

Secular trends: 10 and 20-year comparisons of sexual maturation among students

Tendência secular de 10 e 20 anos da maturação sexual de escolares

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Abstract – The objective of this study was to verify the secular trends of sexual maturation of students between 11 and 15 years old, during a period of 10 and 20 years. The sample was composed by 1,002 students aged between 11 and 15 years; 536 boys (12.6±1.3 years old) and 466 girls (12.5±1.2 years old) who took part in the Ilhabela Mixed-Longitudinal Project on Growth, Development, and Physical Fitness. The students' assessment period occurred in 1990/91 (initial), 2000/01 (10 years later), and 2009/10 (20 years later). Sexual maturation was analyzed according to the self-assessment method and age at menarche (month and year) was collected retrospectively. The statistical analysis used was: one-way ANOVA, and Tukey's post-hoc test. The level of significance was $p < 0.01$. The onset of menarche in the initial analysis was at: 12.5±1.2 years old; in the 2000/01 group: 12.3±1.0 years old ($\Delta = -1.6\%$), and in the 2009/10 group: 12.2±1.0 years old ($\Delta = -2.4\%$). Although there was a tendency towards reduction in age at menarche along the periods investigated, differences were not significant. There were significant differences only in genitals (G4), and pubic hair (P3) in boys after 10 and 20 years. In the same period, it did not occur any significant difference in maturational stages for girls. In conclusion, there was no secular trend of secondary sexual characteristics in boys (genital and pubic hair) and girls (breast and pubic hair) and in age at menarche over 10 and 20 years.

Key words: Child; Menarche; Puberty; Sexual maturation.

Resumo – O objetivo do presente foi verificar a tendência secular da maturação sexual de escolares de 11 a 15 anos de idade, nos períodos de 10 e 20 anos. Foram envolvidos no estudo 1.002 escolares com idade entre 11 e 15 anos; 536 meninos (12,6±1,3 anos) e 466 meninas (12,5±1,2 anos), que participaram do Projeto Longitudinal Misto de Crescimento, Desenvolvimento e Aptidão Física de Ilhabela. Os escolares foram avaliados nos períodos de 1990/91 (Inicial), 2000/01 (10 anos) e 2009/10 (20 anos). A maturação sexual foi realizada de acordo com o método de autoavaliação. A idade de menarca (mês e ano) foi obtida pelo método retrospectivo. A análise estatística utilizada foi Anova "one way" seguido do post hoc de Tukey. O nível de significância adotado foi $p < 0,01$. O início da idade de menarca foi: 12,5±1,2 anos; no grupo 10 anos: 12,3±1,0 ($\Delta = -1,6\%$); e no grupo 20 anos: 12,2±1,0 anos ($\Delta = -2,4\%$). Embora tenha ocorrido um declínio na idade de menarca durante os períodos, não houve diferença significativa. Houve diferença significativa somente em genitais (G4), e pelos púbicos (P3) em meninos após 10 e 20 anos. No mesmo período, não ocorreu diferença significativa nos estágios maturacionais nas meninas. Concluiu-se que a tendência secular das características sexuais secundárias dos meninos (genital e pelos púbicos) e nas meninas (mamas e pelos púbicos) e idade de menarca foi nula no período de 10 e 20 anos.

Palavras-chave: Escolares; Maturidade sexual; Menarca; Puberdade.

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INTRODUCTION

The maturation process has received considerable attention in secular studies, and data show a decline in the age at menarche over the years¹⁻⁵. In a way, this precocity can be seen as a risk factor, since the sooner the women have their first menstruation, the higher are the risks of diabetes and mortality from heart disease and cancer^{6,7}.

Sexual maturation is the process that leads to a complete state of morphological physiological or psychological development, and that has, necessarily, genetic and environmental influences. This process begins in the embryonic period, and continues throughout puberty, which is characterized by adrenarche. Two or three years later, occurs the gonadarche in boys and the thelarche, pubarche, and menarche in girls, until full sexual maturity and fertility^{8,9}.

Tanner¹⁰ proposes a classification of stages of development which identifies the degree of pubertal maturity. This classification can be done conveniently and effectively through self-assessment¹¹, by use of illustration plates, without invasion of privacy. The plates contain photographs to determine the developmental stages of pubic hair in both sexes (P1 to P6), breast for girls (B1 to B5) and genitals for boys (G1 to G5)¹⁰.

It is observed that, for a better understanding of the behavior of sexual maturation over time, longitudinal studies explain the phenomenon more appropriately. However, the number of longitudinal studies is still small over long periods, especially in developing countries¹². Regarding Brazil, the amount of researches that studied secular trends is even lower, and many of them were held as part of the Ilhabela Longitudinal Mixed Project on Growth, Development and Physical Fitness¹²⁻¹⁵, developed by the Physical Fitness Laboratory Study Center of São Caetano do Sul, since 1978.

Given this context, it is valid to point out that the secular trend may be defined as a continuing change in the structural and functional values of the contemporary human being in relation to previous years, and it may be positive, negative or null depending on the adaptation to the environment¹⁴. It can be explained by the interaction between intrinsic (genetic inheritance) and extrinsic (environmental, socioeconomic, health and participation in physical activity programs) factors².

Due to the importance of puberty on growth and development of children, such studies may establish how the transformations of sexual maturation occurred over the years, in order to better understand how time has affected the maturation process of these individuals. The authors' hypothesis is that the maturational stages of boys (pubic hair and genitals) and girls (breasts and pubic hair) and the age at menarche are decreasing over the course of decades. Therefore, the aim of this study was to assess sexual maturation of schoolchildren aged 11 to 15 years in both sexes in the municipality of Ilhabela, over a 10-year and a 20-year period.

METHODOLOGICAL PROCEDURES

Sample

The municipality of Ilhabela is located in the north coast of the state of São Paulo, with a land area of 348 km². We considered the surveys from 1991, 2000 and 2010 with the age group from 11 to 15 years. According to the Brazilian Institute of Geography and Statistics - IBGE, the population of the municipality in 1991 was of 7,800 inhabitants, and 452 were schoolchildren. In 2000, the population was composed 20,836, and 981 people were aged from 11 to 15 years. In 2010, the population was composed of 28,176 inhabitants and 1,138 schoolchildren¹⁶. Therefore, it is possible to verify a population increase and a proportional decrease in the number of schoolchildren over the decades.

The present study is part of the Ilhabela Mixed-Longitudinal Project on Growth, Development, and Physical Fitness, developed since 1978, by the Physical Fitness Laboratory Study Center of São Caetano do Sul.

This is the only longitudinal project in developing countries, whose main feature is the use of unsophisticated materials, easy techniques, and simplicity on a method that allows applicability in large groups.

Data collection

The evaluations are performed twice a year, on three consecutive days and aim to analyze the anthropometric, neuromotor, metabolic, physical activity level, nutritional and sexual maturation variables of children from 7 years old, through a battery of tests and measures standardized by our center¹⁷.

To compose the study sample, a database with more than 3,100 children and adolescents of both sexes who participated in the evaluations was used. Out of these, 1,002 schoolchildren (536 boys and 466 girls), met the inclusion criteria: (a) to be between 11 and 15 years old at the time of the evaluation; (b) to have made the assessment of sexual maturation; (c) to belong to public schools in the municipality of Ilhabela.

The 1,002 students who met the inclusion criteria participated in one of the following evaluations: a) initial (1990/91); b) 10 years (2000/01) and c) 20 years (2009/10), according to Table 1.

Table 1. Distribution of the number of students in relation to sex and sexual maturation in the municipality of Ilhabela, state of São Paulo

Sexual Maturation	Initial 1990/91 (n.)	10 years 2000/01(n.)	20 years 2009/10 (n.)
Menarche	58	100	75
Breasts / Pubic hair	49	222	156
Genitals / Pubic hair	146	204	186

The project was approved by the Research Ethics Committee of Universidade Federal de São Paulo under protocol number 0056/10. Parents and/or guardians signed an informed consent form.

Methods

To determine sexual maturation we used the self-assessment technique, validated ($r=0.61$ to 0.70) by Matsudo and Matsudo¹¹, with the Tanner¹⁰ plates for the identification of maturational stages and classification according to the following stages: a) prepubertal (stage 1); b) puberty (stages 2, 3 and 4) and c) post-pubertal (stages 5 and 6). Stage 6 was not considered because of its great resemblance to stage 5.

The stages of development evaluated in girls were: breasts (B1 to B5) and pubic hair (P1 to P5). We also collected age at menarche (month and year) retrospectively through questionnaire¹⁸. The stages evaluated in boys were: genitals (G1 to G5) and pubic hair (P1 to P5).

Statistical Analysis

The results were analyzed by descriptive analysis (mean, standard deviation and confidence interval set to 95%). Data normality was performed with the Kolmogorov-Smirnov test. One-way variance analysis was performed to assess age at menarche in the same age group in three separate stages (initial, 10 and 20 years), followed by the post-hoc Tukey's test to find possible differences between the groups, and the delta percentage ($\Delta\%$) was used to verify the magnitude of the difference. The software used was the SPSS version 18.0 and the level of significance was set at $p<0.01$.

RESULTS

The results found in Figure 1 show a decrease in age at menarche of schoolgirls from Ilhabela in the period of 20 years: initial period: 12.5 ± 1.2 ; in 10 years: 12.3 ± 1.0 ($\Delta=-1.6\%$) and in 20 years: 12.2 ± 1.0 ($\Delta=-2.4\%$). Despite the values found on age at menarche during the periods analysed, the differences encountered were not statistically significant.

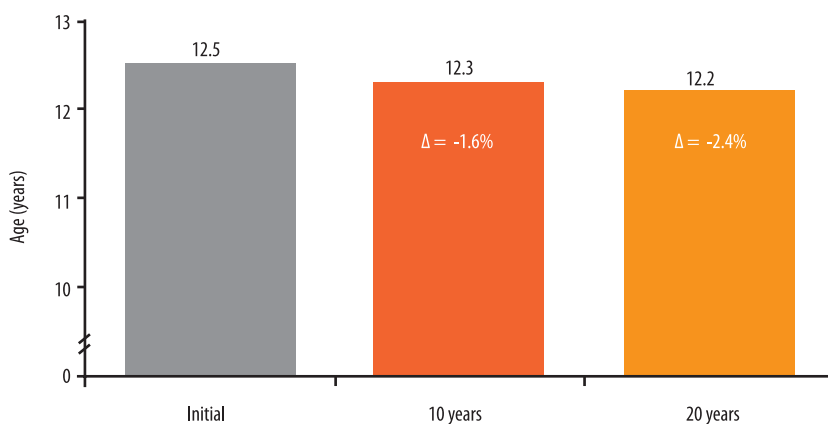


Figure 1. Secular trends of 10 and 20 years on the age at menarche in schoolgirls from Ilhabela.

When the maturational stages of boys were analyzed (Table 2), there was significant difference in the developmental stages of pubic hair (P3) after 10 and 20 years in the period of 1990/91 (initial) and

genitals (G4), when the period of 2000/01 (10 years) was compared to 2009/10 (20 years).

Table 2. Secular trends: 10 and 20-year comparisons of chronological age in the five stages of sexual maturation of genitals and pubic hair of male students from Ilhabela

Sexual Maturation	Initial			10 years			20 years		
	X	SD	95%CI	X	SD	95%CI	X	SD	95%CI
Pubic Hair									
1	11.7	0.8	11.5 – 12.1	12.1	1.2	11.4 – 12.9	11.2	0.4	10.9 – 11.4
2	12.3	1.0	11.9 – 12.6	11.7	0.8	11.3 – 12.0	11.7	0.9	11.4 – 12.1
3	12.9	1.3	12.5 – 13.2	12.0a	1.2	11.6 – 12.3	12.0b	0.9	11.7 – 12.2
4	13.4	0.9	13.0 – 13.8	13.2	1.3	13.0 – 13.6	13.2	1.2	12.8 – 13.5
5	13.5	0.9	12.9 – 14.1	14.1	1.1	13.7 – 14.4	14.2	1.0	13.8 – 14.6
Genitals									
1	12.0	0.8	11.6 – 12.4	11.6	0.8	11.2 – 12.0	11.6	1.1	11.0 – 12.3
2	12.1	1.1	11.5 – 12.6	11.7	0.9	11.4 – 12.0	11.8	0.9	11.6 – 12.2
3	12.3	1.1	12.0 – 12.6	12.3	1.2	12.1 – 12.7	12.1	1.0	11.8 – 12.4
4	13.6	1.0	13.2 – 13.8	13.8	1.2	13.5 – 14.1	13.1c	1.3	12.7 – 13.4
5	13.7	1.4	12.2 – 15.1	14.0	1.1	12.9 – 14.8	14.0	1.0	13.6 – 14.5

p<0.01; a = initial x 10 years; b = initial x 20 years; c = 10 years x 20 years

When the stages of breasts (B1 to B5) and pubic hair (P1 to P5) were analyzed in girls (Table 3), no significant differences were found in the same period of the study, demonstrating a null secular trend in the stages of sexual maturation in females.

Table 3. Secular trends: 10 and 20-year comparisons of chronological age in the five stages of sexual maturation of pubic hair and breasts in schoolgirls from Ilhabela.

Sexual Maturation	Initial			10 years			20 years		
	X	SD	95%CI	X	SD	95%CI	X	SD	95%CI
Pubic Hair									
1	11.0	0.0	11.0 – 11.0	11.2	0.4	11.0 – 11.5	11.6	0.7	11.2 – 12.1
2	11.6	0.9	11.0 – 12.3	11.5	0.7	11.3 – 11.8	11.9	1.1	11.4 – 12.5
3	11.6	0.8	11.0 – 12.2	11.7	0.8	11.4 – 12.0	11.8	0.8	11.5 – 12.2
4	12.9	1.4	12.1 – 13.4	12.9	1.1	12.5 – 13.0	12.6	1.1	12.2 – 12.9
5	13.7	1.0	12.6 – 14.7	13.3	1.1	13.1 – 13.8	13.7	1.1	13.1 – 14.2
Breasts									
1	11.0	0.0	11.0 – 11.0	11.6	0.7	10.9 – 12.1	12.2	1.1	11.5 – 13.2
2	11.7	0.9	11.0 – 12.4	11.3	0.5	11.1 – 11.5	11.6	0.8	11.1 – 11.8
3	11.6	1.2	10.9 – 12.3	11.8	1.0	11.4 – 12.1	11.4	0.6	11.0 – 11.7
4	12.8	1.3	12.2 – 13.3	12.8	1.1	12.3 – 12.9	12.6	1.1	12.3 – 12.9
5	13.8	1.1	12.4 – 15.2	13.5	0.9	13.0 – 13.9	13.6	1.1	13.1 – 14.1

p<0.01; a = initial x 10 years; b = initial x 20 years; c = 10 years x 20 years

DISCUSSION

In the present study there was a slight reduction in boys' age at the stages 4 of genitals and 3 of pubic hair over the period of 10 and 20 years. How-

ever, when the results were analyzed using the confidence level, it could be noticed that the differences overlapped between the maturation stages. Among girls the age at menarche and the stages of sexual maturation of breasts and pubic hair was null in the period of 10 and 20 years, respectively.

Biassio et al.¹³ in a longitudinal study performed within the Ilhabela Project, with 62 schoolgirls aged between 8 and 18 years, found an age at menarche of 12.5 years, similar to the findings in our study. However, in another study reviewing age at menarche, data showed considerable variability. It was verified that girls from Guarulhos and São Caetano do Sul presented an age at menarche of 12.2 years and girls from Monte Belo¹⁹, 13.9 years. For some authors, this variation may be associated with several factors such as: nutrition, environmental changes, social and genetics^{9,20}.

Age at menarche seems to remain low, both in developed and developing countries, but in a much slower way if compared to ages at menarche observed in the late nineteenth and early twentieth centuries. In a review of national and international literature on age at menarche, various racial-ethnic, environmental and socioeconomic aspects influencing age at menarche were presented. For some authors, the prevalence of overweight in the population groups seems to be one of the factors contributing to early menarche⁵.

In a cross-sectional study conducted by Oliveira and Veiga²¹, which analyzed 502 adolescents, both sexes, from 11 to 15.9 years, attending a public school in the municipality of Rio de Janeiro, the lowest age at menarche was registered among obese girls, when compared to non-obese. This fact may be associated to the weight gain and fat in schoolchildren from that municipality.

In a longitudinal study, Demerath et al.²² analyzed 371 white American girls from 2 to 18 years old, demonstrating that the girls who were born in the 80s presented lower age at menarche (12.34 years) when compared to those born in previous decades.

This early menarche has also been described by Freedman et al.²³. While analyzing data from the Bogalusa Heart Study, found that the mean age at menarche declined 0.2 years in white girls and 0.8 years in black girls from 1973-1974 to 1992-1994. O'Connell et al.²⁴ studied 4,720 Irish girls aged between 10 and 18 years, and found a reduction in age at menarche of 13.52 years in 1986 to 12.53 years in 2006.

Recently, a study verified the age at menarche of 94,170 women, aged between 16 and 98 years, born between 1908 and 1993, and living in the United Kingdom. The mean age at menarche has decreased in women born between 1908-19 (13.5 years) compared to those born in 1945-49 (12.6 years). This mean decreased again in women born in 1990-93 (12.3 years). Authors concluded that the age at menarche, after a stabilization period, dropped again in more recent cohorts²⁵.

Although there are few published studies on the time of puberty in boys, some studies report an earlier onset of maturation. Data from a sample of years 1988-94, with 2,114 American boys, aged between 8 and

19 years, showed an earlier mean of onset of pubic hair and genitals when compared to previous periods²⁶. These findings are consistent with the study of Karpati et al.²⁷, who compared measures of 30 years and demonstrated earlier ages of onset of some stages of puberty in boys.

The anthropometric and metabolic profile of the physical fitness of adolescents in the pubertal stage and at the same chronological age, but in different stages of sexual maturation, was assessed in 79 thirteen-year-old male students in the municipality of Ilhabela. Authors concluded that the self-assessment of pubic hair development seems a more effective criterion in the determination of any differences in physical fitness in male students, because the maturation process seems to affect more body mass, height and brain-stem length¹⁷.

In a longitudinal study on the influence of sexual maturation in the physical fitness of schoolchildren, Ferrari et al.¹² analyzed 27 male students who were followed during a period of 4 consecutive years, aged between 10 and 13. Authors verified that sexual maturation explained mainly fat, but also strength, speed and absolute aerobic power (L.min⁻¹).

Souza et al.²⁸ conducted a study on sexual maturation in female students in the municipality of João Pessoa, state of Paraíba, with approximately 1,066 female students and found mean ages of breast and pubic hair development, similar to those found in our study. However, the differences between the studies should be considered, especially regarding the region where the evaluations took place.

Evaluating students in the state of Santa Catarina, Bem and Petroski²⁹ sought to determine the age of sexual maturation in individuals from different climatic regions and concluded that sexual maturation of girls living in colder climates tend to occur later than in girls from warmer climates; and that sexual maturation occurs later than in girls from other regions of the country, evaluated by the same method.

Pasquarelli³⁰ analyzed anthropometric variables and the prevalence of overweight according to stages of sexual maturation and chronological age in students from the municipality of São José dos Campos, state of São Paulo. The study assessed 2,802 students from 10 to 12 of both sexes. The stages of development of pubic hair for boys and girls were different from the findings in this study. The results revealed values of mean age lower in all stages of pubic hair (P1 to P4), besides demonstrating an association of sexual maturation with the prevalence of excess weight in both sexes.

Literature^{4,5,23,30} has shown a steady decline not only in age at menarche, but also in the mean ages of maturational stages in boys and girls. In the review by Duarte¹⁹ the values for mean age of breasts and pubic hair stages in girls and genitals and pubic hair in boys from Santo André-SP, showed means well above the ones found in our study with schoolchildren from Ilhabela.

In contrast to findings in other studies, such as Freedman²³ and Pasquarelli³⁰, the present results showed a statistically null secular trend in age at menarche and stages of development of schoolchildren from Ilhabela over 10 and 20 years.

Despite the richness of a 20-year study that is part of a longitudinal project and that analyzed data from a sample in a developing country, the authors considered that the study had some limitations, such as: sample selection bias, since the children were selected by convenience, involving, therefore, a representative sample; the age group analyzed that excluded schoolchildren with lower and higher ages who could present early or late sexual maturation; lack of data on race, socioeconomic level and family size, besides the non-control of adiposity, even knowing that it has undergone changes in students participating in the Ilhabela Mixed-Longitudinal Project on Growth, Development and Physical Fitness in the last 20 years¹⁵.

CONCLUSION

The secular trend of the secondary sexual characteristics of boys (genitals and pubic hair) and girls (breast and pubic hair) and the age at menarche of schoolchildren from Ilhabela was statistically null after 10 and 20 years.

Despite the fact that the reduction in the age at menarche was not statistically significant, it does exist and it should be considered, due to its negative impacts described in the literature, such as increased risk of diabetes, heart disease and cancer. Future studies are needed in order to demonstrate the causal factors of these results.

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