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Article

Age at menarche in urban Argentinian girls: association with biological and socioeconomic factors

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With 3 figures and 3 tables

Summary: Age at menarche is regarded as a sensitive indicator of physical, biological, and psychosocial environment. The aim of this study was to determine the age at menarche and its association with biological and socioeconomic factors in girls from Santa Rosa (La Pampa, Argentina). An observational cross-sectional study was carried out on 1,221 schoolgirls aged 9–15 years. Menarche data were obtained by the *status-quo* method. Height, sitting height, weight, arm circumference, tricipital and subscapular skinfolds were measured. We also calculated body mass index, measures of body composition and proportions, and fat distribution. To assess socioeconomic factors, parents completed a self-administered questionnaire about their occupation and education, family size, household, and other family characteristics. The median age at menarche − estimated by the logit method − was 12.84 years (95 % CI: 12.71, 12.97). Compared with their premenarcheal age peers, postmenarcheal girls had greater anthropometric dimensions through age 12. After this age, only height was higher in the latter group. Data were processed by fitting two logistic regressions, both including age. The first model included anthropometric variables and birth weight, while the second model included the socioeconomic variables. The significant variables derived from each model were incorporated into a new regression: height, sitting height ratio (first model), and maternal education (second model). These three variables remained significantly associated with menarche. The results suggest a relationship between linear growth and menarche and agree with those found in other populations where the advancement of menarche is associated with improved living conditions. In relatively uniform urban contexts, maternal education may be a good proxy for the standard of living.

Key words: menarche, anthropometry, socioeconomic status.

Introduction

Adolescence is a transitional period, where physical, psychological, and social changes become remarkable. Menarche in particular, besides being a biologically detectable event, is considered in many cultures as a passage from childhood to adulthood (Garg et al. 2001, Yeung et al. 2005).

In girls, the onset of puberty is marked mainly by the adolescent growth spurt and menarche occurs about 1 year after the age of peak height velocity (Tanner 1962).

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Although the sequence of maturational changes during puberty follows a predictable progression, its onset is related to both genetic and environmental factors (Eveleth & Tanner 1990). Age at menarche reflects numerous health aspects of a population including the timing of sexual maturation, growth and nutritional status, and environmental conditions (Chumlea et al. 2003). Because of this relationship, age at menarche and age-at-menarche distribution may be appropriate estimators for the socioeconomic background of historic populations (Lehmann et al. 2010). Therefore, as expected, its occurrence varies among different populations and within populations over time.

Studies on variability of menarche comprise two main dimensions. The research focussing on a "temporal" dimension have reported a secular change with a consistent reduction in the age at menarche in both developed and developing countries (Kac et al. 2000, Chumlea et al. 2003, Padez & Rocha 2003, Ong et al. 2006, Cabanes et al. 2009, Jones et al. 2009, Cho et al. 2010). On a "spatial" dimension, the studies of different social groups, ethnic groups, or other categories within population highlight unique expressions of the interaction between biology and environment. For example, many studies have examined age at menarche according to socioeconomic status. Nevertheless, this relationship may be mediated by other factors such as nutritional status, urbanization, prenatal environment, ethnicity, family relationships, among others (Adair 2001, Ersoy et al. 2004, Wronka & Pawlińska-Chmara 2005, Hernández et al. 2007, Kirchengast & Bauer 2007, Braithwaite et al. 2009).

The aim of this study was to determine the current age at menarche in urban Argentinian schoolgirls aged 9–15 years and to identify its association with biological and socioeconomic variables.

Material and methods

Study area

Santa Rosa is the capital city and the main urban center of the province of La Pampa (Patagonia Argentina) inhabited by about 111,700 people. The city's economy is primarily based on the service sector, as evidenced by the net regional product, where the tertiary economic sector reaches 62 %. In the last few decades, population growth occurred along with a concomitant increase in public services and equipment (drinking water, sewage system, natural-gas supply, paving and public lighting, solid waste collection), covering a large portion of the population's needs. From a sociodemographic and epidemiological point of view, the city undergoes an aging of the population, showing an epidemiological profile defined by a predominance of non-communicable diseases as the major causes of morbidity and mortality (Anuario Estadístico de la Provincia de La Pampa 2008, MSA/OPS 2008).

Study design and participants

An observational cross-sectional study was performed on a non-probabilistic sample of 1,221 schoolgirls aged 9–15 years, who represent 17.8 % of this age range within the overall population of around 6,800 schoolgirls (Anuario Estadístico de la Provincia de La Pampa 2008). The study was carried out in public and private schools, selected from each neighborhood, from September to November, 2009. Permission from the Ministry of Culture and Education was obtained before the study. An informed consent was requested from the parents or legal guardians, who were previously informed about the objectives and methods of the study. Besides the parental consent we also required the assent of each girl. Research protocols were

approved by the Ministry of Culture and Education of La Pampa (Res.1674/09). All the protocols were performed following the recommendations of the Ethic Committee of the Instituto de Desarrollo e Investigaciones Pediátricas "Fernando E. Viteri" (IDIP-MS/CIC), and according to the principles expressed in the Declaration of Helsinki.

Data collection

Anthropometric assessment was performed at the school by the same observer (A.B.O.) following standardized procedures (Cameron 2004), with the subject wearing light clothing. Weight was measured to the nearest 0.1 kg with a digital scale (Tanita BF350), and height and sitting height measured to the nearest 0.1 cm with a mobile stadiometer (SECA S-213). We calculated sitting height ratio [SHR= (sitting height/standing height)*100] and body mass index [BMI = weight (kg)/height (m^2)]. Upper arm circumference (UAC) was measured in centimeters with a flexible steel tape, and tricipital and subscapular skinfolds (TS and SS, respectively) measured in millimeters with a Lange caliper (1 mm of accuracy). These last three measurements were used to estimate the upper-arm muscle and fat areas (UAMA and UAFA, respectively) (Frisancho 1990). The subscapular/tricipital index (STI) was used as an indicator of fat distribution. Each schoolgirl was asked to recall the age at which her menstruation began. Most of them did not remember exactly the date in years and months and only specified their age in years. For that reason we preferred to use the *status-quo* method, and data were coded to indicate whether or not each girl had reached menarche at the time of the assessment. Decimal age was calculated by subtracting the girl's birth date from the measurement date. The grouping by age was defined as follows: 9–11 (9.0–11.99 years), 12 (12.0–12.99 years), 13 (13.0–13.99 years), and 14–15 age group (14.0–15.99 years).

To assess socioeconomic factors parents completed a self-administered questionnaire that elicited information on household, physical amenities, and family characteristics. They also were asked about the birth date and birth weight of their daughters. Among the socioeconomic variables, we included parental occupation and level of formal education (primary, secondary or tertiary/university), family size, home-tenure status, crowding, and health insurance (medical insurance at the expense of the employer or private insurance). The characteristics providing information on building materials of the house and public services were collectively described as environmental variables (Table 1).

Data analysis

The reliability measurements fell within acceptable values. Anthropometric measurements and indices were standardized to age-specific z scores. We used CDC/NCHS 2000 reference data (Kuczmarski et al. 2000) to standardize height, weight, and BMI along with NHANES (Frisancho 1990) to standardize variables of body proportions and composition. Anthropometric differences between pre- and postmenarcheal girls were compared by the Mann-Whitney test. Prevalences of underweight (BMI < 5^{th} centile), overweight ($85^{th} \leq$ BMI < 95^{th} centiles), and obesity (BMI $\geq 95^{th}$ centile) in both groups of girls were compared by the Chi-square test.

A logit model, with age in years as the independent variable, was used to calculate the median age at menarche and the 95 % confidence interval (CI). In this study we will refer to the term *age at menarche* in relation to the estimated median age at menarche. Logistic binary regression was used to model the association between menarche and the independent variables divided in two groups: (1) *biological*: birth weight, standardized anthropometric measurements and indices; and (2) *socioeconomic*: parental occupation and education, family size, home tenure, crowding, and healthcare. The level of statistical significance was set at 0.05. Data analysis was performed by means of the SPSS version 10.0 (SPSS, Inc., Chicago, IL).

Results

Formal employment was the main source of household income at around 60 % (Table 1). Between 33 and 35 % of the parents had completed secondary school and 13–18% had obtained tertiary or university degrees. Almost 75 % of the families were homeowners, composed of 4–5 members on the average. The mean degree of crowding was 1.8 persons/room and overcrowding was below 10 %. About 62 % of the families had healthcare insurance. Most of houses were built of brick, and except for paved streets, the frequency of public services was over 80 %.

The median age at menarche was 12.84 years (95 % CI: 12.71, 12.97) (Fig. 1). Twenty-five percent of the girls menstruated before 12.01 years of age and 75 % before 13.68 years of age. The estimated variance was 1.53 years^2.

Fig. 2 illustrates the anthropometric z scores by age group in pre- and postmenarcheal girls. Except for height and UAMA, all mean z scores were positive in both groups. Girls with menarche had higher values in almost all z scores than their age-

Table 1. Socioeconomic and environmental characteristics of the sample.

Variable	Definition/operationalization	Frequency (%)	Missing data
*Socioeconomic variables**			
Father's occupation	Formal occupation	69.5	
	Informal / Temporary worker	16.4	11.6
	Unemployed	2.5	
Mother's occupation	Formal occupation	59.5	
	Informal / Temporary worker	3.4	10.8
	Unemployed /Housewife	26.4	
Father's education	Primary	41.2	12.7
	Secondary	32.8	
	Tertiary/University	13.3	
Mother's education	Primary	39.6	
	Secondary	35.5	7.2
	Tertiary/University	17.7	
Family size	≤ 3 persons	13.7	
	4 to 5 persons	52.8	5.7
	≥ 6 persons	36.4	
Home tenure	Owner	74.7	3.1
	Tenant	22.2	
Crowding	≤ 3 persons by room	80.2	10.5
	≥ 4 persons by room	9.3	
Health insurance	With medical insurance	62.4	1.1
Environmental variables			
Housing materials	Brick	87.5	6.1
	Other materials	6.4	
Piped water	Main source of clean water	91.1	1.0
Natural gas	Piped gas for fuel and cooking	88.4	1.1
Sewage	Waste water disposal	84.4	1.1
Pavement	Paved street	61.4	1.1
Solid waste disposal	Waste collection	83.1	1.1

*variables included in the logistic analysis

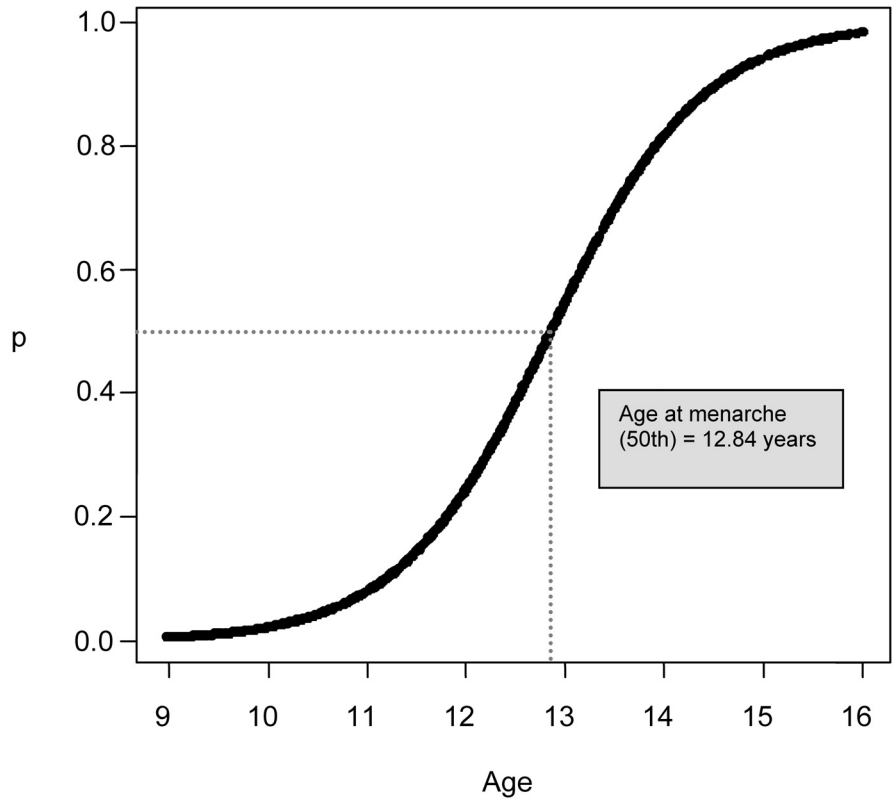

Fig. 1. Logit curve showing the distribution of menarche in girls from Santa Rosa and the 50th centile or median age at menarche.

matched peers without menarche. Table 2 presents the mean differences between z scores by age group and their statistical significance. On the average, postmenarcheal girls were 2.5 years older than their premenarcheal peers, and – through 12 years of age – had greater anthropometric dimensions. After this age, only height was significantly greater in postmenarcheal girls. Differences in birth weight were non significant in all the age groups.

Underweight reached only 2.9 %, with greater prevalence in premenarcheal (4.4 %) than postmenarcheal girls (0.8 %; $p < 0.01$). The rates of overweight and obesity were 13.5 and 7.2 %, respectively. Differences between-groups in overweight (12.6 vs. 14.9 %) and obesity (7.5 vs. 6.8 %) were non significant ($p > 0.05$).

Two logistic regression models − involving the backward method − were fitted; both included age. Birth weight, STI, and anthropometric z scores were used as explanatory variables in the first model. Some variables were removed because of their multicollinearity. Height and SHR remained as significant variables in this equation, both with positive coefficients, meaning that – at the same age – taller girls with higher SHR have an earlier menarche than shorter girls with lower SHR. For the second model we used the socioeconomic variables, with maternal education being

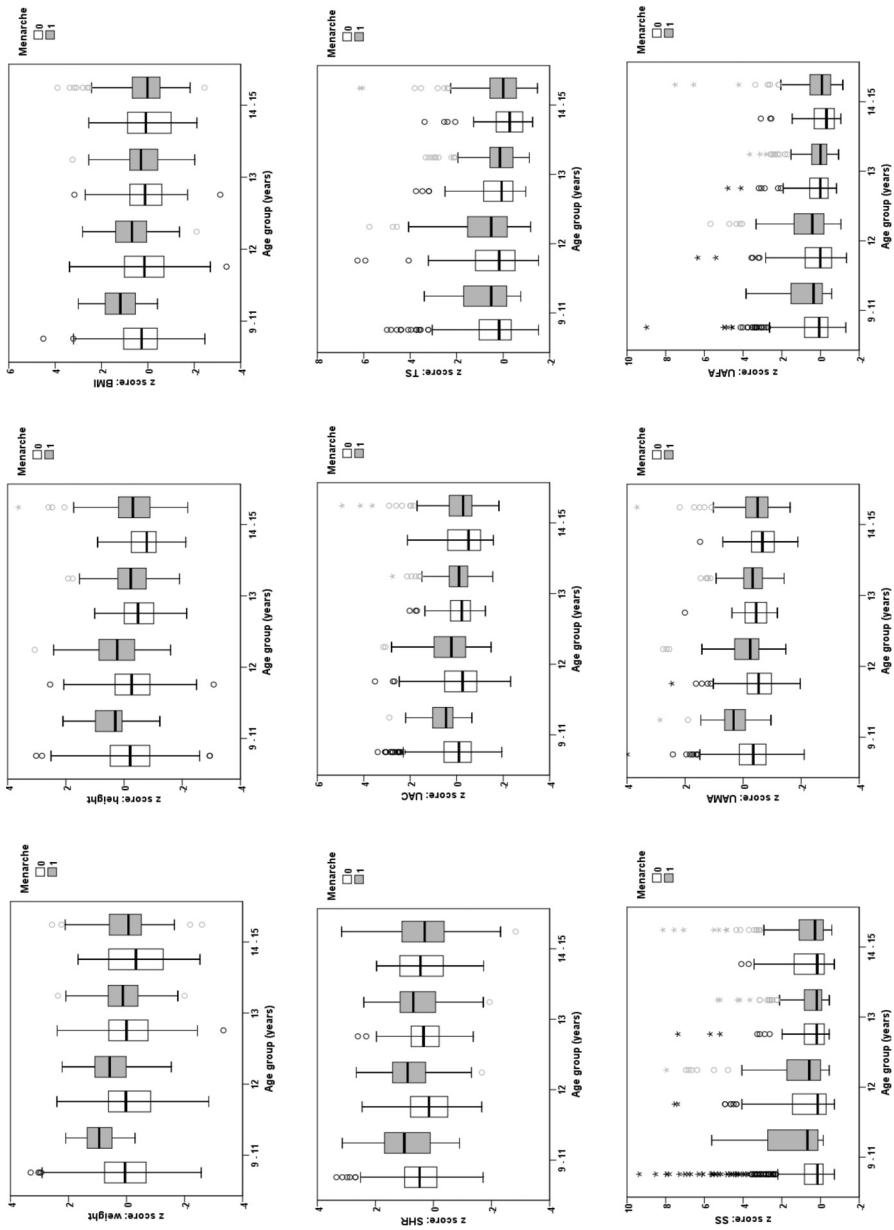

Fig. 2. Box-plot showing the distribution of the anthropometric z scores in premenarcheal (white boxes) and postmenarcheal girls (grey boxes).

the only variable that remained as significant. The median age at menarche decreased progressively from girls whose mothers had completed tertiary/university (12.53 years), secondary (12.77 years), and primary (13.06 years) education (Fig. 3).

Table 2. Mean differences in anthropometric comparisons between pre- and postmenarcheal girls according to age groups.

	Age groups (years)							
	9–11		12		13		14–15	
Variable	Prem – Postm	*p*-value	Prem – Postm	*p*-value	Prem – Postm	*p*-value	Prem – Postm	*p*-value
N (Prem – Postm)	516 – 33		121 – 102		52 – 153		34 – 210	
Mean age (decimal years)	10.5–11.4	0.000	12.5–12.6	0.171	13.4–13.5	0.122	14.7–14.7	0.345
Birth weight *z scores*	–17.8	0.858	–38.3	0.624	0.1	0.999	–4.6	0.963
Weight	–0.81	0.000	–0.63	0.000	–0.19	0.311	–0.28	0.153
Height	–0.63	0.000	–0.54	0.000	–0.32	0.019	–0.34	0.031
BMI	–0.80	0.000	–0.55	0.000	–0.05	0.704	–0.16	0.479
SHR	–0.42	0.020	–0.61	0.000	–0.16	0.119	–0.02	0.961
UAC	–0.64	0.000	–0.49	0.000	0.04	0.544	–0.21	0.116
TS	–0.36	0.051	–0.39	0.010	0.22	0.826	–0.14	0.242
SS	–0.71	0.002	–0.32	0.003	0.18	0.645	–0.12	0.441
UAMA	–0.67	0.000	–0.40	0.000	–0.11	0.170	–0.18	0.115
UAFA	–0.41	0.013	–0.40	0.004	0.19	0.950	–0.13	0.168
STI	–0.22	0.000	–0.03	0.357	–0.03	0.297	–0.01	0.890

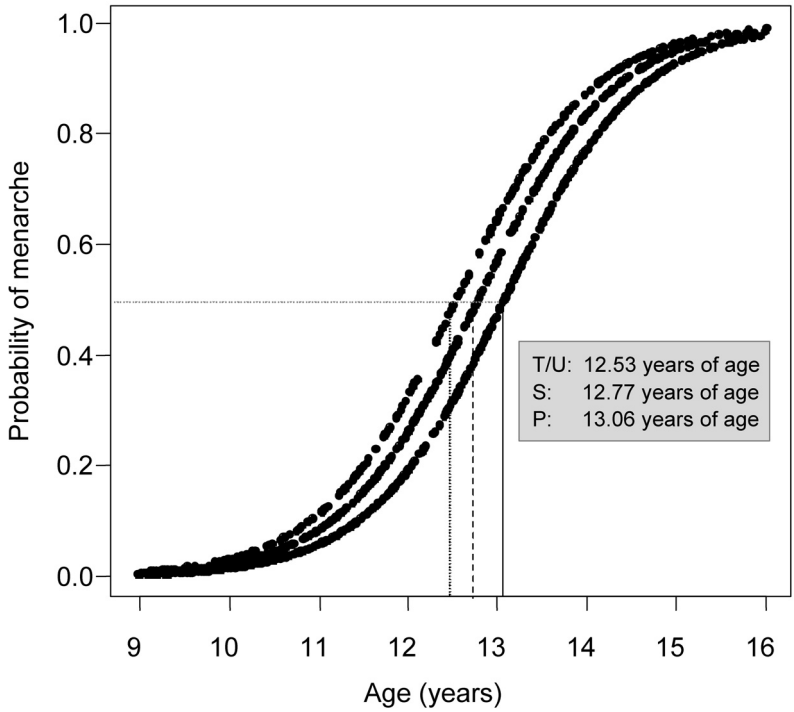

Fig. 3. Median age at menarche according to mother's education: tertiary/university degree (T/U: dotted line), secondary schooling (S: dashed line), and primary schooling (P: solid line). Differences between groups are significant ($p < 0.05$).

The significant variables of these two models were used to rebuild a new regression; this new model confirmed all these parameters as significantly associated with age at menarche (Table 3).

Discussion

Beyond the specific differences within the extensive literature on the subject, our results are consistent with the globally described differences in size, shape, and body composition and proportions between pre- and postmenarcheal girls (Hegg & Hegg 1980, Biassio et al. 2004). Such differences were particularly observed in girls twelve years old and under. Older girls were physically similar, regardless of their menarcheal status. Height, nevertheless, was always greater in postmenarcheal girls – consistent with the regression model, where height was a predictive variable of menarche.

A study by Ellison (1982) found that height velocity was a stronger predictor of menarche than weight. He suggested that age at menarche was closely related to skeletal maturity, and height was an accurate measure of bone growth and skeletal age in childhood. The relationship of childhood height to menarcheal age may, therefore,

Table 3. Logistic regression model showing variables significantly associated with menarche.

Variable	Coef. (ß)	*p*-value	Exp. (ß)
Age	15.153	0.000	4.55
z score Height	0.7834	0.000	2.19
z score SHR	0.5574	0.000	1.75
Mother's education (Secondary)	0.2612	0.199	1.30
Mother's education (Tertiary/University)	0.6007	0.016	1.82

indicate that children with an advanced skeletal maturation (as indicated by height) tend also to have an advanced sexual development (as indicated by menarcheal age; Freedman et al. 2002). Koprowski et al. (1999) also found that skeletal development − as measured by height − was related to menarche. With age at initial assessment held constant, taller girls were more likely to experience menarche at an earlier age. Our results may be interpreted in the similar manner. Although girls who reached menarche had higher anthropometric values than premenarcheal girls – especially in girls younger than thirteen years of age – body weight and BMI, as well as the direct indicators of adiposity (skinfolds), arm fat and muscle mass, were not *per se* significantly associated with the presence of menarche. On the contrary, the girls with greater height and a larger trunk-cephalic ratio had a higher probability of menarche. These findings suggest that the timing of menarche may be determined by linear growth rather than weight.

Focused on the corporal shape, Greil & Kahl (2005) found that girls with a leptomorphic body type had a later menarche than pyknomorphic girls, characterized by higher weight for height, more subcutaneous fat, and higher total body fat. In fact, the advancement of menarche is frequently linked to nutritional status, specifically to an increased prevalence of overweight and obesity (Anderson et al. 2003, Vitalle et al. 2003, Hernández et al. 2007, Amigo et al. 2010). Wronka (2010) reported that the relationship between higher BMI and early menarche occurs regardless of socioeconomic status (SES). The results are not consistent, however. To cite a few examples, a prospective cohort study showed no influence of BMI or BMI increments before menarche on the age at menarche (Banerjee et al. 2007). Some cross sectional studies have found no association between overweight and obese girls and their age at menarche (Kinchergast & Bauer 2007). In agreement, we found similar prevalences of overweight and obesity among pre- and postmenarcheal girls, which result confirmed why the BMI was not a significant predictor in the regression model.

Prenatal factors may have long-term effects on growth and maturation. Because birth weight reflects intrauterine conditions, some variations in the age at menarche have been related to low birth weight (Cooper et al. 1996, Adair 2001, Karlberg 2002). Not all the studies have reported such a correlation, however (Stark et al. 1989). In this work we have not found any difference in birth weight between pre- and postmenarcheal girls, and the prevalence of low birth weight (< 2500 g) was below 7 %, indicating that birth weight was not a relevant explanatory variable.

Research on age at menarche suggests that this event is highly variable across populations, in addition to genetic variability. Several national surveys have shown an overall downward trend, although in some countries this reduction seems to have decreased or even ceased (Cho et al. 2000, Papadimitriou et al.

2008, Gohlke & Woelfle 2009, Gaudineau et al. 2010, Rigon et al. 2010). In developing countries, socioeconomic inequalities and life settings are still prominent and might account for significant variations in the timing of puberty within and among countries (Eveleth & Tanner 1990). In these countries, secular trends can still be observed because of current changes in living standards, when comparing either different countries or girls of different SES from the same country (Parent et al. 2003, Ong et al. 2006).

Argentina has few published studies on the subject, making it difficult to establish whether or not there were changes, and if so, whether the latter were positive or negative. Much of the current data were published after the study by Lejarraga et al. (1980) in girls from middle SES of La Plata, Province of Buenos Aires, who reported a median age at menarche of 12.69 years. Similar results were documented in middle-SES girls from Buenos Aires by De la Parra et al. (1995). In the city of Córdoba, Zurlo de Mirotti et al. (1995) estimated the age at menarche in upper-middle-SES girls. On the average, menarche occurred at 12.59 and 12.75 years of age (retrospective and prospective data, respectively) in girls sampled between 1970 and 1980 and at 12.36 years of age (prospective) in girls sampled between 1981 and 1990.

More recently, Del Pino et al. (2005) reported an age at menarche of 12.45 years based on a national cross-sectional survey, while the national survey of health and nutrition (ENNyS 2007) provided a slightly lower estimate of 12.40 years. This figure was slightly higher (12.46 years) in low-SES women. For the Patagonian region, the available data were published by Ruiz-Muñoz & García-Moro (2007), who studied almost half of the students of Carmen de Patagones, Province of Rio Negro and estimated an age of 12.40 years. Our results indicate a later age at menarche (12.84 years), but the lack of previous data on this population does not allow an assessment of changes over time. Currently available evidence, rather than suggesting any positive secular trend, as stated by Ruiz-Muñoz & García-Moro (2007), would indicate a marked variability in this maturational milestone. This variation is the outcome of both genetic and environmental factors. In this study we aimed at investigating the latter, focussing especially on socioeconomic variables. The variance of 1.5 years^2 indicates that suboptimum SES still contribute to about one third of the menarcheal age variance of our population, since affluent societies tend to show a variance near 1 year^2 (Lehmann et al. 2010).

In general, SES is described in terms of income, parental schooling, household assets, family size, and other factors; or a combination of them. Nevertheless, these indicators can vary, depending on their measurement, and may be differently expressed within different contexts (Parent et al. 2003). Wronka & Pawlińska-Chmara (2005) analyzed urbanization, population size, parental education, and the number of children in a family. They found that in large urban cities, the father's education was associated with an earlier menarche, while in smaller populations the number of children was a better indicator. They did not find any effect of maternal education on menarche. In contrast, we found a significant association between maternal education and age at menarche, indicating that menarche came earlier in girls whose mothers had a higher level of education. The literature on child health and nutrition in a socioeconomic context suggests that mothers play a central role in household and child-rearing activities. As a result, the mother's education has been commonly described as a key determinant of child health. Maternal education enhances child health through better knowledge, greater access to new information,

and more efficient allocation of resources as well as through increasing the family income via maternal participation in economic activities (Armar-Klemesu et al. 2000, Rubalcava & Teruel 2004, Levandowski et al. 2006). Additionally, urban women usually have more schooling, thus increasing the possibilities for them to obtain more highly qualified jobs and higher wages (Ruel 2000). In the present study maternal education was correlated with other measures of SES, but was the single variable that remained associated with menarche, thus suggesting that in relatively uniform urban contexts maternal education may be considered a good proxy for the standard of living.

Conclusions

In contrast to the widely reported correlation between body weight or body fat and menarche, we found that menarche is more closely associated with linear growth, but the numerous changes that occur before menarche – a late maturation event − make it difficult to identify which factor is causative. Only cohort-prospective studies can provide more accurate information in order to establish the changes that operate as causative of menarche. Among the socioeconomic factors, we found that maternal education is the only variable associated with menarche. These results and those reported in the literature suggest that the determinants of menarche are numerous and complex, their relationships are not necessarily linear, and their effects are not always consistent, probably because of the diversity of contexts in which they arise and become manifest. For these reasons, further studies addressing this complexity need to be undertaken.

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