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COMPARISON OF HEIGHT, BODY FATNESS AND SOCIOECONOMIC STATUS BETWEEN PRE- AND POSTMENARCHEAL GIRLS 11 TO 13 YEARS OF AGE IN MERIDA, YUCATAN

ABSTRACT: Age at menarche (AAM) is a growth and development indicator in girls. A study compared height, nutritional status and body fatness between premenarcheal and postmenarcheal girls (11 to 13 years old) from Merida, Yucatan, in relation to socioeconomic status (SES). Height and weight were recorded for 212 girls (90 premenarcheal). Body fat (BF), dry lean mass (DLM) were estimated by bioelectrical impedance analyses. The SES indicators included school type, parents' age, education, occupation, family structure, and mother's age at pregnancy. Mean AAM was 11.21 years. Postmenarcheal girls were taller, had a lower frequency of stunting, and higher BMI, BF (%), DLM than their premenarcheal age peers. A high frequency of excess weight (overweight plus obesity) was noted among premenarcheal (37.77 %) and postmenarcheal (50.82 %) girls. Overweight prevalence was higher in postmenarcheal girls but obesity was higher in premenarcheal girls. Excess weight was more frequent in early menarche (AAM < 12 years) girls (52.70 %) than not early menarche (AMM > 12 years) girls (47.92 %). Height, BF (%), SES, mother's early menarche significantly predicted menarche (pre or post) of the girls.

KEY WORDS: Overweight – Obesity – Fatness – Menarche – Socioeconomic status

INTRODUCTION

Menarche, the onset of menstruation during puberty is associated with growth, nutritional status, and socioeconomic background. Age at menarche (AAM) is affected by overweight and obesity and growth (height-for-age, and weight-for-age) (Freedman *et al.* 2002, Hesketh *et al.* 2002, Lee *et al.* 2007, Martínez *et al.* 2010). In a sample from Canada, body mass index (BMI) and fat mass (% and kg) increased at menarche (Sherar *et al.* 2007). A negative correlation between BMI z-scores and AAM was observed among girls in Santiago,

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Chile (Hernández *et al.* 2007). In a study of Japanese and Caucasian samples, postmenarcheal adolescents had higher mean anthropometric characteristics (height, weight, sitting height, BMI) and body composition values (fat mass and fat-free mass) than premenarcheal adolescents (Sampei *et al.* 2003). Some reports on AAM in relation to anthropometric and body composition characteristics are available from Asian countries like India (Datta Banik 2011), Bangladesh (Rah *et al.* 2009) and Japan (Sampei *et al.* 2003, Tahara *et al.* 2002). Data on AAM are also available from the Mexican states of Oaxaca (Malina *et al.* 2004), and Yucatan (Dickinson *et al.* 1995, Méndez-Domínguez 2011, Wolanski *et al.* 1994, 1998, 2010).

A number of studies addressing different countries and ethnic groups have found BMI, overweight and obesity to explain a conspicuous interrelationship between AAM, socioeconomic background and nutritional status; higher socioeconomic status (SES) and diet were related to earlier AAM (Hernández *et al.* 2007, Osborne *et al.* 2012, Rebacz 2009, Roman *et al.* 2009, Rosenfield *et al.* 2009, Salsberry *et al.* 2009, Terry *et al.* 2009, Wronka 2010). However, lower SES and poor lifestyle were also reported to generate an obesogenic environment and early AAM in a study done in Chile (Codner *et al.* 2004). Lower SES has been reported to be associated with delayed menarche in Mapuche (indigenous) and non-Mapuche populations in Chile; menarche was earlier overall in the non-Mapuche than in the Mapuche girls (Amigo *et al.* 2012). In a report from Ghana, differences in AAM in schoolgirls were significantly correlated to social class, parents' ethnic origin, educational institution and home living area. In the United States of America, African-American girls are reported to have earlier AAM than their Caucasian age peers with both household income and parental education influencing the menarche timing (Braithwaite *et al.* 2009).

Studies reported associations between early age at menarche or EAM (AAM<12 years) and higher BMI and body fat (Adair, Gordon-Larsen 2001, Al-Awadhi *et al.* 2013, Must *et al.* 2005, Oh *et al.* 2012). Familial association of EAM was also recorded in mother-daughter dyads where an association between mother's and daughter's age at menarche was observed (Méndez-Domínguez 2011). In a study of 2,993 urban and 2,855 rural girls in China, urban girls had higher rates of EAM (9.52 %) than rural girls (4.40 %), and postmenarcheal girls were taller and heavier than premenarcheal girls in corresponding age groups between 9 and 18 years of age (Ohsawa *et al.* 1997). In Mexico, EAM has been reported to be associated with overweight and obesity, urban residence and high socioeconomic level (Torres-Mejía *et al.* 2005).

Therefore, based on review of literature in the previous paragraphs, it was hypothesized that growth and nutritional status in girls were related to age of menarche and socioeconomic status of the families. Along with, early menarche was reported to be associated with differential physical growth pattern and body fatness in girls compared to the girls with not early menarche. However, reports on AAM, pubertal growth and related issues including socioeconomic factors, overweight and obesity in girls in Mexico are scarce. Studies on differential growth and nutritional status in pre- and postmenarcheal age peers are also not available. The present study objectives were:

1) To understand differences in anthropometric characteristics (height, weight, BMI) and body composition traits (body fat, fat-free mass, dry lean mass) between premenarcheal and postmenarcheal girls in the 11 to 13 year age range.
2) To estimate nutritional status frequencies (stunting, thinness, overweight and obesity based on height-for-age and BMI-for-age z-scores) and compare them between premenarcheal and postmenarcheal girls.
3) To evaluate nutritional status frequencies between girls who had a relatively early (<12 years) or not early (≥12 years) age at menarche (AAM).
4) To predict age of menarche (pre or post) using height, body fat, EAM in mother, and SES factors.

MATERIALS AND METHODS

The sample analyzed in the present study is a part of a larger sample (n = 1000+) of 9 to 18 year-old children and adolescents documented as part of an anthropometric survey project implemented in 2008–2009. The present cross-sectional study was done by taking a purposive non-probability sample (Cochran 1977) of 212 girls in the 11 to 13 year age-group from selected public and private schools in Merida, Yucatan. This age range was chosen because there were very few (<7) postmenarcheal girls younger than 11 years and equally few premenarcheal girls older than 13 years in the larger sample. The sample size by age included 90 premenarcheal girls (11 years = 48; 12 years = 30; 13 years = 12) and 122 postmenarcheal girls (11 years = 18; 12 years = 53; 13 years = 51). Postmenarcheal girls were classified as either early age at menarche (EAM; <12 years, 60.7 %) or not early age at menarche (NEM ≥12 years, 39.3 %); the cut-off age was determined based on previous references (Must *et al.* 2005, Torres-Mejía *et al.* 2005). Median age at menarche was 12 years (range, 10–14 years) in the original project database that also coincides with an earlier report from Mexican girls (Torres-Mejía *et al.* 2005). Presence of EAM in mothers was considered a predictor of menarcheal status in the studied girls. Age at menarche (AAM) data for the girls and their mothers was collected retrospectively.

Anthropometric and body composition measurement

Trained researchers (FD and assistants) used equipment to record height and weight, and estimate body composition characteristics of lightly-clothed, bare-footed participants wearing no jewelry or accessories. Following international protocols (WHO 1995, Lee, Nieman 2007), height (cm, to nearest 0.1 cm) was measured using a stadiometer with platform (Seca model no. 225, Hamburg, Germany), and body weight (kg, to nearest 0.05 kg) using an electronic scale (Seca model no. 872, Hamburg, Germany). All basic anthropometric measurements were taken in triplicate. Average of the three measurements was treated as the final value for analysis. Body composition traits were estimated using bioelectrical impedance (Bodystat: model 1500 MDD) following the manufacturer's operational manual. Measured traits included fat mass (FM), fat-free mass (FFM) and dry lean mass (DLM), in kilograms (kg), and percentage body fat (PBF) and fat-free mass (FFM) expressed a percentage (%). Body mass index (BMI) was calculated following the standard formula: BMI = weight (kg)/height squared (m^2). Nutritional status was determined following recommended cut-off values for height-for-age (HAZ) and BMI-for-age z-scores (BMIZ) (WHO 2007, de Onis *et al.* 2007). Nutritional status was determined following recommended cut-off values for height-for-age (HAZ) and BMI-for-age z-scores (BMIZ) (WHO 1995, 2007, de Onis *et al.* 2007). Stunting (low height-for-age) was defined as height of an individual for age more than two standard deviations below the median of the NCHS/WHO growth reference. Overweight and obesity were defined as BMI-for-age above +1 and +2 standard deviations above the WHO growth standard median respectively.

Socioeconomic status (SES)

Six proxy indicators for SES were used: 1) type of school (private or public); 2) age of parents; 3) mother's age at pregnancy (with participant); 4) parents had either secondary school education (Basic) or technical and higher education; 5) father's occupation (professional or general services, including technical); and 6) crowding index (number of family members / number of bedrooms in a house; cited in Curiel *et al.* 2005). The crowding index was considered a proxy for family structure. Family size varied from two (one child + single parent) to nine (extended families including up to three generations).

Following Mexican national guidelines (INEGI 1990), father's occupation was initially classified into three groups based on job types and average monthly salary (MS): (A) technical jobs (MS = 600 US$), (B) general services (office assistants) (MS = 800 US$), and (C) professionals (entrepreneurs, administrators, and teachers) (MS = 3000 US$). There was no significant difference ($p > 0.05$, examined by both parametric and non-parametric tests for comparing means) of MS between groups A and B. However, MS of the group C was significantly different ($p < 0.05$) from separate or combined group of B and C. Therefore, in the present study, two occupational groups were considered: professionals and others (general service holders and technicians).

Ethical issues

The study was approved by the Bioethics Committee of the Centre for Research and Advanced Studies (Cinvestav-IPN). The Yucatan State Secretary of Education approved and authorized data collection in the schools. Verbal and written informed consent was obtained in advance from school authorities and the parents and/or legal guardians of the participants recruited for the study, and verbal assent was also given by each participant.

Statistical methods

Descriptive statistics for the means, standard deviation and frequencies (%) were calculated and statistical analyses performed using the SPSS (version 13.00) statistical software. Technical errors of measurement (TEM) were calculated on 50 randomly-selected girls and the errors found to be within reference values (Ulijaszek, Kerr 1999). Therefore, TEM were not incorporated into statistical analyses. Anthropometric trait data exhibited a normal distribution (Shapiro-Wilk test, $p > 0.05$) and required no transformation. A Student's *t*-test was done to calculate significant differences in mean anthropometric and body composition trait values between premenarcheal and postmenarcheal girls. A one-way analysis of variance (ANOVA) was used to identify differences by age in mean anthropometric trait values. Z-scores were calculated using the AnthroPlus software program (WHO 2007). Association between variables was assessed using either a parametric test of Pearson's correlation or a non-parametric Chi-square (χ^2) test (case specific). Factor analysis (principal component analysis) of quantitative data was performed with continuous variables (parents' age, mother's age at pregnancy) and binary variables (school type, parents' education level and father's occupation). Binary logistic regression models for menarcheal status (premenarcheal or postmenarcheal) were developed in response to the covariates (age, height, PBF, General SES and EAM in mother). Statistical significance was set *a priori* at $p < 0.05$.

RESULTS

Mean age (n = 212) was 12.46 years (SD ± 0.81; range = 11.03–13.97 years). Mean age for premenarcheal girls (12.03 years ± 0.68: range = 11.03–13.68 years) did not differ significantly ($p > 0.05$) from that of postmenarcheal girls (12.78 ± 0.73 years; range = 11.14–13.97 years). Overall mean AAM (n = 122) was 11.21 years (± 0.95; range = 11–13 years). Mean AAM in EAM (Early age at menarche) girls (n= 74) was 10.57 years (± 0.75) (median = 11 years) which was significantly younger (t= 18.02, $p < 0.0001$) than the 12.18 years (± 0.39) in not early menarche or NEM girls (n = 48) (median = 12 years).

Significant age difference ($p < 0.001$) for height (11 years: 142.43 ± 6.95 cm; 12 years: 149.42 ± 5.56 cm; 13 years: 150.46 ± 7.42 cm) was observed in all 212 participants (n = 66 at 11 years; n = 83 at 12 years; n = 63 at 13 years). Increases in weight, BMI, PBF, fat mass (kg), FFM (kg), and DLM (kg) by age were observed (*Figure 1*).

When analyzed by age, postmenarcheal girls were in general, taller (except a few cases of stunting), heavier, and had more body fat compared to premenarcheal girls (*Table 1*). They also had higher body fat (kg), FFM (kg) and DLM (kg). The FFM (%) was higher in premenarcheal girls. In combined age samples, differences ($p < 0.05$) in anthropometric values and body composition traits were consistent between the pre- and postmenarcheal girls. The variables exhibited significant age-trend among premenarcheal girls for height, weight, FFM (kg) and DLM (kg), and for postmenarcheal girls for weight, BMI, and all body composition traits. An overall positive age-trend was observed for height, weight, BMI, body fat (% and kg), FFM (kg) and DLM (kg). The increase in FFM (kg) also indicated a positive growth trend for bones and muscles (i.e. DLM) with age.

Prevalence of stunting was lower (7.38 %) among postmenarcheal girls than among premenarcheal girls (13.33 %), without significant difference ($p > 0.05$) (*Table 2*). The trend was similar by age save for marginally higher stunting in postmenarcheal girls at 12 years.

None of the postmenarcheal girls was found to be suffering from thinness (BMI-based undernutrition) (*Table 3*). In the premenarcheal girls, one individual each at 11 and 12 years were thin (<-2 SD BMIZ). The prevalence of overweight in girls was higher in the postmenarcheal group, but obesity was more prevalent in the premenarcheal group. Prevalence for excess weight (overweight + obesity) was very high in both the

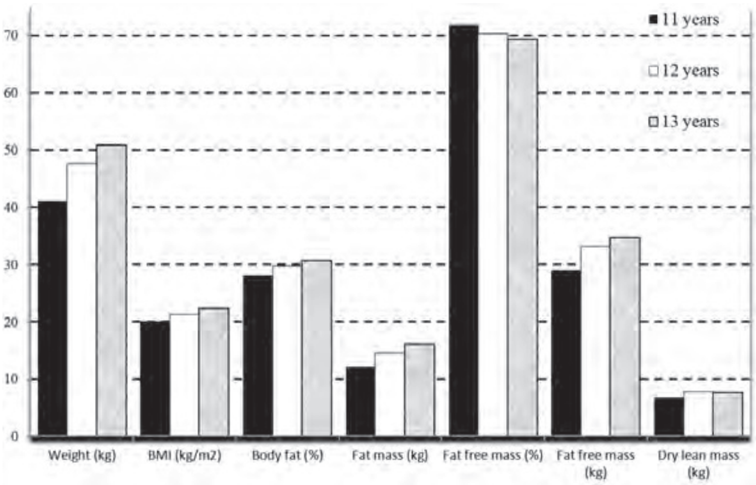

FIGURE 1. Differences by age for anthropometric values and body composition traits in girls (n = 212).

TABLE 1. Descriptive statistics for anthropometric values and body composition traits by age and menarcheal status in girls.SD, Standard deviation; BMI, body mass index; FFM, fat-free mass; DLM, dry lean mass. The p-values in bold font < 0.05.

Variables	Age (years)	Premenarcheal		Postmenarcheal			
		Mean	SD	Mean	SD	*t*	*p*-value
Height (cm)	11	140.61	6.63	147.27	5.41	**-3.81**	**<0.0001**
	12	147.38	5.35	150.57	5.39	**-2.70**	**0.004**
	13	148.03	10.06	151.04	6.65	-1.27	0.209
	All	143.85#	7.56	150.28	6.04	**-6.87**	**<0.0001**
Body weight (kg)	11	39.79	10.55	44.48	8.04	-1.71	0.093
	12	43.70	8.29	49.78	7.82	**-3.35**	**<0.0001**
	13	48.26	19.01	51.45	10.48	-0.80	0.429
	All	42.22	11.61	49.69	9.28	**-5.20**	**<0.0001**
BMI (kg/m^2)	11	19.92	4.09	20.49	3.45	-0.53	0.601
	12	20.15	3.87	21.94	3.13	**-2.26**	**0.014**
	13	21.62	6.86	22.49	3.93	-0.51	0.554
	All	20.23	4.45	21.96#	3.56	**-3.15**	**0.002**
Body fat (%)	11	28.23	6.48	28.05	6.22	0.10	0.918
	12	27.22	6.34	31.15	4.27	**-3.35**	**<0.001**
	13	28.39	9.04	31.23	4.57	-1.57	0.122
	All	27.91	6.76	30.72#	4.82	**-3.39**	**<0.001**
Fat mass (kg)	11	11.84	6.01	12.84	4.77	-0.63	0.532
	12	12.29	4.91	15.79	4.30	**-3.37**	**<0.001**
	13	14.98	10.51	16.40	5.52	-0.66	0.513
	All	12.42	6.46	15.61#	5.03	**-4.02**	**<0.0001**
FFM (%)	11	71.77	6.48	71.95	6.22	-0.10	0.920
	12	72.78	6.34	68.85	4.27	**3.34**	**<0.001**
	13	71.61	9.04	68.77	4.57	1.57	0.122
	All	72.09	6.75	69.28#	4.82	**3.39**	**<0.001**
FFM (kg)	11	28.05	5.34	31.65	4.21	**-2.57**	**0.006**
	12	31.39	4.04	34.18	4.21	**-2.94**	**0.002**
	13	33.27	9.09	35.04	5.38	-0.89	0.378
	All	29.88#	5.90	34.16#	4.84	**-5.76**	**<0.0001**
DLM (kg)	11	6.56	1.26	7.41	1.00	**-2.57**	**0.006**
	12	7.38	0.93	8.02	0.98	**-2.91**	**0.002**
	13	8.15	2.23	8.58	1.32	-0.89	0.380
	All	7.05#	1.44	8.17#	1.20	**-6.09**	**<0.0001**

TABLE 2. Height-for-age (Based on de Onis *et al*. 2007) by menarcheal status in girls. SD, Standard deviation.

Age (years)	Height-for-age	Premenarcheal		Postmenarcheal	
		%	Height: Mean (SD)	%	Height: Mean (SD)
11	Stunted	16.67	131.71 (4.80)	0.00	0.00
	Normal	83.33	142.39 (5.41)	100.00	147.27 (5.41)
12	Stunted	3.33	141.00	3.77	139.20 (1.13)
	Normal	96.97	147.60 (5.31)	96.23	151.12 (4.99)
13	Stunted	25.00	134.83 (6.16)	13.73	139.99(3.59)
	Normal	75.00	152.42 (6.53)	86.27	152.71(5.19)
Total	Stunted	13.33	133.27 (5.42)	7.38	139.81 (3.16)
	Normal	86.67	145.48 (6.46)	92.62	151.11 (5.41)

TABLE 3. BMI and nutritional status frequencies (Based on de Onis *et al*. 2007) by menarcheal status in girls. SD, Standard deviation. BMI, Body mass index.

Age (years)	Nutritional status	Premenarcheal		Postmenarcheal	
		%	BMI: Mean (SD)	%	BMI: Mean (SD)
11	Undernutrition	2.08	14.34 (0.00)	0.00	0
	Normal	58.33	17.60 (1.82)	50.00	17.55 (0.95)
	Overweight	29.17	21.73 (1.10)	38.89	22.62 (1.41)
	Obesity	10.42	28.98 (3.31)	11.11	26.30 (2.51)
12	Undernutrition	3.33	14.56 (0.00)	0.00	0.00
	Normal	60.00	17.82 (1.53)	41.51	18.92 (1.31)
	Overweight	23.33	22.90 (0.94)	45.28	23.13 (0.85)
	Obesity	13.33	27.27 (1.09)	13.21	27.33 (1.82)
13	Normal	66.67	17.60 (1.29)	56.86	20.01 (1.51)
	Overweight	8.33	22.76	31.37	24.01 (1.42)
	Obesity	25.00	31.94 (5.28)	11.76	30.46 (3.99)
Total	Undernutrition	2.22	14.45 (0.16)	0.00	0.00
	Normal	60.00	17.67 (1.63)	49.18	19.24 (1.61)
	Overweight	24.44	22.15 (1.15)	38.52	23.36 (1.24)
	Obesity	13.33	29.15 (3.58)	12.30	28.44 (3.25)

premenarcheal (37.77 %) and postmenarcheal (50.82 %) group, without significant difference between groups ($\chi^2 = 2.02$, $p > 0.05$) when compared with data on excess weight in adolescent girls from Mexico (35.8 %; ENSANUT 2012).

No significant differences ($p > 0.05$) were observed between the EAM and NEM girls in terms of anthropometric and body composition traits. Girls with EAM had a lower frequency of stunting (4.05 %) than the NEM girls (12.50 %) with significant difference ($\chi^2 = 4.11$, $p < 0.05$). Their frequency of excess weight (52.70 %) was slightly higher than that of the NEM girls (47.92 %), but both rates were very high, without significant difference between groups ($p > 0.05$). Overweight was more frequent in EAM girls (43.24 %) than in NEM girls (31.25 %), but obesity was less frequent in EAM girls (9.46 %) than in NEM girls (16.67 %) (*Table 4*).

TABLE 4. Nutritional status frequencies (%) in postmenarcheal girls (n = 122) by age at menarche: early (< 12 years) and not early menarche (≥ 12 years). EAM, early age at menarche; NEM, Not early menarche; HAZ, height-for-age z-score; BMIZ, height-for-age z-score.

Nutritional status		EAM (n = 74) %	NEM (n = 48) %
Based on HAZ	Stunted	4.05	12.50
	Normal	95.95	87.50
Based on BMIZ	Normal BMI	47.30	52.08
	Overweight	43.24	31.25
	Obesity	9.46	16.67

TABLE 6. Factor loading and principal component weights of SES indicators in pre- and postmenarcheal girls. SES, socioeconomic status proxy indicators.

SES	PC 1	PC 2
Father's education	0.919	0.148
School type	0.909	0.174
Mother's education	0.875	0.145
Father's occupation	0.629	0.050
Father's age	0.163	0.596
Mother's age at pregnancy	0.133	0.938
Mother's age	0.130	0.942
Crowding index	- 0.546	- 0.225

Age had a positive ($p < 0.05$) correlation with weight, height, FFM and DLM in premenarcheal girls (above the diagonal, in bold font), and with height and DLM in postmenarcheal girls (below the diagonal) (*Table 5*). The HAZ had a negative ($p < 0.05$) correlation with age in postmenarcheal girls, indicating a lower prevalence of stunting. Negative correlations were also observed between AAM, HAZ, BMIZ, and body fat (%). Both BMI and PBF declined ($p < 0.05$) with higher AAM. The multiple correlation analysis between height, weight, and body composition traits (FFM [kg], FM and DLM) identified significant ($p < 0.01$) association between variables in both the premenarcheal or postmenarcheal groups (*Table 5*).

TABLE 5. Multiple correlation coefficients (r = Pearson's correlation) between age, AAM and anthropometric characteristics in pre- and postmenarcheal girls. AAM, Age at menarche; HAZ, Height for age z-scores; BMI, body mass index; BMIZ, BMI for age z-scores; FM, Fat mass; FFM, fat-free mass; DLM, dry lean mass. * $p < 0.05$. Above the diagonal, in bold font: premenarcheal girls. Below the diagonal: postmenarcheal girls.

Variables	Age (years)	AAM	Height (cm)	Weight (kg)	HAZ	BMI (kg/m^2)	BMIZ	Body fat (%)	FM (kg)	FFM (kg)	DLM (kg)
Age (years)	-	NA	**0.49***	**0.28***	**-0.04**	**0.12**	**-0.08**	**-0.02**	**0.15**	**0.39***	**0.44***
Height (cm)	0.20*	0.06	-	**0.58***	**0.82***	**0.27***	**0.17**	**0.20***	**0.41***	**0.70***	**0.70***
Weight (kg)	0.16	-0.09	0.47*	-	**0.48***	**0.93***	**0.83***	**0.73***	**0.95***	**0.94***	**0.94***
HAZ	-0.37*	-0.20*	0.83*	0.35*	-	**0.23***	**0.24***	**0.25***	**0.37***	**0.54***	**0.51***
BMI (kg/m^2)	0.08	-0.14	0.03	0.89*	-0.02	-	**0.93***	**0.79***	**0.94***	**0.82***	**0.81***
BMIZ	-0.12	-0.24*	-0.03	0.82*	0.03	0.94*	-	**0.79***	**0.84***	**0.71***	**0.69***
Body fat (%)	0.13	-0.20*	0.11	0.70*	0.02	0.75*	0.74*	-	**0.88***	**0.48***	**0.48***
FM (kg)	0.14	-0.15	0.33*	0.95*	0.23*	0.90*	0.83*	0.88*	-	**0.78***	**0.78***
FFM (kg)	0.15	-0.04	0.55*	0.94*	0.43*	0.79*	0.72*	0.46*	0.80*	-	**0.99***
DLM (kg)	0.27*	0.02	0.54*	0.94*	0.35*	0.78*	0.69*	0.46*	0.79*	0.99*	-

TABLE 7. Estimates of logistic regression model for menarcheal status with height as one of the predictors in girls. C.I., Confidence Interval; SES, Socioeconomic status; EAM, Early age at menarche.

Predictors	B	S.E.	Wald	df	Sig. (*p*-value)	Exp(B)	95.0% C.I. for Exp(B)	
							Lower	Upper
Age (years)	1.09	0.29	13.86	1	<0.001	2.97	1.67	5.26
Height (cm)	0.13	0.04	14.08	1	<0.001	1.14	1.07	1.23
General SES	-0.83	0.23	12.55	1	<0.001	0.44	0.28	0.69
EAM in mother	1.16	0.44	7.01	1	<0.001	3.19	1.35	7.55
Constant	-33.39	5.98	31.15	1	<0.001	0.00		

A factor analysis was done to produce linear combinations of eight variables (SES indicators) which accounted for most of the variability in the data. The extraction method was principal component analysis, and the rotation method was set as Varimax with Kaiser Normalization. Variables were either continuous (Mother's age; father's age; mother's age at pregnancy; and crowding index) or binary (school type, public or private; parents' education level, basic or higher; and father's occupation, general services including technicians or professional). Two components were extracted with eigenvalues ≥ 1.0, which together accounted for 82.61 % of the variability in the original data. A scree plot showed the extraction of the two components from the eight SES variables (figure available from corresponding author) and the weights of the variables in principal components were the standardized scores (*Table 6*). The variables clustered together separately in each principal component had correlation coefficients >0.50. Both the Kaiser-Meyer-Olkin (KMO), an estimate of sampling adequacy (0.76), and the Bartlett's test of sphericity ($\chi^2 = 904.94$, $p < 0.0001$) indicated a strong relationship among variables.

The extracted components were assigned labels based on component weights greater than 0.5: Component 1 = General SES (defined by school type, parents' education, father's occupation and crowding index); Component 2 = Parents' maturity (defined by parents' age and mother's age at pregnancy). These two components were used as predictors in the multiple regression analysis.

Logistic regression analysis (*Tables 7 and 8*) was used to display the results of fitting two models to describe the relationship between menarcheal status (premenarcheal = 0 or postmenarcheal = 1) and four independent variables (age, General SES, EAM in mother, and either height or PBF). Parents' maturity was found to have no significant association as the second proxy indicator of SES status and was dropped from the models. All cases were included and no data was found to be missing in either model. The Nagelkerke R-Square showed the variation (48 % in first model; 42 % in second model) in the outcome variable (menarcheal status: postmenarche = 1, premenarche = 0) to be explained by the logistic models. The Wald estimates were quite high (*Tables 8 and 9*), indicating these to be significant models for the predictor values. The predictors in either model were significant ($p < 0.01$) factors for postmenarcheal status (= 1). There was a significant relationship between the variables at the 95.0% confidence level, as shown in the analysis of deviation ($p < 0.05$). The residuals ($p > 0.05$) also indicated that the models fitted for the data at the 95.0 % or higher confidence level. The Hosmer-Lemeshow goodness-of-fit (Chi-squared) test showed the observed and predicted probabilities matched, and the assumption ($p > 0.05$) indicated the logistic regression models to have a good fit for the sample size in the present study. No multicollinearity among predictors was detected in either model.

Model 1: Independent variables- Age (years), height (cm) and General SES were continuous, and EAM in mother was binary (Yes = 1, No = 0) (*Table 7*). Odds ratios were explained by Exp(B). Since age was a quantitative numerical variable, a one-year increase in age resulted in a 197 % (95 % C.I., 67 % – 427 %)

TABLE 8. Estimates of logistic regression model for menarcheal status with percentage body fat as one of the predictors in girls. C.I., Confidence Interval; SES, Socioeconomic status; EAM, Early age at menarche.

Predictors	B	S.E.	Wald	df	Sig. (*p*-value)	Exp (B)	95.0% C.I. for Exp (B)	
							Lower	Upper
Age (years)	1.42	0.28	26.20	1	<0.0001	4.15	2.41	7.15
Body fat (%)	0.10	0.04	3.39	1	<0.05	1.07	1.00	1.15
General SES	-0.51	0.21	5.84	1	<0.05	0.60	0.40	0.91
EAM in mother	0.98	0.42	5.39	1	<0.05	2.67	1.17	6.12
Constant	-19.81	3.60	30.22	1	<0.0001	0.00		

increase in the odds of girls being postmenarcheal. For height, a one centimeter increase produced a 14 % (95 % C.I., 7 % – 23 %) higher probability of being postmenarcheal. Presence versus absence of EAM in mothers made it 3.19 (95% C.I., 1.35–7.55) times more likely to predict postmenarcheal status. Correlations between age, height and General SES were very low. Overall model accuracy for the prediction of menarcheal status was 76.92 % (with a predicted probability of ≥0.05). Model sensitivity was 81.61 %, and its specificity was 70.59 % (Youden Index = 1.51). The positive predictive value was 78.02 % and the negative predictive value was 75 %. The equation for calculating the probability of a girl having postmenarcheal statuswas given by: Prob (postmenarcheal status) = 1 / (1 + e^{-z}). Where,

z = -33.39 + 1.09* Age + 0.13* Height – 0.83* General SES + 1.16* EAM in mother

Using particular values for age (years), height (cm), a factor (specific value) for General SES and EAM status of mothers, we could calculate the probability of a girls being postmenarcheal with predictive values (% confidence) determined by the model. The receiver operating characteristic (ROC) curve area was 0.85, meaning it included almost 85 % of all possible participant pairs, either pre- or postmenarcheal. The logistic regression model would assign a higher probability to postmenarcheal girls.

As an additional predictor, percentage body fat (PBF) was not significant in the above model. However, when included separately as a substitute for height, the logistic regression model (*Table 8*) described the relationship between menarcheal status (premenarcheal or postmenarcheal) and four independent variables (age, PBF, General SES, and EAM in mother). Overall model accuracy for predicting participant's postmenarcheal status was 74.68 % (with a predicted probability of ≥0.05). Model sensitivity was 79.07 %, and its specificity was 69.12 % (Youden Index = 1.47). The positive predictive value was 76.40 % and the negative predictive value was 72.31 %. Accordingly, the equation for calculating the probability of a participant having postmenarcheal status was given by: z = -19.81 + 1.42* Age + 0.10* PBF – 0.51* General SES + 0.98* EAM in mother.

A 1% increase in body fat caused a 7 % (95 % C.I., 0 % – 16 %) increase in the odds of having postmenarcheal status. Early AAM in the mother again played a vital role in determining menarcheal status. When compared to absence of EAM in mothers, presence of EAM in mothers made it 2.67 (95 % C.I., 1.17–6.12) times more likely to predict postmenarcheal status in girls. Age had more relation than the other model covariates. Area under the ROC curve was 0.83.

DISCUSSION

Mean AAM in the present study (11.21 ± 0.95 years) was lower than reported for other Latin American countries. In the city of El Yopal, Colombia, mean AAM was 12.63 (±1.11) years (Ireton *et al.* 2011), in Bogota, Colombia, it was 12.68 (±1.31) years (Chavarro *et al.* 2004), and in Santiago, Chile it was 12.68 (Codner *et al.* 2004) and 12.7 years (Hernández *et al.* 2007). The same holds when comparing the present results with relatively older studies (cited in Ireton *et al.* 2011). The present

TABLE 9. Comparative study of age at menarche (AAM), early age at menarche (EAM) and body mass index (BMI) in selected earlier studies.

Mean AAM (years)	Defined age at EAM (<years)	% EAM	BMI	Populations	Country	References
12.80	12	25	17.8	Caucasian	USA	Freedman *et al*. 2003
12.90	12	30	17.6	African-American	USA	Freedman *et al*. 2003
12.47	12	---	21.7	Mapuche (indigenous)	Chile	Amigo *et al*. 2012
12.22	12	---	20.6	Non-indigenous	Chile	Amigo *et al*. 2012
12.40	12	24.3	---	White and non-White	Brazil	Martínez *et al.* 2010

results for mean AAM in the girls (11.21 years) and their mothers (12.02 years) are also lower than previous reports from Yucatan, Mexico (Wolanski *et al*. 1994). In a study done in 1989–90, AAM was documented for girls in the city of Merida and the port of Progreso, both in Yucatan (Wolanski *et al.*1994). Mean AAM for girls in Merida was 12.09 years, which was lower than their mothers' AAM (12.66 years). In Progreso, mean AAM was 12.24 years, which again was lower than their mothers (12.41 years). These results suggest a gradual decline in AAM over time in Yucatan. The same study (Wolanski *et al.* 1994) also provided data for other states in Mexico and other Latin American countries (Guatemala, Cuba, Venezuela, Argentina, Chile, Brazil and others) showing a similar trend of declining mean AAM over decades in Latin America. Also of note is that the present mean AAM results are lower than recent AAM figures in the United States (*Table 9*).

Body mass index (BMI) values in the present study (21.22 ± 4.05 kg/m^2) were near those reported for Mapuche girls in Chile (Amigo *et al.* 2012) (*Table 9*). The trends observed here for height, weight, BMI and body composition traits and the comparison between premenarcheal and postmenarcheal girls (*Table 2*) were very similar to those reported in a study of girls in Austria (Kirchengast, Bauer 2007). In both studies, postmenarcheal girls were taller, had significantly higher weight, BMI, body fat (% and kg), FFM (kg), and DLM (kg) by age (11 to 13 years). In another study, differences between pre- and postmenarcheal weight (38.5 kg and 43.9 kg respectively) and BMI (17.8 kg/m^2 and 18.7 kg/m^2 respectively) have been reported as predisposing factors for development of overweight and obesity in adulthood (Must *et al.* 2005). A study based on NHANES III data for girls 10–14 years of age from different racial backgrounds (Hispanics, non-Hispanic Whites and Blacks), showed menarche to be more closely related to fat distribution (Lassek, Gaulin 2007).

In the present study, EAM girls were shorter, had higher weight, BMI, body fat, and FFM than the NEM girls, without significant difference ($p > 0.05$). This pattern coincides with a study of girls in Spain in which EAM (<12 years) girls were shorter than NEM (≥12 years) girls, but had higher BMI, fat-free mass index, fat mass index and waist circumference values (Labayen *et al.* 2009). Previous studies have also reported interrelationships between EAM and body fatness in two senses. In one, girls with higher body fatness tend to have earlier menarche (Freedman *et al.* 2002) and in the other, EAM girls have higher body fat percentage (%) and BMI than average and late-menarcheal girls (Oh *et al.* 2012). The deduction is that EAM is a predisposing factor, causing a higher risk of developing overweight and body fat deposition in late adolescence and adulthood (Bratberg *et al.* 2007, Dunger *et al.* 2005, Pierce, Leon 2005).

The negative correlation observed here between AAM, BMI and PBF agreed with previous studies (Bau *et al.* 2009, Bralić *et al.* 2012, Currie *et al.* 2012, Hernández *et al.* 2007, Labayen *et al.* 2009, Mandel *et al.* 2004, Oh *et al.* 2012,Trikudanathan *et al.* 2013, Wronka 2010). The present results showed EAM girls to have a higher prevalence of excess weight (overweight + obesity) (52.70 %) than the NEM girls (47.92 %). This agrees with a previous study (Adair, Gordon-Larsen 2001) in which overweight prevalence was significantly higher in early maturing (<11 years) girls (41.5 %) of all racial/ethnic groups compared to average (11–13 years) maturing (25 %) and late maturing (≥14 years) girls (18.7 %) (Adair, Gordon-Larsen 2001). In that study, overweight was reported as most frequent among early maturing Black girls (57.5 %), followed by early maturing Hispanic (41.9 %), White (36.4 %) and Asian girls (21.4 %) (Adair, Gordon-Larsen 2001). A significant inverse association between AAM and obesity or overweight has also been reported in recent studies in China (Mi *et al.* 2007, Xiao-Yan, Cheng-Ye 2011), Portugal (Leitão *et al.* 2013), Tehran, Iran (Moayeri *et al.* 2006), Kuwait (Al-Awadhi *et al.* 2013), Norway (Bratberg *et al.* 2007), the USA (Kaplowitz *et al.* 2001, Wang 2002, Chumlea *et al.* 2003, Freedman *et al.* 2003, Demerath *et al.* 2004, Lee *et al.* 2007) and among African-Americans (Wattigney *et al.* 1999, Freedman *et al.* 2002).

However, some questions remain to be answered. Menarche is known to occur after the spurt in height growth (Hughes 1998). In theory, this would explain why the postmenarcheal girls (who had probably already reached peak height growth velocity) would be taller than their same-age peers. However, in the present context, no growth velocity or age at peak height (premenarcheal or postmenarcheal) data were available for the studied girls. Another limitation in the present study is that the 11 to 13 years age range was too short to explain such issues. In a study based on the principal database of the same research project (Conacyt), it was observed that girls in the studied population (sample size = 500; range = 9–18 years) had the greatest height growth (cm/year) at 12 years (Datta Banik *et al.* 2012). Girls with EAM were marginally shorter (mean difference 0.64 cm) than the NEM girls studied here but this cannot be compared to the earlier study because height growth in EAM girls was not analyzed separately (Datta Banik *et al.* 2012). This data could clarify the relationship between EAM and age at peak height growth velocity.

CONCLUSION

The present results generally agree with previous studies in Yucatan and other parts of the world, and contribute to understanding differential growth and body composition traits in girls, highlighting the vital role of menarche in determining physical differences among same-age peers. Socioeconomic factors also found to be clearly associated with menarcheal status. Early menarche in mothers was also found to have a significant impact and to be a key predictor of menarcheal status in daughters. No significant difference between EAM and NEM girls was observed here for weight, BMI and body composition traits, although EAM girls did have marginally higher mean anthropometric and body composition trait values. Future research will need to explore the relationship between timing of menarche and peak height growth velocity in girls from 9 to 18 years of age in the entire available database (Conacyt project). Further analyses using the Conacyt project database and/or other data sources will need to widen the age range to better understand how AAM is associated with adiposity and body composition traits, or conversely, the effects it may have on overweight and obesity rates in late adolescence.

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