

## Pubertal Development in Caracas Upper-Middle-Class Boys and Girls in a Longitudinal Context

COROMOTO MACÍAS-TOMEI,<sup>1\*</sup> MERCEDES LÓPEZ-BLANCO,<sup>1,2</sup>  
ISBELIA ESPINOZA,<sup>1</sup> AND MAURA VÁSQUEZ-RAMÍREZ<sup>3</sup>

<sup>1</sup>*Departamento de Auxología, División de Investigaciones Biológicas,  
Fundacredesa, Caracas, Venezuela*

<sup>2</sup>*Fundación Cavendes, Caracas, Venezuela*

<sup>3</sup>*Escuela de Estadística, Universidad Central de Venezuela,  
Caracas, Venezuela*

**ABSTRACT** Changes between pubertal stages (PS) are best analyzed in a longitudinal context. A sample of 67 boys and 48 girls from the Caracas Longitudinal Study who presented data for the full range of pubertal development: genitalia (G2–G5), breast (B2–B5), pubic hair (PH2–PH5), axillary hair (AH2–AH3), and age at menarche (AM) during follow-up, were assessed at clinical examination. Medians and standard errors for ages at each stage were estimated with the logit method. For length of intervals between stages of genitalia, breast, pubic hair and axillary hair, intervals B2–M and PH2–M, survival analysis was used according to life tables and Cox regression analysis. In boys, G2 occurred at 11.61 years; in girls, B2 occurred at 10.35 years and AM at 12.55 years of age. In both sexes, length of the intervals PS 2–3 and 3–4 were approximately 1 year, while PS 4–5 was 1.5 years. Duration of puberty reached 3.7 years in boys (G2–G5) and 3.3 years in girls (B2–B5); corresponding intervals for PH2–PH5 were 3.1 and 3.0 years in boys and girls, respectively. B2–AM was 1.8 years (with a range of 0.3–3.6 years) and PH2–AM was 1.5 years (with a range 0.3–3.5 years). These results are useful for screening and monitoring: identifying abnormal pubertal patterns in subjects who are advanced or delayed with respect to their peers, together with other pubertal events such as age at peak height and weight velocity and skeletal age. *Am. J. Hum. Biol.* 12:88–96, 2000. © 2000 Wiley-Liss, Inc.

Adolescence, as described by the World Health Organization (WHO), comprises the years of transition between childhood and adulthood, from 10 to 19 years of age. This definition is vague in terms of physical maturation. Puberty relates to sexual maturity and to the physical and functional changes that take place during adolescence. Variations both between and within populations have been described in the onset of puberty and its duration, and related to genetic and environmental factors and their interrelationships (Tanner, 1962, 1978; Marshall and Tanner, 1969, 1970, 1986; Cameron, 1994). Variation in pubertal development is described in terms of the sequence of events, age at entry of each event, and onset and duration of puberty.

The objective of this study is to describe

the pattern of sexual maturation of upper strata Venezuelans and its variation, particularly the estimation of intervals between pubertal stages in both sexes, and the intervals between the initiation of puberty—in terms of breast and pubic hair development—and menarche in girls.

### MATERIALS AND METHODS

The Caracas Mixed-Longitudinal Study was conducted between 1976 and 1982 (López-Blanco et al., 1995a) in upper strata

Contract grant sponsors: CONICIT, Fundación Cavendes Fundacredesa; contract grant number: S1-541.

\*Correspondence to: Coromoto Macías-Tomei, Center for Studies on Growth and Development of the Venezuelan Population, FUNDACREDESA, P.O. Box 61660, Chacao, Caracas 1060-A, Venezuela. E-mail: omacias@usb.ve; j0018324-1@cantv.net

Received 26 January 1998; Revision received 25 January 1999; Accepted 26 January 1999

TABLE 1. Stages of sexual maturation: median ages at entry in boys (years)

Pubertal stages	N	Median age	SE	Minimum	Maximum	IQR
G2	67	11.61	0.08	9.00	13.50	0.57
G3	67	12.57	0.09	10.97	14.52	0.84
G4	67	13.58	0.11	11.83	15.61	1.22
G5	62	14.75	0.12	12.68	17.02	1.52
PH2	67	11.76	0.10	10.50	14.16	0.93
PH3	67	12.56	0.10	11.35	14.75	1.26
PH4	67	13.55	0.11	12.10	15.61	1.62
PH5	62	14.58	0.13	12.69	17.03	1.55
AH2	74	12.53	0.14	10.22	15.79	1.75
AH3	74	13.82	0.13	11.66	16.54	1.39

IQR: interquartile range; SE: standard error; G: genitalia; PH: pubic hair; AH: axillary hair.

TABLE 2. Stages of sexual maturation: median ages at entry in girls (years)

Pubertal stages	N	Median age	SE	Minimum	Maximum	IQR
B2	48	10.35	0.20	7.42	12.01	2.52
B3	48	11.00	0.18	8.17	13.21	2.06
B4	48	11.96	0.17	9.64	15.04	1.88
B5	46	14.00	0.17	10.70	16.53	1.67
PH2	50	10.50	0.18	7.41	13.07	2.22
PH3	50	11.44	0.17	8.55	14.42	1.82
PH4	50	12.37	0.16	9.70	15.56	1.84
PH5	45	13.98	0.18	10.70	16.54	1.44
AH2	62	11.30	0.15	7.95	12.70	1.63
AH3	62	12.22	0.13	9.70	14.17	1.21
AM	48	12.55	0.14	9.55	15.96	1.28

IQR: interquartile range; SE: standard error; B: breast; PH: pubic hair; AH: axillary hair; AM: age at menarche.

healthy children classified according to Graffar's modified method (Méndez Castellano and Méndez, 1994). The total sample consisted of 254 boys and 200 girls who were healthy and apparently normal, and who started follow-up at ages 4, 8, and 12 years of age. The comprehensive study included 19 anthropometric variables, skeletal maturity assessment with the TW2 and Greulich-Pyle methods, and puberty assessment. Clinical, neurological, psychological, biochemical, odontological, and food consumption variables were also included. A subsample of 67 boys and 48 girls, who presented data for the full range of pubertal maturation, was chosen. They were examined at 3-month intervals over 5 years. A total of 1,485 examinations were performed with a mean of  $13.4 \pm 3$  visits.

The social stratification method proposed by Graffar for Belgium was adapted for Venezuela by Méndez Castellano (Méndez Castellano and Méndez, 1994). It is based on four variables: profession of the head of the family, mother's education level, main source of income, and housing conditions. In each of these variables, there are five items with an increasing numerical importance

(1–5) as the quality of life decreases. The sum of the items determines the social stratum of the family; the highest score corresponds to the lowest social level: stratum I (scores 4, 5, 6), stratum II (scores 7, 8, 9), stratum III (scores 10, 11, 12), stratum IV (scores 13, 14, 15, 16), and stratum V (scores 17, 18, 19, 20). The highest social level is strata I+II, middle class corresponds to stratum III, working class to stratum IV, and the marginal class to stratum V.

Pubertal stages (PS) were assessed using the criteria of Tanner (1978; see also Marshall and Tanner, 1969, 1970) at clinical examination without knowledge of previous ratings: genitalia (G) in boys, breast (B) in girls, pubic hair (PH) and axillary hair (AH) in both sexes. Age at menarche (AM) was assessed with the recall method, considering the brief intervals between visits (Marshall and Tanner, 1986; Izaguirre-Espinoza et al., 1989; Koo and Rohan, 1997).

Length of intervals between PS were defined as the time in years between two successive stages. The estimation of the duration of puberty was defined as the interval between G2, B2, PH2, and AH2 and adult stages (G5, B5, PH5, AH3).

TABLE 3. *Intervals between stages of sexual maturation in boys (years)*

Interval	N	Median	Minimum	Maximum	IQR
G2-G3	67	1.03	0.31	2.13	0.34
G3-G4	67	1.02	0.29	2.33	0.42
G4-G5	62	1.27	0.30	2.99	0.95
G2-G5	62	3.75	2.01	5.52	1.04
PH2-PH3	67	1.00	0.31	2.28	0.50
PH3-PH4	67	0.98	0.25	2.68	0.47
PH4-PH5	62	1.09	0.30	2.73	0.61
PH2-PH5	62	3.15	2.01	5.26	1.26
AH2-AH3	62	1.11	0.35	2.68	0.89

IQR: interquartile range; G: genitalia; PH: pubic hair; AH: axillary hair.

Medians and standard errors of ages at each PS and AM were estimated by the logit method (Ashton, 1972). A chi-square was used to test the goodness of fit; no significant differences were found.

Survival analysis included two methods: "Life Tables" (Miller, 1981) in terms of the probability of the occurrence of the event, using intervals of 0.5 years for PS and yearly intervals for the duration of puberty, and Cox regression analysis, for the intervals B2-AM and PH2-AM, by which "age at entry" (B2 or PH2) was associated to the length of these intervals (Cox and Oakes, 1990).

## RESULTS

### *Stages of sexual maturation in boys and girls*

The median ages of entry to each stage of sexual maturation in boys and girls are presented in Tables 1 and 2, respectively. Median ages are earlier than corresponding medians in the cross-sectional analysis of the total sample due to the fact that confidence intervals are more accurately documented in a longitudinal methodology.

Onset of puberty in boys, based on G2, occurred between 9.0 and 13.5 years of age, with a median of 11.6 years. G5 varied between 12.7 and 17.0 years, with a median of 14.7 years. PH2 started between 10.5 and 14.2 years of age (PH2) with a median of 11.8 years, while PH5 varied between 12.7 and 17.0 years, with a median of 14.6 years. PH2 was earlier than the British reference due in part to the earlier maturation of Venezuelans and also to the fact that the ratings were made from photographs in the British sample. AH2 started between 10.2 and 15.8 years, with a median of 12.5 years; it is a late event in pubertal development. At 11.7 years, some boys had already

reached AH3, the adult stage, while others reached it as late as 16.5 years, with a median of 13.8 years (Table 1).

Onset of puberty in girls started with B2 in 85% of the sample, with a range between 7.4 and 12.0 years of age and a median of 10.3 years. B5 occurred between 10.7 and 16.5 years, with a median of 14.0 years, similar to the British reference. PH2 started between 7.4 and 13.1 years of age, with a median of 10.5 years. PH5 varied between 10.7 and 16.5 years, with a median of 14.0 years. AH2 started between 7.9 and 12.7 years of age, with a median of 11.3 years. AH3 varied between 9.7 and 14.2 years, with a median of 12.2 years. AM occurred late and varied between 9.5 and 16.0 years of age, with a median of 12.5 years. AM occurred, on average, 6 months (0.5 years) after B4, 2 months after PH4, and 4 months (0.33 years) after AH3 (Table 2).

The sequence of events was similar to reference values, with an earlier onset of puberty compared to the British reference (Marshall and Tanner, 1969, 1970, 1986), while G5, B5, and PH5 were similar to the Venezuelan reference derived from Project Venezuela (Méndez Castellano et al., 1995). This tendency toward an early maturation has been reported previously for height, weight, and sexual and skeletal maturation. When Venezuelans are compared to the British reference, differences in size are smaller before puberty, while afterwards they increase with age; this occurs even in children from the upper strata, whose quality of life is comparable to that of children from industrialized countries; the medians for the Venezuelan population approach the British median during puberty and, at the end of growth, approximate the 25<sup>th</sup> centile. The rapid skeletal maturation is most evident when the RUS TW2 method is used, especially in girls. The Venezuelan median

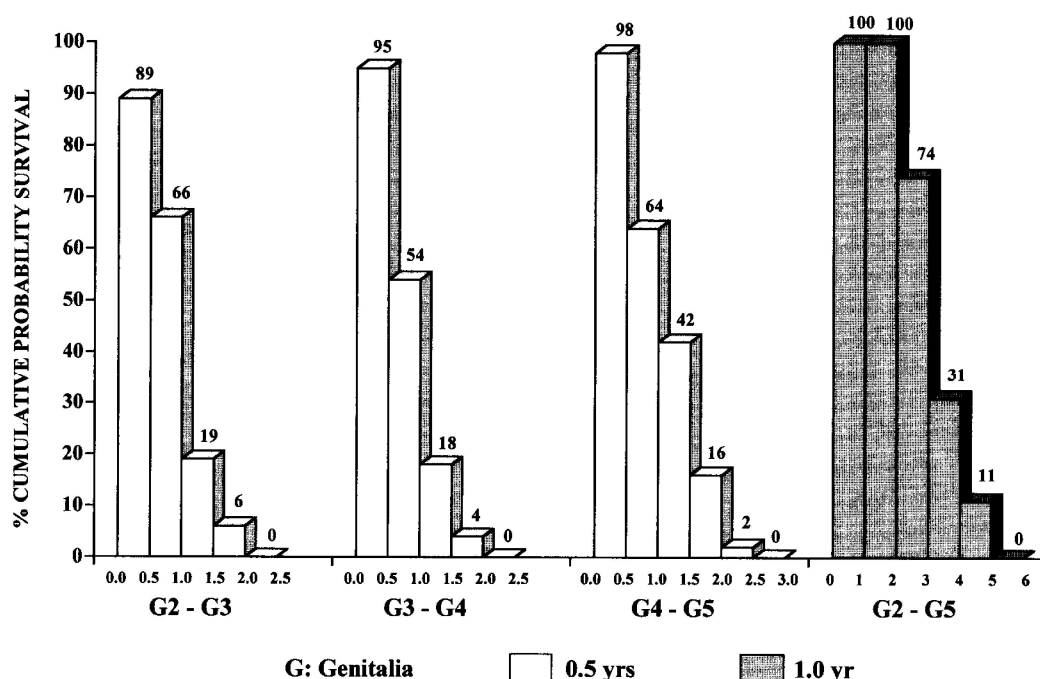


Fig. 1. Cumulative probability survival: intervals in years between stages of genitalia development (G2-G3, G3-G4, and G4-G5). Clear bars indicate intervals of 0.5 years between stages. Shaded bars indicate intervals of 1.0 year from the onset of puberty (G2) to adult stage (G5).

at 11 years of age reaches the 90<sup>th</sup> British centile (Izaguirre de Espinoza et al., 1989; López-Blanco et al., 1995b,d; Macías-Tomei et al., 1995). The early maturation of Venezuelans has also been reported for age at peak height velocity (APHV), 13.6 years in boys and 11.5 years in girls (López-Blanco et al., 1994, 1995c).

#### *Intervals between stages in boys*

The median length of intervals between stages G, PH, and AH was approximately 1.0 year, with a range of 0.3–3.0 years. The duration of puberty from G2 to G5 was longer than PH2 to PH5, 3.7 and 3.1 years, respectively, with a similar range of 2.0–5.5 years (Table 3).

At the end of the first year of follow-up after “age at entry” into stages G2, G3, and G4, more than one-half of the boys remained in the same stage of development. This probability diminished greatly at 2 years of follow-up, at which time a change in stages had occurred in all boys. Two years after the start of puberty (G2, PH2), none of the boys had reached the adult stage (G5, PH5), but

4 years after G2, over one-fourth (31%) of the boys had not attained G5 (Fig. 1).

The probability of a boy remaining in the same stage of PH development was high at 0.5 years of follow-up; however, at the end of the first year after PH2 and PH3, one-half of the boys had attained the adult stage. In the interval after PH4, 62% of the boys remained in this stage. Although AH2 occurred later than G2 and PH2, the interval between “age at entry” and the adult stage was shorter, so that 1.5 years after AH2 only 34% of the boys remained in this stage (Fig. 2).

#### *Intervals between stages in girls*

The median length of intervals between B, PH, and AH showed greater variation. Intervals were as short as 0.2 years and as long as 2.7–3.0 years. The duration of puberty from B2 to B5 was longer than PH2 to PH5: 3.3 and 3.0 years, respectively, with a range of 2–5.5 years (Table 4).

The probability of a girl remaining in the same stage of breast development varied according to stage. It was low for B2 to B3, due

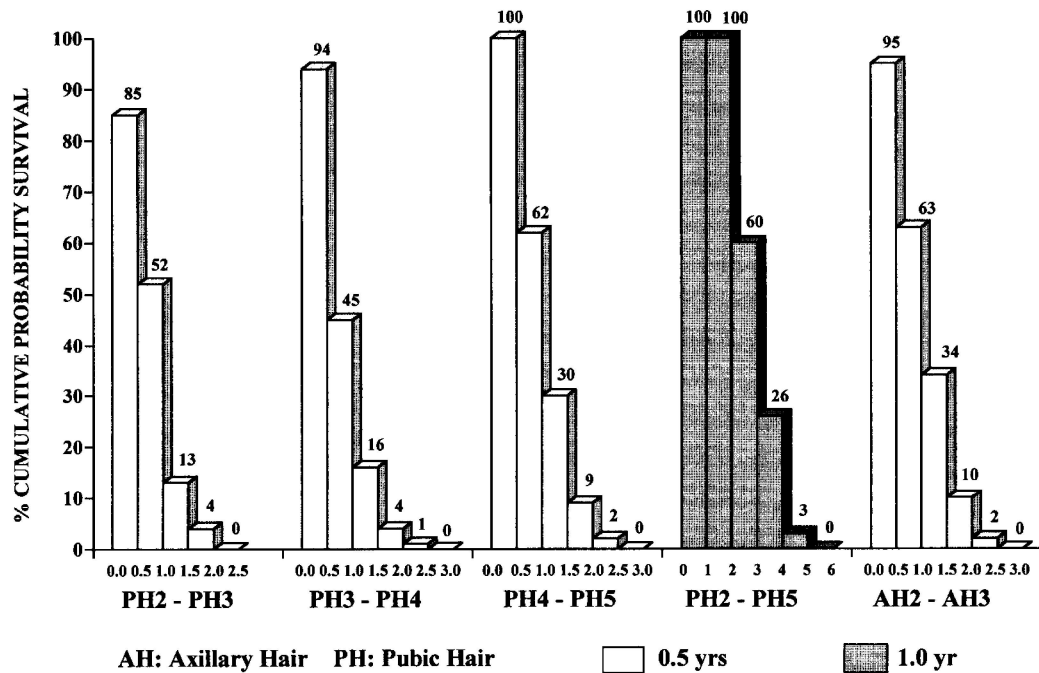


Fig. 2. Cumulative probability survival in years between stages of pubic hair (PH2-PH3, PH3-PH4, and PH4-PH5) and axillary hair (AH2-AH3) development in boys. Clear bars indicate intervals of 0.5 years between stages. Shaded bars indicate intervals of 1.0 years from the onset of puberty (PH2) to adult stage (PH5).

TABLE 4. Intervals between stages of sexual maturation in girls (years)

Interval	N	Median	Minimum	Maximum	IQR
B2-B3	48	0.69	0.20	2.16	0.65
B3-B4	48	1.32	0.35	2.96	0.89
B4-B5	32	1.27	0.70	2.25	1.03
B2-B5	32	3.27	2.05	6.18	1.33
PH2-PH3	48	1.00	0.20	2.72	0.50
PH3-PH4	48	0.77	0.24	1.96	0.35
PH4-PH5	32	1.59	0.51	2.25	0.98
PH2-PH5	32	3.01	2.05	5.34	1.28
AH2-AH3	48	1.08	0.33	3.12	0.69
B2-AM	46	1.78	0.31	3.60	0.69
PH2-AM	46	1.53	0.30	3.50	0.82

IQR: interquartile range; B: breast; PH: pubic hair; AH: axillary hair; AM: age at menarche.

to the fact that at the end of the first year after B2 a change in stage occurred in most of the girls. The probability for intervals B3-B4 and B4-B5 was greater at the end of the same period (Fig. 3).

At the end of the first year of follow-up, one-half of the girls were still in PH2 and 31% were in PH3. At the end of the second year, the probability of remaining in the same stage was minimal. In contrast to the interval PH4-PH5, the change of stage had not occurred in 37% of the girls at the end of

the second year of follow-up. Although AH2 occurred later than B2 and PH2, the interval between "age at entry" and the adult stage was shorter; 1.5 years after AH2, only 31% of the girls remained in this stage (Fig. 4).

Two years after the onset of puberty (B2/PH2), none of the girls had reached the adult stage (B5/PH5); 4 years after B2, only one-half of the girls had attained B5 and 4-6 years after B2 one-third of the girls had not attained B5. Thus, B2-B5 was more pro-



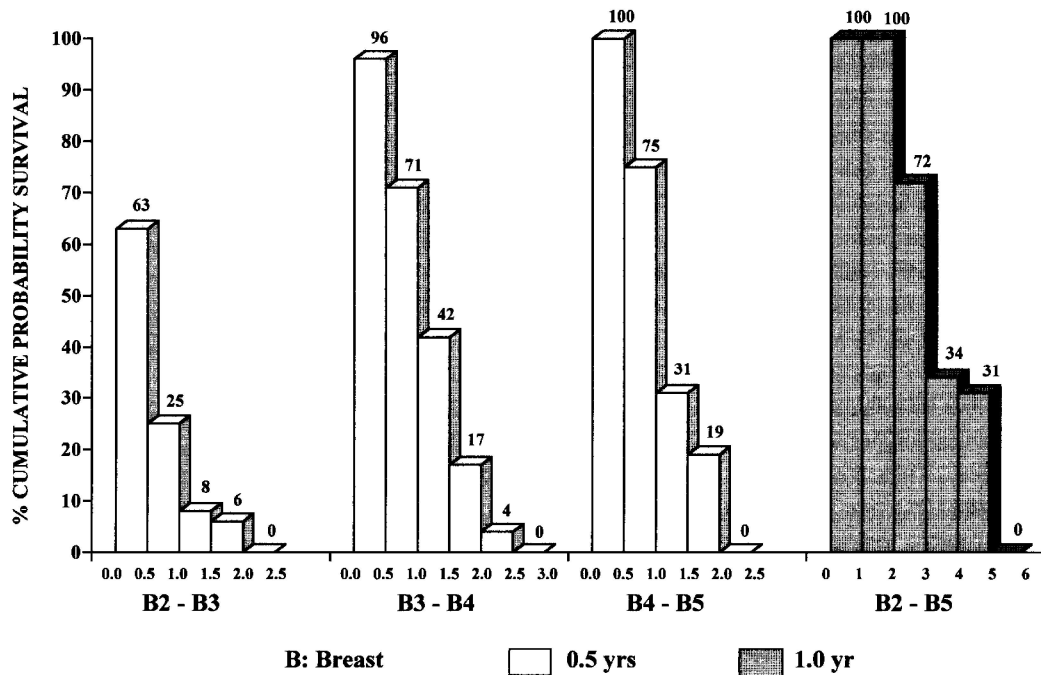


Fig. 3. Cumulative probability survival: intervals in years between stages of breast development (B2-B3, B3-B4, and B4-B5). Clear bars indicate intervals of 0.5 years between stages. Shaded bars indicate intervals of 1.0 year from the onset of puberty (B2) to adult stage (B5).

longed than PH2-PH5. This pattern was similar to data derived from Project Venezuela (López-Blanco et al., 1995b) and the British reference (Tanner, 1978; Marshall and Tanner, 1986).

#### *Interval between onset of puberty and age at menarche*

The median length of B2-AM and PH2-AM was 1.8 and 1.5 years, respectively, with a large range: 0.3 to 3.5-3.6 years (Table 4). The curve that describes the probability that menarche (M) had not occurred at the end of a time interval (Fig. 5) presented a steep slope between 1 and 2 years of follow-up after the start of puberty (B2). Thus, the probability that M had not occurred at the end of the first and third years after B2 were 0.97 and 0.17, respectively. This is explained by the fact that B2 is the first overt event of puberty and M is a relatively late event. The Cox regression analysis indicated that B2 did not significantly influence the length of the interval B2-AM ( $P = 0.086$ ).

The curve that describes the probability

that M had not occurred after PH2 was similar to the B2-AM curve, although changes were less intense after 2 years. The probability that M had not occurred at the end of the first year after PH2 was 0.89; on the other hand, 2 years after PH2 the probability that M had not occurred dropped to 0.24, indicating that most girls presented AM in this interval. The Cox regression analysis indicated that PH2 did not significantly influence the length of interval PH2-AM ( $P = 0.063$ ) (Fig. 5).

#### DISCUSSION

Age at entry was earlier in the present study compared to the Italian Mixed-Longitudinal Study (Nicoletti, 1992): 0.25 years in boys (G2 and PH2) and 0.3 years in girls (B2). The interval G2-G4 and PH2-PH4 was 0.5 and 1.6 years greater in Venezuelan boys, while the corresponding interval in girls was similar. Compared to the Swedish Longitudinal Study (Taranger et al., 1976), age at entry in both sexes and age at menarche occurred 0.5 years earlier. The interval between age at entry and the end of

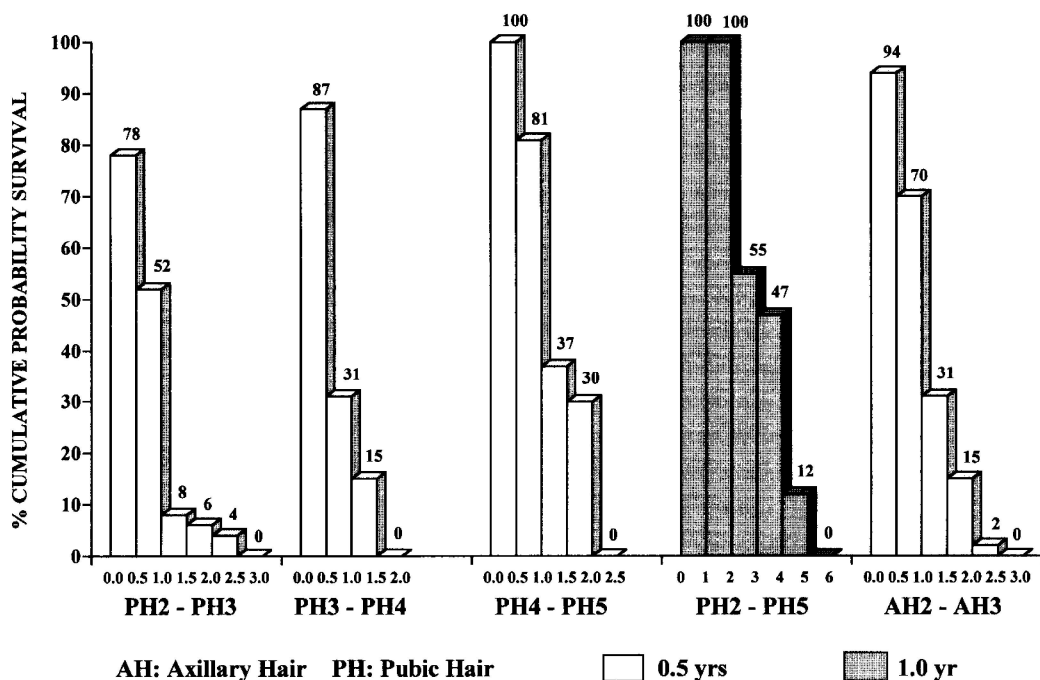


Fig. 4. Cumulative probability survival in years between stages of pubic hair (PH2-PH3, PH3-PH4, and PH4-PH5) and axillary hair (AH2-AH3) development in girls. Clear bars indicate intervals of 0.5 years between stages. Shaded bars indicate intervals of 1.0 years from the onset of puberty (PH2) to adult stage (PH5).

puberty was more prolonged in Venezuelan boys and shorter in girls, due to the fact that B5 was very late in the Swedish sample. Compared to the British reference (Marshall and Tanner, 1969, 1970), age at entry in boys was similar in G2, while PH2 occurred 1.7 years earlier. As reported by others in European populations (Bourguignon, 1984; Dacou-Voutetakis et al., 1983; Onat and Ertem, 1996), age at menarche is a late event of puberty.

Compared to European longitudinal studies, Venezuelan youth seem to mature earlier. Are Venezuelans similar to other Latin American populations? Although Latin American longitudinal studies are not available for comparison, cross-sectional results from Cuba (Jordán, 1979) and from the Mexican American population serve as a comparison. Venezuelan girls start puberty earlier than Cubans in breast or pubic hair development, but Venezuelan boys start up to 1 year earlier when PH2 is considered, and present a median age of G2 only 0.2 years earlier compared to Cuban boys.

When Venezuelan youth are compared

with Mexican Americans in the Hispanic Health and Nutrition Examination Survey, a possible bias must be considered due to the fact that the Mexican American sample covered the age range of 10-17 years, which by definition excluded very early maturers. In addition, the sample was from the largely lower economic stratum (Villareal et al., 1989). Venezuelan boys attained G2 0.3 years earlier and the difference reached 0.6 years for G5. PH2 was 0.6 years earlier, while the medians of PH5 were similar. B2 occurred up to 1 year earlier in Venezuelans compared to Mexican American girls, PH development was more similar.

Only longitudinal studies can give information on the extent of variation in the rate at which children pass through puberty. Boys and girls of the Caracas Longitudinal Study showed a tendency toward an earlier onset of puberty compared to European adolescents. Even though other longitudinal data from Latin America are not available, Venezuelans mature earlier compared to Cubans and Mexican Americans. The longer duration of puberty in Venezuelans is the

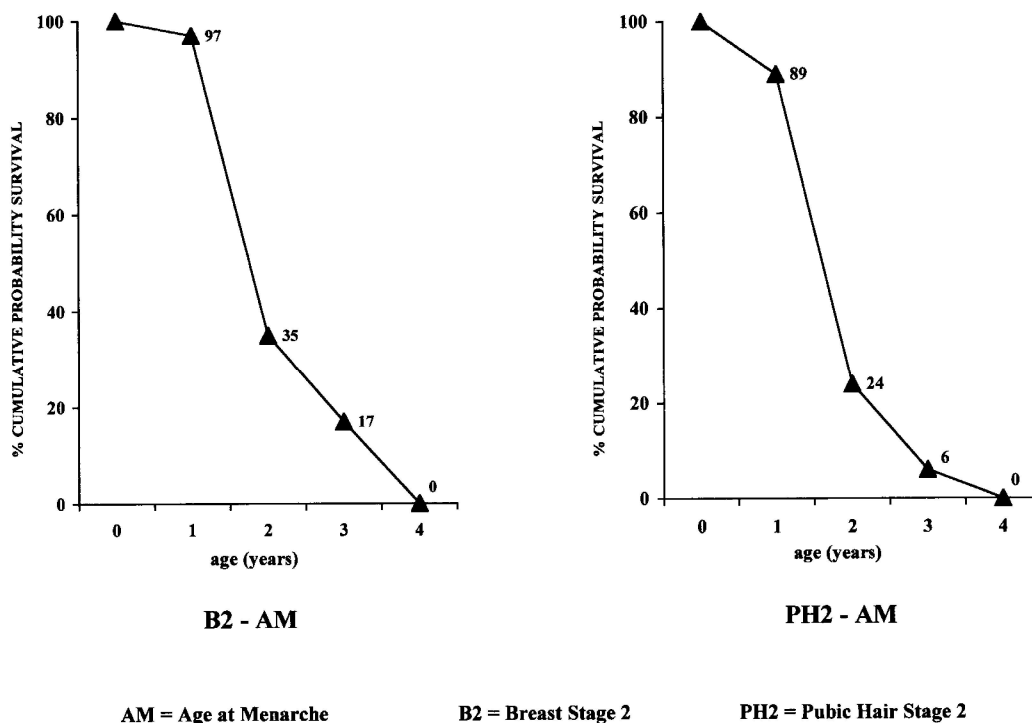


Fig. 5. Cumulative probability survival: intervals in years from onset of puberty (B2 and PH2) to age at menarche (AM). Survival function at mean of B2 and PH2.

result of its early onset. This characteristic was found in all social strata as well as in urban and rural samples of Project Venezuela.

Menarche occurred after B4 and PH4 and coincided with AH3. Age at the start of puberty (B2/PH2) did not significantly influence the length of intervals B2-AM and PH2-AM.

Intervals between stages 2-3 and 3-4 of G, B, and PH were shorter than the corresponding intervals of stages 4-5. Duration of puberty, in terms of G2-G5, B2-B5, and AH2-AH3 varied greatly, due to the fact that some adolescents completed puberty in a short period of time. The variability in the length of intervals and in the duration of puberty according to sex is a better indicator of normality than the chronological age at which they occur, and are useful in clinical practice for screening of normal vs. abnormal patterns in subjects that are advanced or delayed with respect to peers, together with other pubertal events such as age at peak height and weight velocity and skeletal age.

#### ACKNOWLEDGMENTS

We thank Jenny Mendoza, Jhonny Acevedo, and the personnel of Fundaredesa for their help and contributions.

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