

# Menarche among rural adolescent girls in Dervan (Data from the KONKAN region of the state of Maharashtra, India)

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## ABSTRACT

**Context:** Associations between age at menarche and risk of type 2 diabetes and cardiovascular disease are well established in adults. But little is known about these risks in adolescents. **Aim:** To examine the association between age at menarche and anthropometric indicators, and also examine nutrition among the rural adolescent girls of KONKAN region. **Setting and Design:** We investigated 1,071 school going adolescent girls who underwent holistic education and various clinical investigations as a part of community program. Age at menarche was recorded and anthropometric measurements were performed. Macronutrient intake was estimated by 24 h recall. **Statistical Analysis Used:** We used trend statistics and logistic regression to examine the association. **Results:** A total of 813 girls had attained menarche. Mean age at menarche was 13.0 years. When compared with premenarchal girls anthropometric parameters were significantly higher in postmenarchal girls ( $P < 0.05$  for all) and the prevalence of stunting and thinness was lower ( $P < 0.001$  for both). There was a decreasing trend for weight ( $P < 0.001$ ), BMI ( $P < 0.001$ ), and waist circumference ( $P < 0.05$ ) with increasing age of onset of menarche, and increasing trend for stunting and thinness ( $P < 0.001$  for both). More than 65% of the girls were eating below the recommended daily allowance of calories, protein, and fat. Adolescents with late onset of menarche had increased likelihood of stunting ( $P < 0.01$ ) and thinness ( $P < 0.001$ ). **Conclusions:** Adolescent girls in the KONKAN region with late menarche are thin and stunted. There is an urgent need to improve nutritional status of adolescent girls from KONKAN as malnutrition can affect the onset of menarche.

**Keywords:** Adolescent, KONKAN, menarche, stunting, under nutrition

## Introduction

Adolescent girls form a crucial segment of the population, bridging the generations. Their nutrition and subsequent development will influence both their own health and that of a

future child. Frequent illness and inadequate nutrition prevents adolescent girls in many developing countries from achieving their growth potential. This is true in rural India where the poor socioeconomic, environmental, and nutritional situation combined with gender discrimination causes adolescent girls to experience serious health problems. An adequate and healthy diet during all phases of growth from infancy through childhood and adolescence is necessary for appropriate growth. As puberty triggers a growth spurt with a corresponding increase in nutritional needs, it follows that diet will affect its progression.

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Received: 31-03-2020

Revised: 25-04-2020

Accepted: 08-05-2020

Published: 30-10-2020

### Access this article online

#### Quick Response Code:



**Website:**  
www.jfmpc.com

**DOI:**  
10.4103/jfmpc.jfmpc\_509\_20

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**How to cite this article:** Patil SN, Joglekar CV, Mohite RB, Surve MM, Sonawane S, Chavan R. Menarche among rural adolescent girls in Dervan (Data from the KONKAN region of the state of Maharashtra, India). J Family Med Prim Care 2020;9:5276-81.

On one hand severe primary or secondary malnutrition can delay the onset and progression of puberty and Menarche,<sup>[1-3]</sup> while over the past 150 years the age of menarche has fallen by a full 4 years in the industrialized West. This has been attributed to an adaptive response to an increasingly nutritionally rich diet.<sup>[4]</sup> There are reports from United States,<sup>[5,6]</sup> Europe,<sup>[7-11]</sup> Asia<sup>[12]</sup> linking early age at menarche with increased risk of type 2 diabetes, breast cancer, and coronary heart disease. Also there are varieties of reports on the changing age of menarche from Africa,<sup>[13-15]</sup> as well as Asia.<sup>[16-19]</sup> There are many reports on the age of menarche from India. The Indian Human Development survey<sup>[20]</sup> found secular decline in age at menarche among Indian women. A study in south India<sup>[21]</sup> reported a mean age at menarche of 12.9 years while two studies from North India<sup>[22,23]</sup> reported the mean age at menarche as 12.38 years and 12.3 years, respectively. A report from city of Nasik<sup>[24]</sup> in western state of Maharashtra reported mean age of 13.7 years.

KONKAN is a 720 km long Arabian Sea coastline running north to south covering four western Indian states of Maharashtra, Goa, Karnataka and Kerala. BKL Walawalkar Hospital is located in a remote, rural village of Dervan which falls in KONKAN segment of the state of Maharashtra situated 250 km south of the Mumbai. Dervan falls in the administrative district of Ratnagiri. Hospital has developed a network of local schools in the entire Ratnagiri District for various community programs which consist of screening for anemia, physical, and nutritional assessment and holistic education. As a part of these programs young adolescent girls are examined and undergo various clinical investigations every 6 months. The school network consists of 45 schools.

This report presents the data on age at menarche and analyses its association with anthropometric and nutritional indicators in school going adolescent girls from Ratnagiri district.

## Materials and Methods

Adolescent girls from schools in the network were examined as a part of community program. School authorities gave the written permission to bring the girls to the hospital. Sometimes if permission could not be granted due to shortage of teachers to accompany the girl, the hospital team comprising medical officers, social workers, and psychologist visited the school and school premises were used to conduct the study. Over the period of 1 year, adolescent girls from all the 45 schools in the network attended community program either on school premises (30 schools) or hospital (15 schools). The total number of adolescent girls in each group varied from 20 to 30. All girls underwent holistic education session and various clinical investigations.

All the subjects underwent anthropometry. Height and weight were recorded using portable stadiometer and electronic scale respectively. Mid upper arm circumference (MUAC), waist circumference and hip circumference were measured using standardized protocols. Body mass index (BMI) and waist to

hip ratio (WHR) were calculated. A 24-hour diet recall was used to estimate the intake of energy, protein, fats, calcium, and iron using nutritive values from a national database of National Institute of Nutrition.<sup>[25]</sup>

Subjects were classified as stunted, thin, overweight, and obese using standard deviation (SD) scores generated using World Health Organization (WHO) standards.<sup>[26]</sup> Anthropometric morbidity refers to stunting, thinness, and overweight. Macronutrient morbidity refers to macronutrient intake (energy, protein, fats) below Recommended Dietary allowance (RDA).

## Statistical analysis

Skewed variables were transformed for normality using the following transformations: Data are presented as median (inter quartile range, IQR) for those not normally distributed or mean (SD) for those distributed normally or as percentages for frequencies. Comparisons of adolescents between those attaining menarche and those not were made using *t*-test for continuous variables and by Chi-square test for categorical variables. We divided adolescents according to age at menarche in to five groups (<12 y, <13 y, <14 y, <15 y, and ≥15 y). Analysis of relation between anthropometric parameters and age at menarche was done by tabulation of means and using trend test. Trend in anthropometric morbidity across these five groups was tested by Cochran–Armitage test. Logistic regression was used to estimate the risks (using odds ratios) for stunting, thinness, and overweight. Statistical analysis was performed using SPSS 16.0 (SPSS Inc, Chicago, US). We also used STATA 11.1 (STATA Corp, College Station, US).

## Ethics

Ethical permission was granted by Ethics committee of BKL Walawalkar Rural Medical College and Hospital. Parents gave informed written consent for the participation of their adolescent child. Written permission was also given by local village leaders where the girls were residing and also by the school authorities. Written assent was obtained from the adolescent girls. The study was conducted between 1<sup>st</sup> January 2017 and 31<sup>st</sup> December 2017. Our institute ethics committee is registered with the Government of India. Registration code is EC/755/INST/MH/2015/RR-18.

## Results

Table 1 shows the mean age at menarche was 13.0 years with a standard deviation of 1.1 years and a range of 10–17 years. As expected postmenarchal girls were taller, heavier, and had higher BMI ( $P < 0.001$ ) and also had higher circumferences ( $P < 0.05$  for waist, hip, and MUAC) and higher WHR ( $P < 0.001$ ). They also had significantly higher SD score for height and BMIs and had lower proportion of adolescents who were stunted ( $P < 0.001$ ). The proportion of overweight and obese adolescents was similar in both groups while the proportion of thin adolescents was significantly lower in the postmenarchal group.

**Table 1: Adolescent girls characteristics (n=1071)**

	Unit	All (n=1071)	Postmenarchal (n=813)	Premenarchal (n=258)	P for difference
Age and family structure					
Age at follow-up	years	14.5 (1.6)	14.9 (1.4)	13.3 (1.6)	0.001
Age at follow-up (min, max)	years	(10, 17)	(11, 17)	(10, 17)	
Age at menarche	years	13.0 (1.1)	13.0 (1.1)	NA	NA
Age at menarche (min, max)	years	(10, 17)	(10, 17)	NA	
Anthropometry					
(Raw data) <sup>1</sup>					
Height	Cm	148.7 (7.6)	150.4 (6.3)	143.2 (8.7)	<b>0.001</b>
Weight	Kg	37.5 (6.2)	38.9 (6.6)	32.7 (6.9)	<b>0.001</b>
BMI	kg/m <sup>2</sup>	16.9 (2.8)	17.2 (2.8)	15.9 (2.7)	<b>0.001</b>
Waist circumference	Cm	59.3 (13.6)	59.8 (13.5)	57.7 (13.8)	<b>0.03</b>
Hip circumference	Cm	73.3 (15.9)	74.7 (15.9)	69.2 (15.2)	<b>0.002</b>
WHR	-	0.81 (0.07)	0.80 (0.06)	0.83 (0.07)	<b>0.024</b>
MUAC	Cm	21.5 (2.8)	21.9 (2.7)	20.2 (2.7)	<b>0.001</b>
WHO standards					
Height SD score	SD	-1.53 (0.96)	-1.45 (0.91)	-1.79 (1.07)	<b>0.001</b>
Stunting (height SD score <-2)	%	28.4	24.4	41.2	<b>0.001</b>
BMI SD score	SD	-1.43 (1.26)	-1.35 (1.22)	-1.69 (1.34)	<b>0.001</b>
Overweight + Obese (BMI SD score >1.0)	%	3.7	3.7	3.5	0.89
Thin (BMI SD score <-2.0)	%	33.1	30.0	42.7	<b>0.001</b>
Macronutrient intake					
Calorie	Kcal	1256.7 (507.1)	1269.2 (510.4)	1222.2 (498.1)	0.36
% Below RDA		96.3	96.8	94.8	0.30
Protein	G	34.9 (13.1)	35.2 (13.4)	34.1 (12.4)	0.42
% Below RDA		87.4	89.3	82.2	<b>0.03</b>
Fat	G	37.8 (13.0)	37.1 (15.0)	39.7 (16.0)	0.46
% Below RDA		67.9	67.8	68.1	0.95
Carbohydrates	G	217.2 (84.2)	219.7 (82.6)	208.8 (89.1)	0.23

Mean (standard deviation) otherwise %. SD: SD units, NA: Not Applicable. <sup>1</sup>: P is additionally adjusted for current age

Macronutrient intakes were similar. Significantly more postmenarchal girls consumed below the RDA for protein.

Table 2 shows mean values of anthropometric parameters, SD scores (for height and BMI) according to age at menarche. All anthropometric parameters and SD scores were inversely related to age at menarche. These relationships remained significant after the adjustment for the current age except height, hip circumference, and WHR.

Table 2 shows percentages of anthropometric morbidity by increasing age of menarche. Significant positive association was seen for stunting and thinness and negative association for being overweight was observed using WHO standards.

Table 3 shows multivariate association between age at menarche and anthropometric morbidity using logistic regression. Increasing age at menarche was associated with a significant increasing trend of odds ratios for stunting and thinness (*P* for trend <0.01 and <0.001 respectively). There was also a decreasing trend of odds ratios for overweight (*P* for trend <0.05).

## Discussion

We have recorded age at menarche, measured anthropometric parameters and estimated the Macronutrient intake by 24 hour recall in a large sample of rural Indian adolescent girls from a segment of Ratnagiri district of KONKAN region. In our study mean age at menarche was 13 years. A study from Bangladesh has also reported similar findings in anthropometric data as ours.<sup>[27]</sup>

There are few studies from India reporting the association of early menarche with later outcomes like birth weight,<sup>[28]</sup> marriage before the age of 18 years<sup>[29]</sup> and risk of breast cancer.<sup>[30]</sup> We do not have birth weight data on our adolescents and none of them were married.

In our study we have also examined the association of age at menarche with anthropometric morbidity and also macronutrients morbidity. We also calculated the risk of stunting which increased with increasing age at menarche. Stunting is known to be a risk factor for adult metabolic diseases. In most of the reports across the world linking early menarche and subsequent disease risks (obesity, diabetes, breast cancer) subjects were either middle aged or old aged who have already developed the disease or carrying the disease risk.<sup>[6-8]</sup> There are very few reports investigating menarche among children in adolescent

**Table 2: Association between age at menarche and anthropometric measures**

Outcomes	Unit	Age at menarche (years)					P for trend	P *
		<12 (n=50)	<13 (n=202)	<14 (n=295)	<15 (n=212)	>=15 (n=54)		
		Body composition by anthropometry						
Height (cm)	cm	149.9 (7.0)	149.3 (6.5)	150.4 (6.3)	151.4 (5.7)	150.4 (6.9)	<b>0.001</b>	0.27
Height SD score (WHO)	SD	-1.01 (1.07)	-1.34 (0.91)	-1.51 (0.88)	-1.51 (0.88)	-1.73 (0.97)	<b>0.001</b>	<b>0.001</b>
Weight (kg)	Kg	42.2 (7.7)	39.6 (7.4)	38.4 (5.9)	38.8 (6.3)	37.5 (6.4)	<b>0.001</b>	<b>0.001</b>
BMI	kg/m <sup>2</sup>	18.7 (2.8)	17.8 (3.5)	16.9 (2.3)	16.9 (2.6)	16.5 (2.4)	<b>0.000</b>	<b>0.001</b>
BMI SD score (WHO)	SD	-0.32 (1.10)	-0.92 (1.23)	-1.49 (1.10)	-1.67 (1.19)	-1.86 (1.06)	<b>0.000</b>	<b>0.001</b>
Waist circumference (cm)	Cm	63.1 (12.1)	61.2 (14.5)	58.8 (13.9)	59.6 (12.1)	55.6 (12.8)	<b>0.015</b>	<b>0.041</b>
Hip circumference	Cm	78.9 (13.4)	75.2 (16.4)	73.5 (16.6)	75.3 (15.1)	71.4 (15.9)	0.14	0.08
WHR	-	0.79 (0.06)	0.81 (0.06)	0.80 (0.06)	0.79 (0.07)	0.78 (0.05)	<b>0.018</b>	0.48
MUAC	Cm	22.9 (3.0)	22.3 (3.1)	21.6 (2.5)	21.7 (2.4)	20.8 (2.4)	<b>0.000</b>	<b>0.001</b>
Stunting (WHO)	%	14.0	21.4	26.8	23.6	35.8	<b>0.029</b>	
Thin (WHO)	%	6.0	18.9	31.6	40.6	44.2	<b>0.000</b>	
Overweight+Obese (WHO)	%	12.0	5.0	17.0	3.8	1.9	<b>0.02</b>	

P: unadjusted, P\*: Additionally adjusted for current age for raw body composition measures (height, weight, BMI, waist, hip, WHR and MUAC)

**Table 3: Determinants of anthropometric morbidity (WHO standards)**

Age at menarche (years)	n	Stunting			Thin			Overweight		
		OR	95% CI	P	OR	95% CI	P	OR	95% CI	P
<12 (Reference)	50	1	-	-	1	-	-	1	-	-
<13	202	1.67	(0.70, 3.98)	0.24	3.65	(1.08, 12.4)	0.000	0.38	(0.13, 1.11)	0.08
<14	295	2.24	(0.97, 5.20)	0.059	7.25	(2.20, 23.89)	0.000	0.13	(0.04, 0.43)	0.001
<15	212	1.89	(0.80, 4.48)	0.15	10.69	(3.22, 35.46)	0.001	0.29	(0.09, 0.87)	0.027
>=15	54	3.43	(1.29, 9.11)	0.013	12.43	(3.42, 45.1)	0.04	0.14	(0.02, 1.24)	0.078
P for trend		0.029			0.000			0.02		

OR: Odds Ratios CI: Confidence Interval. The OR are adjusted for macronutrient intake ( calories, protein and fat)

age range.<sup>[13,18,24,30]</sup> Though we do not have sophisticated body composition measurements, we were able to calculate the prospective risks using simple anthropometric indicators. In our data there was a decreasing trend in waist and hip circumferences across all groups of age at menarche. Hip circumference plays protective metabolic role. It is a proxy for gluteofemoral body fat which has been shown to be associated with reduced risk of cardiovascular disease and cardiovascular mortality.<sup>[31-34]</sup> Thus, our adolescent girls are more prone to cardiovascular diseases in future as they have less gluteofemoral fat.

Our hospital is an outreach centre. KONKAN region is characterized by malnutrition. In a cross-sectional study at our hospital on adolescent girls the prevalence of underweight was 61%.<sup>[35]</sup> Nutrition is one of the most important factors affecting growth and pubertal development. We estimated macronutrient by 24 h recall. In our data almost all girls (>95%) had a diet providing less than the RDA. We could not study dietary pattern using food frequency questionnaire due to time constraints imposed by the schools. Also we could not record the portion sizes of the foods consumed in 24 h recall data. We feel these are major weaknesses of this study. However, in another study done by us in 2018, there was a high prevalence of micronutrient deficiencies of varying degrees in adolescent girls and more than 75% had a low RDA of macronutrients.<sup>[36]</sup>

Consuming an adequate and balanced healthy diet during all phases of growth (infancy, childhood, and adolescence) appears

necessary both for adequate growth and normal pubertal development. As a group postmenarchal girls were taller and heavier but within postmenarchal group late menarche was associated with stunting and thinness. Puberty triggers a growth spurt, which increases nutritional needs including macro and micronutrients. Increased caloric, protein, iron, calcium, zinc, and folate needs have to be provided during this critical period of rapid growth. But in our data estimates of macronutrient intake were similar in both premenarchal and postmenarchal group. A study in Ethiopia<sup>[13]</sup> compared girls with food security and those without and found a significant earlier age at menarche among the former. Similar findings have been reported in other regions.<sup>[37,38]</sup> Food secure girls were more likely to have early menarche in a recent report from United states.<sup>[39]</sup> Whenever children experience severe environmental stress such as malnutrition or disease, maturation is delayed until conditions improve. Severe primary or secondary malnutrition also can delay the onset and progression of puberty.<sup>[40]</sup> Hormonal pathway has been suggested where those with more severe degrees of wasting and stunting had low levels of gonadotropin which may be responsible for the delay in the onset of menarche commonly encountered in cases of malnutrition.<sup>[41]</sup> Good nutrition accelerates the formation of gonadotropin hormone and other hormones that affect the coming of menarche. Our adolescents are rural and the main occupation is farming. Delayed age at menarche in our study can be explained by the fact that poor nutrition might have caused deficiency of gonadotropin.

In summary, increasing age at menarche was associated with more stunting, more thinness, and reduced obesity among undernourished adolescent girls of KONKAN. Developmental Origins of Health and Disease (DoHAD) hypothesis by Barker<sup>[42]</sup> has proposed the role of intrauterine exposures as possible determinants of later disease risk. Menarche is a critical milestone in the development of female adolescents. Early onset of menarche has been associated with early marriage in developing countries and is a risk factor for breast cancer and heart disease. Thus it is possible that intrauterine exposures may also influence age at menarche. Our results point to the need of adolescent intervention to introduce balanced nutrition which will benefit her and next generation in terms of reduced the risk of non communicable diseases. To attain menarche at optimum age, balanced nutrition, and healthy anthropometric parameters is the key.

Adolescent population is considered to be a healthy population in the society. So a general practitioner (GP) plays a key role in shaping and improving the quality of care of teenagers. Menarche can be postponed in adolescents with very low body mass due to starvation or malnutrition which reflects as stunting. Practicing GP is always the first contact. Practicing GP should look for these morbidities and treat them accordingly so that it helps in reducing the subsequent risks of early as well as delayed menarchy.

### Acknowledgements

We are grateful to the community, in particular the adolescent girls for taking part in this study. We would also like to thank their parents for giving the consent to study the adolescent.

### Financial support and sponsorship

We did not receive any outside financial support. The study was conducted as a part of hospital funded holistic education program.

### Conflicts of interest

There are no conflicts of interest.

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