the two Menstrual Cycle



Age at menarche is influenced by a number of factors including genetic factors, anthropometric indices, body composition, diet and physical activity. We have collected data on these, which are expressed as below.

Anthropometric profile of the study population:

So far as anthropometric profile was concerned height and weight of the girls were recorded and BMI was calculated. Waist and hip circumference were also measured and WHR was calculated for the total population. The results obtained are shown in Table 6:

Table 6: Anthropometric Profile of the study population

Anthropometric Measurements	AM Group Mean ± SD	N	PM Group Mean ± SD	N
Height (cm)	151.05cm ± 6.39	370	144.33 cm ± 8.04	1647
Weight (kg)	44.44 kg ± 9.57	370	36.62 kg ± 9.31	1647
BMI (kg/m^2)	19.47 kg/m^2 ± 3.79	370	17.46 kg/m^2 ± 3.50	1647
Waist circumference (cm)	68.72 cm ± 8.12	253	63.33cm ± 8.95	1069
Hip circumference (cm)	85.56 cm ± 8.24	253	77.97 cm ± 9.92	1069
WHR	0.80 ± 0.054	253	0.81 ± 0.055	1069

As observed from the above table all the anthropometric parameters are higher in the AM group as compared to PM group except WHR which was found to be almost similar in both the groups. Thus, it is evident that girls who are better in their anthropometric profile attain menarche at an earlier age. According to Frisch (1970) also 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 the onset and maintenance of regular menstrual cycles.

When age at menarche was statistically correlated with anthropometric measurements following results were obtained (Table 7).

Table 7: Correlation between Age at Menarche with Anthropometric Measurements

Parameters Tested	Pearson Correlation		
	N	**Pearson Correlation**	**Sig. (2-tailed)**
Height (cm)	274	.029	.638
Weight (kg)	274	-.125*	.038
BMI (kg/m^2)	274	-.161**	.008
Waist circumference (cm)	226	-.054	.422
Hip circumference (cm)	226	.151*	.023
WHR	226	.115	.084

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

As observed from the above table weight, BMI and hip circumference were negatively correlated with age at menarche which was statistically significant. Whereas there was negative correlation found between waist circumference and age at menarche but it was not statistically significant. WHR showed positive correlation with age at menarche with less statistical significance. Thus, overall we can say that weight and thereby BMI showed negative impact on age at menarche i.e. higher the weight and BMI of a girl lower is her age at menarche. Our findings are substantiated by some of the literature which is reviewed.

A survey on physical measurements of youth in 2005 showed that the group that experienced menarche between the ages of 11 and 13 had greater height, weight, and BMI than those of the group that did not experience menarche during those ages (Kim JY, Oh IH, 2010). A study using National Health and Nutritional Examination Survey 2005 also found that the

group that experienced menarche had greater BMI than the group that did not, even after adjusting for age (Cho GJ, Park HT, 2010). In Korea, the continuous decline of the age at menarche and increase in BMI among adolescents suggest that the earlier age at menarche may be associated with increase in BMI, which is a surrogate indicator of body fat percentage (%) (Ku SY, Kang JW, 2006; Cho GJ, Park HT, 2010).

Kirchengast and Bauer, (2007) have similarly suggested that, girls who achieved menarche at an early age are significantly taller and heavier than their non menarcheal counterparts even between the ages of 11-14years but height observations in our study population did not show any effect on age at menarche.

Assessment of Body Composition for the study population:

Body composition was assessed using BIA principle with the help of Tanita body composition analyzer. Given Below are the mean ± SD figures for various parameters tested in both the population groups (Table 8).

Table 8: Comparison of various Body Composition parameters of both groups

Parameter Tested	AM Mean ± SD	N	PM Mean ± SD	N
Fat (%)	26.016 ± 8.70	370	21.191 ± 9.45	1647
Fat Mass (kg)	12.322 ± 6.55	370	8.412 ± 5.56	1647
Fat Free Mass (kg)	32.119 ± 4.06	370	28.228 ± 4.52	1647
Muscle Mass (kg)	30.334 ± 3.66	370	26.677 ± 4.18	1647
Total Body Water (kg)	23.667 ± 3.21	370	20.678 ± 3.31	1647
Total Body Water (%)	54.125 ± 6.32	370	57.792 ± 6.30	1647

It is evident from the above table all the body composition parameter except total body water percentage (TBW %) were higher in AM group compared to PM group. The theory of Frisch and Revelle (1970) also suggest that menarcheal age is related to attainment of appropriate weight for reproduction rather than appropriate skeletal status. During adolescence, usually from 10 to 15 years, a girl grows by 9.25 inches and gains 46 pounds. This weight gain is mainly caused due to changes in body composition.

Correlation between various body composition parameters and age at menarche was tested using Karl Pearson's coefficient of correlation. Following results were obtained (Table 9):

Table 9: Correlation between Age at Menarche with Body Composition Parameters

Parameters Tested	**Pearson Correlation**		
	N	**Pearson Correlation Coefficient**	**Sig. (2-tailed)**
Fat (%)	274	-.206**	.001
Fat Mass (kg)	274	-.184**	.002
Fat Free Mass (kg)	274	-.005	.933
Muscle mass (kg)	274	-.032	.595
Total Body Water (kg)	274	-.023	.700
Total Body Water (%)	274	.208**	.001

It was observed that fat percentage and fat mass was negatively correlated with age at menarche which was found to be statistically significant at 0.01 levels. Fat free mass, muscle mass, TBW (kg) were weakly negatively correlated whereas TBW (%) was positively correlated with age at menarche which was found to be statistically significant at 0.01 levels. There are some studies which are in agreement with this finding. Siervogel (2003) has shown that greater TBF, FFM and body fat higher in girls with an earlier age of menarche and onset of puberty than their later-maturing peer and acquiring an optimum amount of body fat and

body weight is essential for the sexual maturation of the individual which is an important factor for onset of menses (Matkovick, 1994).

Along with TBF distribution of fat in the body is very important. Our findings on WHR and waist circumference did not substantiate the significance of this fact but hip circumference of the study population was significantly negatively correlated with age at menarche. Thus indicating higher the fat storage in the body there is earlier maturity resulting into early menarche. This study also suggested that while the total estimated amount of body fat and weight are not significant predictors of menarche when added to skeletal growth, the distribution of body fat, as indicated by the relative amounts of upper-body and lower-body fat, is significantly .related to menarche, especially in young women who reach this reproductive landmark with unusually low levels of total body fat. This suggests that body fat distribution may influence the timing of menarche although, alternatively, there may be a pubertal mechanism that increases lower-body fat deposition concurrent with or after menarche (Lassek, 2006).

Age at Menarche and Nutrient Intake:

Nutrition has always been considered a major influential factor in pubertal growth period. Not only the quantity but also quality of food intake is found to be influencing puberty (Berkey et al, 2000). Nutrition intake and storage during childhood may influence the timing of menarche through hormones such as leptin, insulin and growth factors such as Insulin-like Growth Factor I (IGF-I), all of which are involved in the regulation of growth and maturation (Parent A.S. et al, 2003).

Nutritional status and body weight play a vital role in the timing of pubertal development in female adolescents (Bau A.M.et al 2009; Davison K.K.et al 2003; Slyper A.H.2006).

Adolescents gain 50% of adult weight and more than 20 % of their adult height during this period (Bharati P, Bharati S., 1998). It has been suggested that decrease in the age at menarche until the mid-1960s resulted from “positive” changes, such as better nutrition, whereas decreases since that time are related to “negative” changes, such as overeating and decreased physical activity (Paula J.W. et al 2008). Kulin H.E. et al (1982) compared between 342 privileged, urban children and 347 impoverished rural adolescents in Kenya and found that chronic malnutrition leads to a delay in menarche of girls by 2.1 years. This could be attributed to the effects of chronic malnutrition in the first decade of life leading to stunting as the mean height differences of 7.4 cm was found in both the groups in their pre pubertal stages in spite of catch up growth in early years.

In the present study information data regarding nutrient intake was collected only from 1223 subjects out of the total study population of 2017 subjects, using the 24-hr dietary record. The carbohydrate, protein, fat and total energy intake were calculated using the food value tables (ICMR, 2009). The mean intake of the above-mentioned nutrient intakes are presented in Table 10:

Table 10: Mean Nutrient Intake for both groups

Nutrients	AM group		PM Group	
	N	Mean ± SD	N	Mean ± SD
Energy (kcal)	212	1215 ± 297.46	1011	1320 ± 267.78
Carbohydrates (gm)	212	167.81 ± 49.92	1011	179.51 ± 42.60
Proteins (gm)	212	36.24 ± 10.53	1011	39.49 ± 10.33
Fats (gm)	212	50.03 ± 17.63	1011	51.39 ± 13.85

As observed from the above Table 10, mean intakes of all the nutrients are notably higher in the PM group compared to AM group. Thus it appears that perimenarcheal girls were better nourished.

Analysis of the data of the present study population showed statistically significant correlation of energy (p value < 0.01) and fat intake (p value < 0.05) with age of onset of menarche suggesting role of energy dense and fat rich foods in impacting menarcheal age through modulation of body composition.

Table 11: Correlation between Age at Menarche and Nutrient Intake

Nutrients	Pearson Correlation		
	N	Pearson Correlation Coefficient	Sig. (2-tailed)
Energy (kcal)	169	.201**	.009
Carbohydrates (gm)	169	.095	.219
Proteins (gm)	169	.091	.241
Fats (gm)	169	.160*	.038

The mean fat intake of the study population was much higher than the RDA prescribed by the Expert Group of the Indian Council of Medical Research 2009 .i.e. approximately 35 – 45 grams / day indicating that visible dietary fat contributed to a substantial contribution to the overall energy intake throughout the day.

Studies have shown that delayed menarche is a sign of malnutrition and as nutritional status improves, the age at menarche is lowered drastically (Abioye-Kuteyi, 1997; Acharya, 2006). Under nutrition subsequently leading to poor health have been considered as reason for the late onset of menarche as well, late onset of menarche can be attributed to low dietary intake of carbohydrate fats and proteins and overall poor health (John, 2008). Meyer et al (1990) reported that higher dietary energy intake was associated with earlier menarche.

Some studies in the past have also shown, to the contrary, that higher intakes of carbohydrate in girls aged 6–15 y were associated with a later timing of menarche.(Kissinger, 1997 ;Cheng, 2010.)

Studies have also reported that non vegetarians tend to attain menarche at an early age as compared to vegetarians (Bagga.A and Kulkarni 2000). According to Gunther (2009) higher total protein intake in girls is associated with the early attainment of menarche. Some other researchers have suggested that greater intake of milk or milk-related nutrients such as calcium, protein, or fat have contributed to earlier menarche. (Chevalley, 2005; Berky 2000) June(2003) suggested that milk may be related to its contribution to somatic growth and other mechanisms related to reproductive maturation or it may act via a common pathway such as IGF1 pathway as IGF is involved in somatic growth and reproductive maturation. Our study could not generate findings which are substantiating this theory. The reason could be lack of authenticity in reporting dietary information as well as lack of repetitive attempts to collect this data by the researchers. It would therefore be worthwhile to study the dietary intake in greater detail using a 3 or 7 day food record validated by a food frequency questionnaire to obtain a better insight in this aspect.

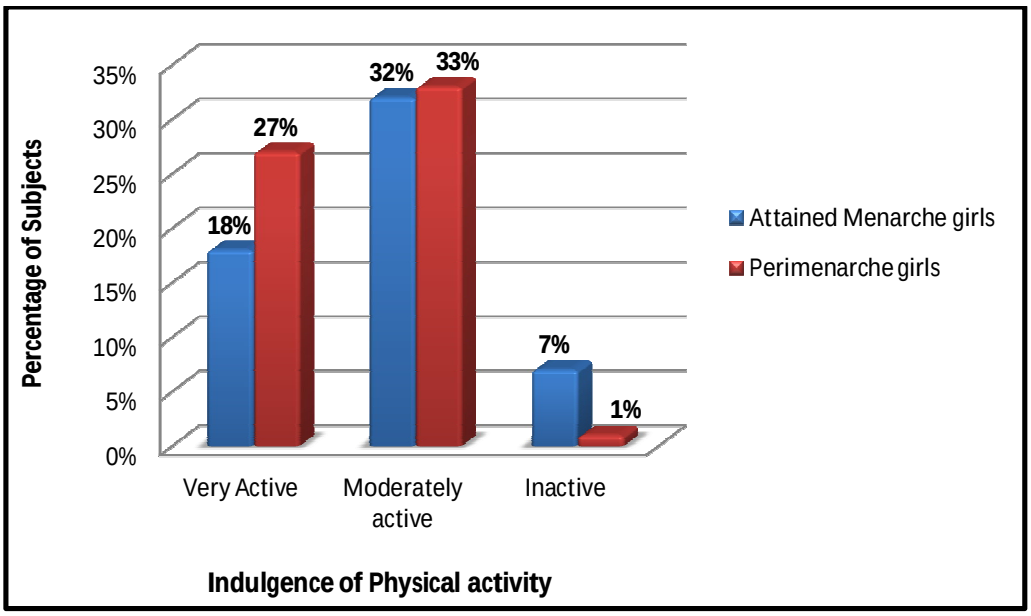
Physical Activity:

Even though there is an important role of nutritional intake in modulating body composition and thereby age at menarche, physical activity is also very important factor for this modulation. Individuals indulging in regular physical activity show optimum fat mass along with lean body mass and are in good physique. Physical activity and menarche are as much connected as the other factors. Too less physical activity leads to increased fat percent in the body that result in early menarche, where as it appears later in excessive activity. Vigorous

physical training causes amenorrhea and is found to be associated with delayed menarche (Frisch R.E.1984, Bernstein L et al 1987).

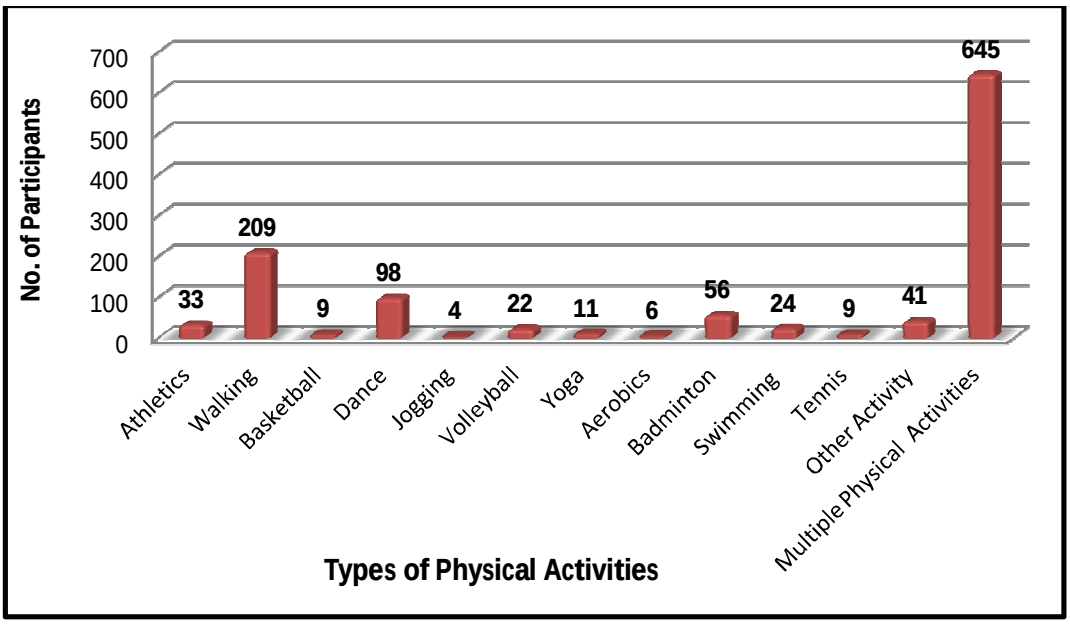
When physical activity of our study population was recorded, based on the response obtained from participants from both groups it was observed that overall 8% were totally inactive. In both groups more or less equal (32 -33 %) girls were moderately active but percentage of very active girls in PM group was much higher (27%) than (18%) in AM group (Figure 10)

Figure 10: Indulgence in Physical Activity



Majority of the girls were found to be indulging in multiple activities followed by walking and then dance. Number of students in other sport or physical activities was comparatively less (*Figure 11)*.

Figure 11: Type of Physical Activity



When duration and frequency of physical activity was tested, it was observed that duration as well as frequency was better observed in PM group compared to AM group (Figure 12).

***Figure 12*:** Duration of Physical Activity

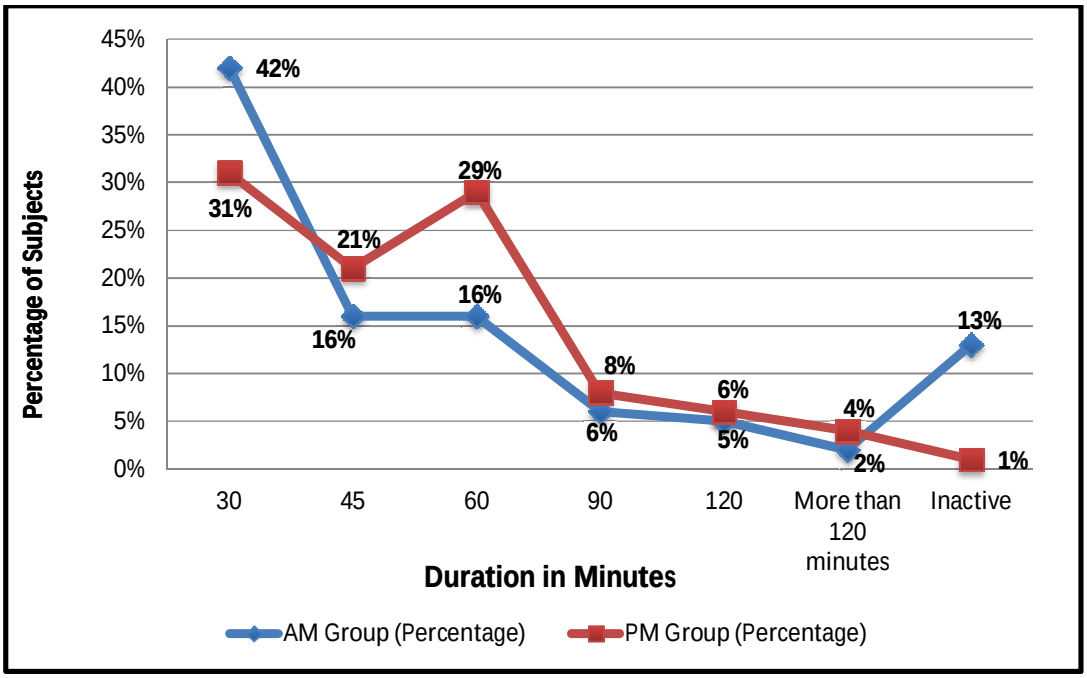
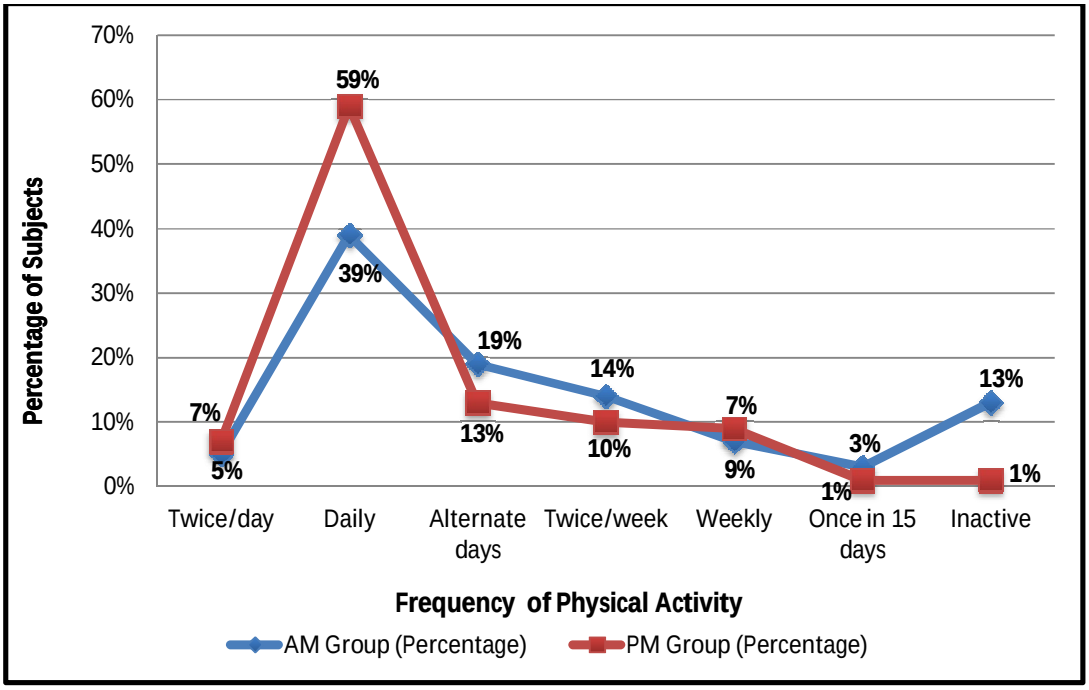


Figure13: Frequency of Physical Activity



Physical activity index was developed for purpose of calculating total amount of activity of the study group for the whole day. This was cumulative score of intensity factor (depending on the type of activity) *duration*frequency. The means of the physical activity index of both groups were as follows (Table 12):

Table 12: Mean Physical Activity Index of both groups

Parameter tested	AM group		PM Group	
	N	Mean ± SD	N	Mean ± SD
Physical Activity Index	205	15.22 ± 17.32	1003	23.16 ± 22.27

As is evident from the table, mean physical activity index of PM group is much higher than AM group. Or to put it in different words girls indulging in more physical activity reach their menarche later. When these means of two groups were statistically tested there was

statistically significant difference with p value .000 which is significant at .01 level (Table 13).

Table 13: Correlation of Physical Activity Index of both groups

Parameter tested	**Levene's Test for equality of Variances**		**Pearson Correlation**		
	F	Sig.	t	df	Sig. (2-tailed)
Physical Activity Index	14.603	.000	-4.814	1206	.000

Our findings are in congruence with many studies conducted in the past in this field. A cross sectional study performed in a group of Colombian university women demonstrated that age at menarche was positively associated with the practice of at least 2 hours daily physical activity (Chavarro J, 2004).

Moison et al (1991) observed that participation in dance, ballet, gymnastic figure skating, synchronized swimming and diving competition had lower risk of reaching menarche at an early age. Menarche on an average occurs later in athletes, including ballet dancers, than in general population, with the exceptions of swimmers, suggesting that intense exercise delays puberty (Warren, 1980; Frisch et al., 1981). 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 (Karapanou O. & Papadimitriou A., 2010).

The delay in menarche is observed as secondary amenorrhoea may continue throughout the teenage years as long as strenuous physical activity continuous (Frisch et al., 1980; Warren 1980; Frisch et al., 1981; Wakat et al., 1982). Rigorous physical activity delays the age at menarche and therefore lowers the risk of breast cancer and of reproductive cancer (Frisch et

al., 1985). However such rigorous activity also increases susceptibility to reduced bone density (Cann et al., 1984; Drinkwater et al., 1984).

Merzenish et al (1993) noted that the increased sport activity is associated with delay in the age at menarche. It may be the vigorous exercise, intense physical and mental stress which delays the menarche. Girls who undergo regular daily training before and after menarche come to lose the balance in the ratio of body weight to fat, and that the excessive physical and mental stress from regular training in female athletes tends to cause delayed menarche. (Malina, 1983)

The age at menarche differs in athletes and non-athletes. Malina et al (1973) found that mean age at menarche for athletes was significantly higher (13.58years) as compared to that of controlled group (12.23 years). Also Malina et al (1978) noted that college athlete's attained menarche significantly later than non-athletes and various groups' of national and Olympic athlete's attained menarche significantly later than high school and college athletes.

Sidhu and Grewal (1980) observed a significant difference between the mean age at menarche in Indian sports women (n=264) (15.21 years) and control samples (n=108) (14.05 years). These studies substantiate the findings of Malina et al (1978) that there is a possibility of different maturity relationships for different sports and competitive levels among women athletes of different countries.

Girls who indulge in moderate physical activity, averaging more than 600 kcal of energy expenditure in activity per week through participation in two or more hours per week in activities like aerobic exercise classes, swimming, jogging or tennis, are significantly more likely than less active girls to have a normal menarcheal age and less risk for breast cancer (Bernstein L et al.1987)

Maternal Menarcheal age:

Menarche or first menstrual period is a landmark in reproductive life span and it is the most prominent change of puberty which shows successful reactivation of hypothalamic-pituitary-gonadal axis, leading to sexual maturation (Ebling FJ, 2005). Several studies have indicated that the time of menarche can be under the influence of genes as well as individual environmental factors interacting with genetic factors (Loesch DZ et al, 1995; Palmert MR, Hirschhorn JN, 2003; Meyer JM et al, 1991).

The factors related to heredity comprise of the genetic composition and the maternal age at menarche. Study done by Ong et al (2007) have found that mother's age at menarche in turn predicts her offspring's infancy growth rate and daughter's menarche provide some important insights into the trans generational influences on childhood growth.

Mother's age of menarche seems to be a better predictor of daughter's age of menarche than socioeconomic, contextual stressors such as mother's education, age at first marriage, and employment status of mother and/or current husband (Campbell & Udry, 1995). Because early menarche is associated with early sexual intercourse and consequent single motherhood, it may be that mothers predisposed to raise children without a biological father in the home genetically transmit an early menarcheal age to their daughters (Caspi, 1998; Surbey, 1990).

The developmental event of a daughter's menarche (first menstrual period) is an early adolescent transition that is most commonly addressed by mothers in families where mothers are present (Carlson & Wilson, 1994; Costos, Ackerman & Paradis, 2002; Kalman, 2003).

Data was collected from mothers of girls from AM group about their age at menarche. Following table gives the mean maternal age at menarche:

Table 14: Means of Mothers Age at Menarche and Daughters Age at Menarche

Parameter tested	AM group		PM Group	
	N	Mean ± SD	N	Mean ± SD
Mothers age at menarche (year)	212	13.48 ± 1.36	1012	13.72 ± 1.55
Daughters age at menarche (year)	205	12.16 ± 1.13		

The Karl Pearson's correlation coefficient showed that there is no statistically significant effect of mothers' age at menarche on their daughters' age at menarche (Table 15).

Table 15: Correlation of Mothers Age at Menarche with Daughters Age at Menarche

Parameters tested	Pearson Correlation		
	N	Pearson Correlation Coefficient	Sig. (2-tailed)
Mothers age at menarche	169	.070	.368

Results of Discriminant Analysis:

Efforts were made to classify the anthropometric as well as body composition analysis data as per the chronological age of the study population. The following four tables show the age wise data collected (Refer to Table 16, 17, 18, 19).

Table 16: Group statistics -Age 10

Parameters tested	AM Group		PM Group	
	N	**Mean ± SD**	**N**	Mean SD
Anthropometric Profile				
Height (cm)	16	145.75± 6.4	330	138.49 ± 6.3
Weight (kg)	16	40.35 ± 7.35	330	32.60 ± 7.5
BMI (kg/m^2)	16	19.47 ± 3.2	330	16.87 ± 3.10
Waist circm. (cm)	14	70± 7.9	182	61.9 ± 11.5
Hip circm. (cm)	14	86.32 ± 6.6	182	75.07 ± 12.9
WHR	14	.81 ± .05	182	.82 ± .04
Body Composition Parameters				
Fat (%)	16	22.62 ± 7.9	330	20.422 ± 8.2
Fat mass (kg)	16	11.18 ± 5.6	330	7.2 ± 4.6
FFM (kg)	16	30.41 ± 3.9	330	25.40 ± 3.4
Muscle mass (kg)	16	28.69 ± 3.6	330	24.03 ± 3.22
TBW (kg)	16	22.26 ± 2.8	330	18.62±2.5
TBW (%)	16	54.45 ± 5.8	330	58.31±6.1

Table 17: Group statistics -Age 11

Parameters tested	AM Group		PM Group	
	N	**Mean ± SD**	**N**	**Mean SD**
Anthropometric Profile				
Height (cm)	51	150 ± 6.7	531	143 ± 7.36
Weight (kg)	51	44.52 ± 9.07	531	36.32 ± 8.8
BMI (kg/m^2)	51	19.74 ± 3.38	531	17.53 ± 3.38
Waist circm. (cm)	25	70.48 ± 7.07	362	62.45 ± 8.51
Hip circm. (cm)	25	87.9 ± 7.49	362	77.51 ± 9.45
WHR	25	.80 ± .04	362	.80 ± .05
Body Composition Parameters				
Fat %	51	27.40 ± 8.97	531	21.39 ± 8.84
Fat mass (kg)	51	12.92 ± 6.66	531	8.51 ± 5.59
FFM (kg)	51	31.21 ± 4.47	531	27.86 ± 4.14
Muscle mass (kg)	51	29.91 ± 3.36	531	26.33 ± 3.83
TBW (kg)	51	23.32 ± 2.75	531	20.39 ± 3.05
TBW (%)	51	53.22 ± 6.73	531	57.51 ± 6.46

Table 18: Group statistics -Age 12

Parameters tested	AM Group		PM Group	
	N	**Mean ± SD**	**N**	**Mean SD**
Anthropometric Profile				
Height (cm)	138	151 ± 6.21	527	146 ± 7.36
Weight (kg)	138	44.97 ± 9.69	527	38.28 ± 9.92
BMI (kg/m^2)	138	19.58 ± 3.57	527	17.74 ± 3.87
Waist circm. (cm)	97	67.38 ± 7.65	345	63.76 ± 7.69
Hip circm. (cm)	97	85.33 ± 8.13	345	78.84 ± 8.53
WHR	97	.79 ±.046	345	.80 ± .058
Body Composition Parameters				
Fat %	138	26.29 ± 9.01	527	21.35 ± 8.75
Fat mass (kg)	138	12.64 ± 6.68	527	8.90 ± 5.93
FFM (kg)	138	32.33 ± 3.94	527	29.42 ± 4.56
Muscle mass (kg)	138	30.49 ± 3.67	527	27.79 ± 4.19
TBW (kg)	138	23.67 ± 2.89	527	21.55 ± 3.32
TBW (%)	138	53.84 ± 6.40	527	57.64 ± 6.41

Table 19: Group statistics -Age 13

Parameters tested	AM Group		PM Group	
	N	**Mean ± SD**	**N**	**Mean SD**
Anthropometric Profile				
Height (cm)	118	151 ± 6.46	193	148 ± 7.03
Weight (kg)	118	44.58 ± 9.69	193	38.24 ± 7.92
BMI (kg/m^2)	118	19.51 ± 4.27	193	17.23 ± 2.97
Waist circm. (cm)	92	68.62 ± 8.33	136	64.72 ± 7.63
Hip circm. (cm)	92	84.97 ± 8.51	136	79.22 ± 7.39
WHR	92	.81 ± .058	136	.81 ± .063
Body Composition Parameters				
Fat %	118	25.69 ± 8.21	193	21.21 ± 13.86
Fat mass (kg)	118	12.14 ± 6.39	193	8.29 ± 4.86
FFM (kg)	118	32.43 ± 4.04	193	29.87 ± 3.97
Muscle mass (kg)	118	30.58 ± 3.74	193	28.24 ± 3.64
TBW (kg)	118	23.99 ± 3.82	193	21.90 ± 2.89
TBW (%)	118	54.39 ± 6.01	193	58.34 ± 5.57

As seen from the means of all the anthropometric and body composition parameters it is evident that all these parameters were found to be higher in girls who had already attained menarche at the respective ages compared to their peers who had yet to attain menarche. Thus, theories proposed by various researchers already put forth by us in review of literature and at other places are proved correct through our findings also. Early maturing girls not only

have higher height and body weight but their fat mass lean body mass with fat percentage and overall body water percentage are substantially higher than the girls who mature late and reach this important landmark of menarche later.

When this age wise data was statistically analyzed using t-test for equality of means, following results are obtained which are depicted in the following two tables (Refer to Table 20 and Table 21):

Table 20: t-test for equality of means for effect of Chronological Age on Anthropometry

Parameters tested	**t-test for equality of means**	**Age in Years**			
		10 yrs	**11 yrs**	**12 yrs**	**13 yrs**
Height (cm)	t	4.496	6.144	6.763	3.471
	df	344	580	663	309
	Sig. (2-tailed)	.000	.000	.000	.001
Weight (kg)	T	3.997	6.277	7.086	6.279
	df	344	580	663	309
	Sig. (2-tailed)	.000	.000	.000	.000
BMI (kg/m^2)	t	3.268	4.457	5.059	5.531
	df	344	580	663	309
	Sig. (2-tailed)	.001	.000	.000	.000
Waist circumference (cm)	t	2.572	4.601	4.100	3.645
	df	194	385	440	226
	Sig. (2-tailed)	.011	.000	.000	.000
Hip circumference (cm)	t	3.203	5.405	6.685	5.409
	df	194	385	440	226

	Sig. (2-tailed)	.002	.000	.000	.000
WHR	t	-.887	-.455	-3.091	-1.216
	df	194	385	440	226
	Sig. (2-tailed)	.376	.649	.002	.225

***Table 21*:** t-test for equality of means for effect of Chronological Age on Body Composition parameters

Parameters tested	**t-test for equality of means**	**Age in Years**			
		10 yrs	**11 yrs**	**12 yrs**	**13 yrs**
Fat (%)	t	2.458	4.627	5.871	3.186
	df	344	580	663	309
	Sig. (2-tailed)	.014	.000	.000	.002
Fat mass (kg)	t	3.261	5.279	6.419	5.991
	df	344	580	663	309
	Sig. (2-tailed)	.001	.000	.000	.000
FFM (kg)	t	5.610	5.477	6.869	5.450
	df	344	580	663	309
	Sig. (2-tailed)	.000	.000	.000	.000
Muscle mass (kg)	t	5.608	6.425	6.884	5.451
	df	344	580	663	309
	Sig. (2-tailed)	.000	.000	.000	.000
TBW (kg)	t	5.514	6.589	6.843	5.479
	df	344	580	663	309

	Sig. (2-tailed)	.000	.000	.000	.000
TBW (%)	t	-2.478	-4.507	-6.208	-5.878
	df	344	580	663	309
	Sig. (2-tailed)	.014	.000	.000	.000

As is seen from the data, except WHR all other parameters of anthropometry are very significantly correlated with chronological age. This interpretation is based on the foundation that the significance value in all other parameters except WHR is so low that it is displayed as .000 meaning close relationship between two variables.

So far as body composition is concerned above findings hold true for all other parameters which are highly significant at 0.01 level. But fat % and total body water % are not highly significant statistically. Thereby suggesting that probably at that age these two parameters do not have major effect in body composition modulation compared to other parameters.

Thus, to conclude the present study has tried to explore various determinants of age at menarche in the Indian population specifically the school girls from Maharashtra. In our study population positive effect of various factors such as anthropometry, body composition, dietary intake and physical activity was observed which was proved with appropriate statistical tests resulting in high statistical significance. Our findings are suggesting that girls who mature early, who are well nourished and who do not indulge into heavy physical activity attain their menarche earlier. Effect of heredity which was assessed through correlating maternal menarcheal age with daughters' menarcheal age could not be substantiated due to lack of statistical significance in these two variables.

SUMMARY AND CONCLUSION

Through this major research project an endeavour has been made to study the effect of various factors such as anthropometry, body composition, dietary intake and physical activity of girls on their age at menarche. The study started with 2500 school girls from Mumbai and Pune city who were selected for the preparatory talk as an initial part. Based on their willingness to participate and availability in the school on the day when data collection was done and consent from parents' finally 2,017 students actually participated in the study. Out of the total number, 370 students had attained menarche (AM) in the recent period when they were recruited for this study whereas 1,647 girls had not attained menarche meaning they were perimenarcheal (PM) at the recruitment.

Following tools were used to collect data:

- General questionnaire to collect information on age of the subjects, medical history, maternal menarcheal history and information related to subject's physical activity.
- Assessment of anthropometric measurements such as height, weight, waist and hip circumference and WHR
- Body Composition analysis with the help of Body composition analyzer using BIA principle
- Food Frequency Questionnaire and 24 hr Dietary record

Following conclusions were derived based on results obtained:

- The study population constituted from 5^{th} to 9^{th} standard with mean age of 11.59 yrs ± 1.114.
- The total number of girls who had attained menarche was 370. Their mean age was12.35 yr ± 1.009 whereas the total number of girls in the perimenarchel group was 1647 with the mean age 11.42 yr ± 1.065.

- The mean age at menarche of the sample (n=274) was 12.16 yrs ± 1.132. 143 out of 274 (52.18%) girls had attained menarche before they were 12 yrs of age. This is a significant finding which substantiates the changing trend in today's Indian society so far as lowering of menarche is concerned. Out of the total population 10% of the girls had attained menarche when they were just 11 yrs of age. This is very concerning.
- As observed from the data all the anthropometric parameters were higher in the AM group as compared to PM group except WHR which was found to be almost similar in both the groups.
- When age at menarche was statistically correlated with anthropometric measurements weight (p= .038), BMI (p= .008) and hip circumference (p= .023) there was negative correlation of these parameters with age at menarche which was statistically significant. Whereas there was negative but weak correlation found between waist circumference and age at menarche. WHR showed positive correlation with age at menarche with less statistical significance. Thus, overall we can say that weight and thereby BMI showed negative impact on age at menarche i.e. higher the weight and BMI of a girl earlier is her attainment of menarche.
- Body composition was assessed using BIA principle with the help of Tanita body composition analyzer (model MA 420). All the body composition parameter except total body water percentage (TBW %) were higher in AM group compared to PM group. It was observed that fat percentage and fat mass was negatively correlated with age at menarche which was statistically significant at 0.01 levels. Fat free mass, muscle mass, TBW (kg) were weakly negatively correlated whereas TBW (%) was positively correlated with age at menarche which was statistically significant at 0.01 levels.

- Nutritional status and body weight play a vital role in the timing of pubertal development in female adolescents thereby impacting age at menarche. In the present study information data regarding nutrient intake was collected only from 1223 subjects out of the total study population of 2017 subjects, using the 24-hr dietary record. The mean intakes of all nutrients were notably higher in the PM group compared to AM group. Thus it appears that perimenarcheal girls were better nourished. Statistically significant correlation of energy (p value < 0.01) and fat intake (p value < 0.05) with age of onset of menarche was found, suggesting role of energy dense and fat rich foods in impacting menarcheal age through modulation of body composition. In addition the mean fat intake of our study population was much higher than the RDA.
- Physical activity is also very important factor for modulation of body composition thereby connecting it to menarche. Too less physical activity leads to increased fat percent in the body that result in early menarche, where as it appears later in excessive activity. Observations on physical activity revealed that overall 8% were totally inactive. In both groups more or less equal (32 -33 %) girls were moderately active but percentage of very active girls in PM group was much higher (27%) than (18%) in AM group. The mean physical activity index of PM group was much higher than AM group. Girls who were indulging in more physical activity reached their menarche later. There was statistically significant difference in the means of physical activity index with p value .000 which is significant at .01 level.
- Data was collected from mothers of girls from AM group about their age at menarche. The karl pearsons correlation coefficient showed that there was no statistically significant effect of mothers age at menarche on their daughters age at menarche (p=.368).

- Anthropometric and body composition analysis data was classified as per the chronological age of the study population. It was seen that all these parameters were higher in girls who had already attained menarche at the respective ages compared to their peers who had yet to attain menarche. Thus, theories proposed by various researchers already put forth by us are proved correct through our findings also. Early maturing girls not only have higher height and body weight but their fat mass, lean body mass, with fat percentage and overall body water percentage are substantially higher than the girls who mature late and reach this important landmark of menarche later. When this age wise data was statistically analysed using t-test for equality of means it was seen that except WHR all other parameters of anthropometry were very significantly correlated with chronological age with p value very close to .000. Above findings hold true for all body composition parameters which are highly significant at 0.01 level except fat and total body water % which were not highly significant statistically.

Thus, to conclude the present study has tried to explore various determinants of age at menarche in the Indian population specifically the school girls from Maharashtra. In our study population positive effect of various factors such as anthropometry, body composition, dietary intake and physical activity was observed which was proved with appropriate statistical tests resulting in high statistical significance. Our findings are suggesting that girls who mature early, who are well nourished and who do not indulge into heavy physical activity attain their menarche earlier. Effect of heredity which was assessed through correlating maternal menarcheal age with daughters' menarcheal age could not be substantiated due to lack of statistical significance in these two variables.

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APPENDIX – B

Letter of Informed Consent

To,

Respected Madam,

Here with I introduce myself as Dr. Leena Raje, PhD. in Foods and Nutrition. I have been working as a Vice-Principal in Smt. SPN Doshi Women's College, Ghatkopar for the past 25 years. During this tenure I have undertaken many research projects with sponsorship from UGC. The areas of my interest have been Health of girl child and its betterment, Anemia and its prevention, Food habits of adolescent girls and its impact on pregnancy outcome, Physical activity of girls and changes in their body composition impacting future health etc. Being an administrator as well as a teacher I have worked with girl students closely and therefore have constantly observed some common health related problems faced by them. My experience so far has created deep interest in the area of "women health" which is of great social relevance today. Presently I have taken up a major research project under UGC sponsorship titled "The peri-menarcheal weight gain patterns/ body composition and its correlation to age of menarche; maternal anthropometric profile"

This study is being undertaken to assess the body fat percentage as well as muscle and fat percentage in school-going girls along with their food habits since these parameters have an influence on the age at menarche. Age at menarche is important from the point of view of future reproductive health as various research studies have shown that girls maturing early are at risk of diseases such as breast cancer, cardiovascular diseases, diabetes, etc. Hence through this study we want to establish present age at menarche of Indian girls and effect of various factors on it. A renowned gynecologist and a statistician are part of this study. Through this study girls body composition will be assessed using a hi-tech specialized instrument. The cost of the assessment will be entirely borne by the researchers. The findings of this project will not only make the girls and their parents aware about their body and health profile in their recent future but will also give them insight about how to remain healthy, eat balanced diet and thereby to perform to their maximum potential.

This study will involve data collection from over 2000 students. Some of them will be selected from your institution. We want to clarify that no incidental expenses will be paid to the volunteer for participating in the study. The present study has been reviewed and approved by the Ethics Committee of Kasturba Gandhi Hospital, Ville Parle as per the government guidelines. Participation in this study is entirely voluntary but is immensely beneficial to the girls. Hence I request you to encourage maximum participation.

We are looking forward to your kind co-operation for the smooth conduct of this project. The logistics of the study are attached herewith.

Thanking You,

Dr. Leena Raje

Logistics:

1. 1st meeting with the students(5th to 9th standards Girls only) :
   Preparatory talk followed by Pre-questionnaire (screening)

2. 2nd meeting with the selected students :
   Peri menarcheal questionnaire and Body Composition analysis with height and weight assessment

3. 3rd meeting with the mothers:
   Filling up of Consent forms, general questionnaire and Food frequency questionnaire and distribution of 24 hour diet record

4. Collection of forms.

   - Girls initially not enrolled for the study as they had not attained menarche will be followed up and enrolled as soon as they attain their menarche.

APPENDIX – C

PRE-QUESTIONNAIRE (for Screening)

Name: _____

DOB: _____/_____/_____ Age: _____ yr

Name of the School: _____

Standard: _____ Division: _____

Contact no: _____

Please answer the following questions by putting a tick in the checkbox.

1. Have you started periods/menses?

Yes ☐

No ☐

2. When did you start your periods?

Date: _____ Month: _____ Year: _____

APPENDIX – D

Informed Consent

Part A

Dear Parent,

I Dr. Leena Raje, PhD. in Foods and Nutrition have been working as a Vice-Principal in Smt. SPN Doshi Women's College, Ghatkopar for the past 25 years. Being an administrator as well as a teacher I have worked with girl students closely and therefore have constantly observed some common health related problems faced by them such as anemia, problems related to menstruation as well as body weight and composition. All these problems are diet related and have lot of influence on academic performance and well being of a child. My experience so far has created deep interest in the area of "women health" which is of great social relevance today. Presently I have taken up a major research project under UGC sponsorship titled "The peri-menarcheal weight gain patterns/ body composition and its correlation to age of menarche; maternal anthropometric profile"

This study is being undertaken to assess the body fat percentage as well as muscle and fat percentage in school-going girls along with their food habits since these parameters have an influence on the age at menarche. Age at menarche is important from the point of view of future reproductive health as various research studies have shown that girls maturing early are at risk of diseases such as breast cancer, cardiovascular diseases, diabetes, etc. Hence through this study we want to establish present age at menarche of Indian girls and effect of various factors on it. A renowned gynecologist and a statistician are part of this study. Through this study girls body composition will be assessed using a hi-tech specialized instrument. The cost of the assessment will be entirely borne by the researchers. The findings of this project will make you aware about your daughter's body and health profile in their recent future. We will also give them insight about how to remain healthy, eat balanced diet and thereby to perform to their maximum potential.

The present study has been reviewed and approved by the Ethics Committee of Kasturba Gandhi Hospital, Ville Parle as per the government guidelines. Participation in this study is entirely voluntary but is immensely beneficial to the girls hence we recommend that you participate with your daughter in this study. We will have 1 session with you and 2 sessions during school periods with your daughter in the school premises on a pre specified day.

We are looking forward to your kind co-operation for the smooth conduct of this project.

Thanking You,

Dr. Leena Raje
(Principal Investigator)

Part B

I have been invited to participate in research conducted by Dr. (Mrs.) Leena Raje and her colleagues. I understand that it will involve collection of information about frequency of the consumption of variety of the foods and measurement of height, weight, waist and hip circumference and the menstrual details. I have been provided with the name and contact of the researcher who can be easily contacted. I have read the foregoing information, or it has been read and informed to me. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction.

With full knowledge of all these details, I agree to me and my daughter's participation in this study.

Participant Name: _____

Participant Signature: _____

Parent's/guardian's Name: _____

Parent's/guardian's Signature: _____

APPENDIX – E

Invitation for the Meeting

Date: _____

Respected Mothers,

As you are already aware we have enrolled your daughter as one of the participant in our research study. This study is going to benefit your daughter in many ways. You will get an insight into your daughter's health/reproductive profile along with diet, physical well being and academic excellence. To be able to achieve these benefits we would like to interact with you and hence invite you for a meeting for an hour.

Date:

Time:

Venue:

During this meeting we intend to complete the following:-

1. Briefing of the Research and clarification of doubts
2. Collection of information
3. Your weight and height measurements

We thereby request you to attend the meeting and kindly co-operate for the smooth conduct of this project.

In case the schedule of the meeting is not convenient to you kindly get back to us on the following number so that alternative arrangements can be made.

Contact no. 9970042594 (Ms. Devaki Gokhale)

Thanking You,

Dr. Leena Raje

APPENDIX – F

GENERAL QUESTIONNAIRE

Name of the student: _____

Date of birth: _____ Age: _____ yrs

Std: _____ Div: _____

Residential address : _____

_____

Telephone/ Mobile number: _____

Email Id: _____

Occupation of father: Service ☐ Business ☐

Occupation of mother: Service ☐ Business ☐ Homemaker ☐

Monthly family income: Below Rs. 15,000/- ☐

Rs. 15,000/- to less than Rs, 25,000/- ☐

Rs. 25,000/- to less than Rs.50, 000/- ☐

Rs. 50,000/- to less than Rs.75, 000/- ☐

Above Rs. 75,000/- ☐

Is there a family history of: Diabetes Mellitus ☐ Hypertension ☐

Obesity ☐ Thyroid Disorder ☐

Any other, please specify: _____

(Restrict your answer up to one generation)

Please enter your daughters known medical problems in the table below along with the medications including insulin, Over-The Counter Medication, Vitamin and Mineral Supplement, Herbal Preparations etc.

Type of Medical problem	Duration in months/years	Prescribed Medicines

Q. 1 Record of your daughter's menstrual details:-

a) Age of appearance of first menstruation-

9 yrs ☐ 10 yrs ☐ 11 yrs ☐ 12 yrs ☐ 13 yrs ☐

b) Regularity of menstrual cycle-

Regular ☐ Irregular ☐

c) Number of days of Menstrual cycle

Less than 28 days ☐ 28 to 30 days ☐ More than 30 days ☐

d) Number of days of menstruation

Less than 4 days ☐ 4 to 6 days ☐ More than 6 days ☐

Q. 2 Record of your daughter's physical activity-

a) Indulgence in physical activity?

Very active ☐ Moderately Active ☐ Inactive ☐

b) Duration of physical activity

30 min ☐ 45min ☐ 60min ☐

90min ☐ 120min ☐ more than 120 min ☐

c) Frequency of physical activity

Twice/day ☐ Daily ☐ Alternate days ☐

Twice/week ☐ Weekly ☐ Once in 15 days ☐

d) Type of physical activity

Athletics	☐	Walking	☐	Basket ball	☐
Dance	☐	Jogging	☐	Volley ball	☐
Yoga	☐	Aerobics	☐	Badminton	☐
		Swimming	☐	Tennis	☐

Any other, please specify: _____

e) Observations on weight due to physical activity

Weight Loss ☐ Weight Gain ☐ No change ☐

Specify in Kg: _____

Q. 3 Record of your menstrual and anthropometric details

	At Menarche	**Current**
Age (years)		
Height (cms)		
Weight (kg)		
BMI (kg/m^2)		

a. Type of body structure at first menstruation

Small ☐ Medium ☐ Large ☐ Extra Large ☐

b. Current body structure

Small ☐ Medium ☐ Large ☐ Extra Large ☐

APPENDIX - G

24 HOUR DIET RECORD

Sample Menu

Meal	*Timing*	*Food eaten*	*Amount*	*Size*		
				Small	*Average*	*Large*
Early morning	6am	Milk	1 glass		✓	
Break fast	7am	Bread Butter sandwich	2 slices		✓	
		Almonds	5		✓	
Lunch	11:30am	Roti	1		✓	
		Sprouts Usal	1katori		✓	
		Grated carrot	1	✓		
Snacks	3:30pm	Milk	1cup	✓		
		Poha	1 medium katori		✓	
Mid evening	5pm	Apple	1			✓
Dinner	8pm	Rice	1 katori	✓		
		Fish/Chicken curry/Dal	1 medium katori		✓	
		Roti	1		✓	
		Spinach/cabbage vegetable	1 katori	✓		
Bed Time	9:30pm	Milk/Buttermilk	1 glass		✓	

24 HOUR DIET RECORD

Students name:_____ Std:_____

Meal	*Timing*	*Food eaten*	*Amount*	*Size*		
				Small	*Average*	*Large*
Early morning						
Break fast						
Lunch						
Snacks						
Mid evening						
Dinner						
Bed Time						

APPENDIX – H

Food Frequency Questionnaire

Name: _____ Class: _____ Div: _____ School: _____

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
MAIN FOODSTUFFS								
Chapati/Roti (with soya flour)								
Chapati/Roti (with out soya flour)								
Phulka								
Paratha								
Thepla								
Thalipeeth								
Puri								
Bhakri (Bajra)								
Bhakri (Jowar)								
Bhakri (Ragi)								
Plain Rice								
Moongdal Khichdi								

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
Veg Pulav/Fried Rice								
Plain Dal thick								
Plain Dal thin								
Dal with vaghar thin								
Dal with vaghar thick								
Sprout usal								
Soyabean vegetable								
BREAKFAST ITEMS								
Upma								
Poha								
Idli /Dosa Chutney								
Sheera								
Bread jam								
Bread butter								
Veg sandwich								
Cheese sandwich								
Kellogs Cornflakes/chocos/ wheat flakes with milk								
Oats								

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
Muesli								
Any other								
SWEET PREPARATION								
Wheat ladoo								
Besan ladoo								
Rava ladoo								
Groundnut ladoo								
Sevai kheer								
Milk Burfi								
Coconut Burfi								
Basundi								
Gulab jamun								
Shrikhand								
Jalebi								
Pastry								
Any other								
MILK BASED RECIPES								
Tea /coffee cow milk								

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
Tea /coffee buffalo milk								
Milk cows								
Milk buffalo								
Fruit milkshake								
Lassi								
Buttermilk								
Plain curd								
Paneer cubes								
Ice Cream								
Any other								
PROTEIN SUPPLEMENTS								
Bournvita								
Complan								
Proteinex								
Any other								
FRIED SNACKS (all items as 1 plate)								
Batata Vada/ Batata Vada Pav								
Bhajjiya								

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
Kachori/Samosa/ Samosa Pav								
Vegetable Frankie								
Cheese veg Frankie								
Finger chips								
Wafers(lays,kurkure)								
Farsan								
Chivda								
Any other								
CHAAT ITEMS (all items as 1 plate)								
Pani Puri								
Ragda Puri								
Sev puri								
Dahi Puri								
Bhel								
Ragda Pattice								
FAST FOOD								
Veg Burger								
Pizza								

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
Pav Bhaji								
Misal pav								
Maggie Noodles								
Any other								
NON VEGETARIAN FOOD STUFFS								
Egg Boiled								
Egg Bhurji/omlette								
Egg curry								
Chicken Curry								
Fried Chicken								
Chicken Biryani								
Mutton Curry								
Mutton kheema								
Mutton Biryani								
Fish Curry								
Fried Fish								
Fish Biryani								
Any other								

Food Item	Amount (Number)	Daily once	Daily Twice	Weekly Once	Weekly Twice	Once in 15 days	Once in 30days	Calculation
Nuts								
Plain Biscuits								
Cream Biscuits								
Chocolates								
Aerated Drinks								
Fresh/Ready made Fruit Juices								

Appendix – I

Approximate energy expenditure for some physical activities:

Sr.No.	Physical Activity	Energy Expenditure per hour	Intensity Factor
1.	Walking (moderate)	139 kcal	1
2.	Yoga	172 kcal	1
3.	Bicycling (8.8km/hr)	165 kcal	1
4.	Dancing (moderate)	183 kcal	1
5.	Basketball	240 kcal	2
6.	Swimming (moderate)	242 kcal	2
7.	Aerobics	260 kcal	2
8.	Badminton	270 kcal	2
9.	Karate/Judo	300 kcal	3
10.	Tennis	330 kcal	3
11.	Volleyball	384 kcal	3
12.	Hockey	430 kcal	4
13.	Running	433 kcal	4
14.	Football	510 kcal	5
15.	Jogging	520 kcal	5

(Source: Mudambi S.R. and Rajagopal M.V. (2007) and Oxford Food and Fitness)