



Sexual maturation and physical activity in adolescents: association and interaction

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Abstract

Background The decrease in physical activity after adolescence seems to be more related to biological age than to chronological age. The sexual maturation may explain this decline in physical activity in adolescents.

Aims This study aimed to verify the interaction of sexual maturation with sex, nutritional status, and socioeconomic condition in association with insufficient physical activity of 3979 students, of both sexes, aged between 11 and 19 years of public schools from two cities in southern Brazil adolescents.

Methods Measurements of body mass, height, sexual maturation, socioeconomic condition, and level of physical activity were collected. Poisson regression analyzed the association and interaction with insufficient physical activity providing prevalence ratios (PR) with 95% confidence intervals and $p < 0.05$.

Results Girls regardless of the pubertal stage and students of middle and low economic classes were more likely to be insufficiently active. The likelihood of girls being insufficiently active increases with the pubertal stage.

Conclusion Special attention should be paid to girls and students of intermediate and low economic classes.

Keywords Physical activity · Sexual maturation · Socioeconomic status · Nutritional status · Adolescents

Introduction

Insufficient physical activity is a significant public health problem due to its association with the increased risk of several chronic diseases and the increased costs of physical and mental health care [1].

According to the World Health Organization [2], to obtain health benefits, children and adolescents must perform physical activity for at least 60 min a day of moderate-to-vigorous intensity. However, recent evidence [3] reveals that 81% of adolescents do not meet this recommendation for physical activity. In Brazil, in the Study of Cardiovascular Risks

in Adolescents (ERICA) [4], the prevalence of adolescents who do not comply with the minimum recommendations for physical activity was 54.3%, being higher in girls (70.7%) than in boys (38%).

Physical activity is a phenotypic behavior that tends to decrease in adolescence [5–7]. In the study by Marques et al. [8] with 520,533 adolescents (251,788 boys; 268,745 girls), from 105 countries, the prevalence of physical activity decreases from 28.2% at age of 11–12 years (95% CI 27.4; 29.0) to 21.2% at age of 16–17 years (95% CI 20.3; 22.0) among boys, and from 19.4% (95% CI 18.5; 20.2) to 11.1% (95% CI 10.1; 12.0) among girls. Therefore, for a better understanding of its decrease and the possible implementation of interventions, it is essential to consider the factors associated with insufficient physical activity [5, 9]

Biological factors might explain the decreases in physical activity throughout the adolescence [6, 10]. Evidence indicates that physical activity is more related to biological age than chronological age [6, 7, 11]. Chronological age refers to the individual's date of birth and analyzes the passage of time in years and months. Biological age indicates the individual's maturation process over time until reaching

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maturity or adulthood. Each individual has an internal biological clock that influences their evolution toward the mature state. Biological age can be assessed by skeletal maturation, age at peak height velocity, and sexual maturation.

Adolescents with the same chronological age may have different biological rhythms being at different stages of pubertal development and having different levels of physical activity [11]. Differences on the timing of sexual maturation (the moment when a maturation event occurs, such as the age of menarche or the growth spurt) may explain the decline in physical activity in adolescents [6]; however, the effect of timing of sexual maturation on individual levels of physical activity is still unclear, and evidence is sparse [12].

Sexual maturation is inversely related to physical activity. Adolescents at the higher pubertal stages are less physically active, especially girls [6, 10]. Therefore, other variables might influence the relationship between sexual maturation and insufficient physical activity [13, 14]. The magnitude or the direction of the association between sexual maturation and physical activity may differ among adolescents according to sex, nutritional status, and economic classes [14]. Understanding the influence of the sexual maturation process in the practice of physical activity and the influence of sex, nutritional status, and economic class on its association may help identify the ideal maturation times for intervention toward the physical activity behavioral changes. The aim of this study was to verify whether sex, socioeconomic status, and nutritional status affect the magnitude or direction of the association between sexual maturation and insufficient physical activity in adolescents.

Methods

Design

This study is a cross-sectional descriptive correlational epidemiological survey conducted with a stratified random sample of students aged 11–19 years enrolled in elementary and high school grades from state schools of two cities in southern Brazil (Curitiba and São José dos Pinhais, Parana).

Sample

The sample size calculation adopted an insufficient physical activity prevalence of 50%, confidence level of 95%, sample error of 3%, design effect (DEF) of 1.5, and 30% sample addition to minimize losses. Given these criteria, the minimal sample size was estimated at 2053 (Curitiba) and 1869 students (São José dos Pinhais).

A total of 4518 adolescents participated in this study. We excluded adolescents were outside the age group of interest ($n=215$), who had some momentary or permanent physical

limitation ($n=4$), who was pregnant ($n=1$), those who filled out the questionnaires incorrectly ($n=145$) or incompletely ($n=78$) and who did not deliver the informed consent form signed by their parents or guardians ($n=96$). Besides, 26 adolescents refused to participate in the study on the day of collection. Thus, the final sample included 3979 students, resulting in a response rate of 88.07%. We calculate statistical power using the software GPower 3.1.7, indicating that the present sample can detect significant prevalence ratios of 1.06 with 93% power.

We use a multiple stage sample. All public state schools that offered high school were listed and stratified according to the ten administrative regions in the city of Curitiba and the five urban regions in the city of São José dos Pinhais, Parana. In Curitiba, we drew one school for each school district, and in São José dos Pinhais, we invited all schools to participate. We random selected two classes for each grade and invited all students in the drawn class to participate.

All the procedures followed the research standards involving human beings established by the National Health Council (resolution n°. 466/2012) and the Research Ethics Committee of the Federal University of Paraná (protocol number: 722.529; CAAE: 30350514.3.0000.0102) approved the present study. All the participants signed an assent form and provided consent written forms signed by a parent/guardian. Trained evaluators from the Research Center on Physical Activity and Health—CEAFS/UFPR performed all the data collection.

Measures

The students answered a structured questionnaire in the classroom and measured their height and weight in the school's physical education room. We collected information regarding the sex, age, economic class, nutritional status, sexual maturation, and physical activity. The students were grouped into male and female and in three age groups (11–13, 14–16, and 17–19 years).

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The Criteria of Economic Classification Brazil (CCEB) [15] evaluated the economic class, and the students were classified in three economic classes: high (scores from 45 to 100), middle (scores form: 29 to 44), and low (scores form 0 to 28).

We calculated the body mass index (BMI) to identify the nutritional status according to the reference for adolescents proposed by the World Health Organization for age and sex

[16]. The students were classified as eutrophic (z-scores from -2.00 to 0.99), overweight (z-scores from 1.00 to 1.99), and obese (z-scores >2.00).

The Tanner’s self-assessment of pubic hair [17] evaluated sexual maturation. We grouped students into three categories: 1 (prepubertal–Pp: stage 1), 2 (pubescent–P: stages 2–4), and 3 (postpubertal–PP: stage 5).

The Physical Activity Questionnaire for Adolescents [18] measured the physical activity. This questionnaire has adequate validity to measure the physical activity of Brazilian children and adolescents [19–21]. Students with ≤ 420 min/week of physical activity were considered insufficiently active [2].

Analysis

We use absolute and relative frequency to describe the variables for the overall sample, and for each sex. The Chi-square test analyzed differences between sex. We used a principal component analysis (PCA) to reduce the dataset dimensionality and identify possible uncorrelated variables (principal components) based on a set of possible correlated independent variables (sex, age, nutritional status, economic class, and sexual maturation). Eigenvalues greater than 1 were used to identify the principal components. Since the

eigenvalues for the all the principal component were lower 0.50, we used each variable as possible predictor of the physical activity level in the regression models. We created terms of interaction of sexual maturation with sex, nutritional status, and economic class. Poisson regression verified the unadjusted and adjusted association of sex, age, nutritional status, economic class, and sexual maturation with physical activity. We also used Poisson regressions to verify the associations of the terms of interaction with physical activity. We obtained prevalence ratios (PR) with 95% confidence intervals (95% CI) and used $p < 0.05$ as a significance level. The analyses were performed using the IBM SPSS 21.0 software.

Results

Table 1 shows descriptive data of the sample. The study included 3979 students, 51.2% ($n = 2039$) girls, 50.5% ($n = 2009$) in the age group of 14–16 years, and 54.1% ($n = 2152$) from middle economic class. The prevalence of overweight and obesity reached 18.2% ($n = 702$) and 10.1% ($n = 388$), respectively. Most of the students were pubescent 75.7% ($n = 2976$), and insufficiently active 57% ($n = 2263$).

Table 1 Descriptive data stratified by sex of students from 11 to 19 years old from two Brazilian cities

Variables	Total		Boys		Girls		X^2	p
	n	%	n	%	n	%		
Sex								
Boys	1940	48.8						
Girls	2039	51.2						
Age range								
11 and 13 years	1509	38.0	714	36.8	795	39.0	0.71	0.40
14–16 years	2009	50.5	1005	51.9	1004	49.3		
17–19 years	458	11.5	219	11.3	239	11.7		
Economic class								
High	446	11.2	254	13.1	192	9.4	13.95	0.001
Middle	2152	54.1	1051	54.2	1101	54.0		
Low	1381	34.7	635	32.7	746	36.6		
Nutritional status								
Eutrophic	2760	71.7	1290	69.4	1470	73.8	18.69	0.001
Overweight	702	18.2	334	18.0	368	18.5		
Obese	388	10.1	234	12.6	154	7.7		
Sexual maturation								
Prepubertal	84	2.1	37	1.9	47	2.3	84.54	0.01
Pubescent	2976	75.7	1330	69.6	1646	81.6		
Post-pubertal	870	22.1	545	28.5	325	16.1		
Physical activity								
< 420 min	2263	57.0	903	46.6	1360	66.8	163.12	0.01
> 420 min	1710	43.0	1033	53.4	677	33.2		

X^2 Chi-square, $p < 0.05$

Table 2 Associations of sex, age, economic class, nutritional status, and sexual maturation with insufficient physical activity of students of 11 the 19 years, of both sexes in two Brazilian cities

Variables	Insufficiently active		Unadjusted model	Adjusted model
	n	%	PR (95% CI)	PR (95% CI)
Sex				
Boys	903	39.9	1.00	1.00
Girls	1360	60.1	1.43 (1.35–1.51)	1.43 (1.35–1.51)
Age range				
11–13 years	604	26.7	1.00	1.00
14–16 years	1293	57.2	1.61 (1.50–1.72)	1.64 (1.53–1.76)
17–19 years	363	16.1	1.98 (1.83–2.13)	1.99 (1.84–2.16)
Economic class				
High	190	8.4	1.00	1.00
Middle	1229	54.3	1.34 (1.20–1.50)	1.26 (1.13–1.40)
Low	844	37.3	1.43 (1.28–1.61)	1.35 (1.21–1.50)
Nutritional status				
Eutrophic	1604	73.4	1.00	1.00
Overweight	377	17.3	0.92 (0.86–0.99)	0.94 (0.87–1.01)
Obese	204	9.3	0.90 (0.82–0.99)	1.00 (0.91–1.10)
Sexual maturation				
Pubescent	1692	75.4	1.00	1.00
Prepuberal	41	1.8	0.86 (0.69–1.07)	1.03 (0.84–1.27)
Post-pubertal	511	22.8	1.03 (0.97–1.10)	0.99 (0.94–1.06)

p < 0.05; adjusted for all independent variables; *PR* prevalence ratio, *95% CI* 95% confidence interval

Table 2 shows the associations of sex, age, economic class, nutritional status, and sexual maturation with insufficient physical activity. Girls (*PR* = 1.43; *95% CI* = 1.35–1.51), students aged 14 to 16 (*PR* = 1.64; *95% CI* = 1.53–1.76) and 17 to 19 years (*PR* = 1.99; *95% CI* = 1.84–2.16); students from middle (*PR* = 1.26; *95% CI* = 1.13–1.40) and low (*RP* = 1.35; *95% CI* = 1.21–1.50) economic classes were more likely to be insufficient active.

Table 3 shows the associations of the age group, economic class, nutritional status, and sexual maturation with the insufficient physical activity of the students stratified by sex. It was found that boys and girls, from 14 to 16 (boys: *PR* = 1.87; *95% CI* = 1.64–2.15; girls: *PR* = 1.53; *95% CI* = 1.41–1.66), and from 17 to 19 years old (boys: *PR* = 2, 61; *95% CI* = 2.2 5–3.02; girls: *PR* = 1.67; *95% CI* = 1.52–1.83) were more likely to be insufficiently active.

Boys and girls from the middle (Boys: *RP* = 1.23, *95% CI* = 1.03 -1.45; Girls: *PR* = 1.28; *95% CI* = 1.11–1.47) and low (Boys: *PR* = 1.35; *95% CI* = 1.14–1.61; Girls: *PR* = 1.33; *95% CI* = 1.16–1.53) economical classes were more likely to be insufficiently active. Overweight girls were less likely to be insufficiently active (*PR* = 0.91; *95% CI* = 0.84–0.99).

Figure 1 shows the associations of the terms of interaction with insufficient physical activity for students of both sexes. P—Pubescent (*PR* = 1.42, *95% CI* = 1.33–1.52), Pp—prepubertal (*PR* = 1.44, *95% CI* = 1.13–1.83), and PP—postpubertal (*PR* = 1.44; *95% CI* = 1.32–1.57) girls were more likely to be insufficiently active.

Pubescent (P) students of middle (*PR* = 1.26; *95% CI* = 1.11–1.42) and low economy classes (*PR* = 1.35;

Table 3 Associations of age, economic class, nutritional status, and sexual maturation with insufficient physical activity level stratified by sex of students of 11–19 years old from two Brazilian cities

Variables	Boys		Girls	
	Unadjusted model	Adjusted model	Unadjusted model	Adjusted model
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
Age range				
11–13 years	1.00	1.00	1.00	1.00
14–16 years	1.80 (1.58–2.04)	1.87 (1.64–2.15)	1.53 (1.41–1.65)	1.53 (1.41–1.66)
17–19 years	2.55 (2.23–2.93)	2.61 (2.25–3.02)	1.67 (1.53–1.83)	1.67 (1.52–1.83)
Economic class				
High	1.00	1.00	1.00	1.00
Middle	1.27 (1.07–1.52)	1.23 (1.03–1.45)	1.32 (1.15–1.53)	1.28 (1.11–1.47)
Low	1.41 (1.18–1.69)	1.35 (1.14–1.61)	1.36 (1.18–1.58)	1.33 (1.16–1.53)
Nutritional status				
Eutrophic	1.00	1.00	1.00	1.00
Overweight	0.96 (0.84–1.09)	0.99 (0.87–1.13)	0.91 (0.84–0.99)	0.91 (0.84–0.99)
Obese	1.04 (0.90–1.20)	1.13 (0.99–1.29)	0.86 (0.75–0.99)	0.89 (0.78–1.02)
Sexual maturation				
Pubescent	1.00	1.00	1.00	1.00
Prepuberal	0.82 (0.54–1.24)	1.16 (0.78–1.71)	0.88 (0.68–1.12)	0.98 (0.77–1.24)
Post-pubertal	1.06 (0.96–1.18)	0.97 (0.88–1.07)	1.14 (1.06–1.23)	1.03 (0.96–1.11)

p < 0.05; adjusted for all independent variables *PR* prevalence ratio, *95% CI* 95% confidence interval

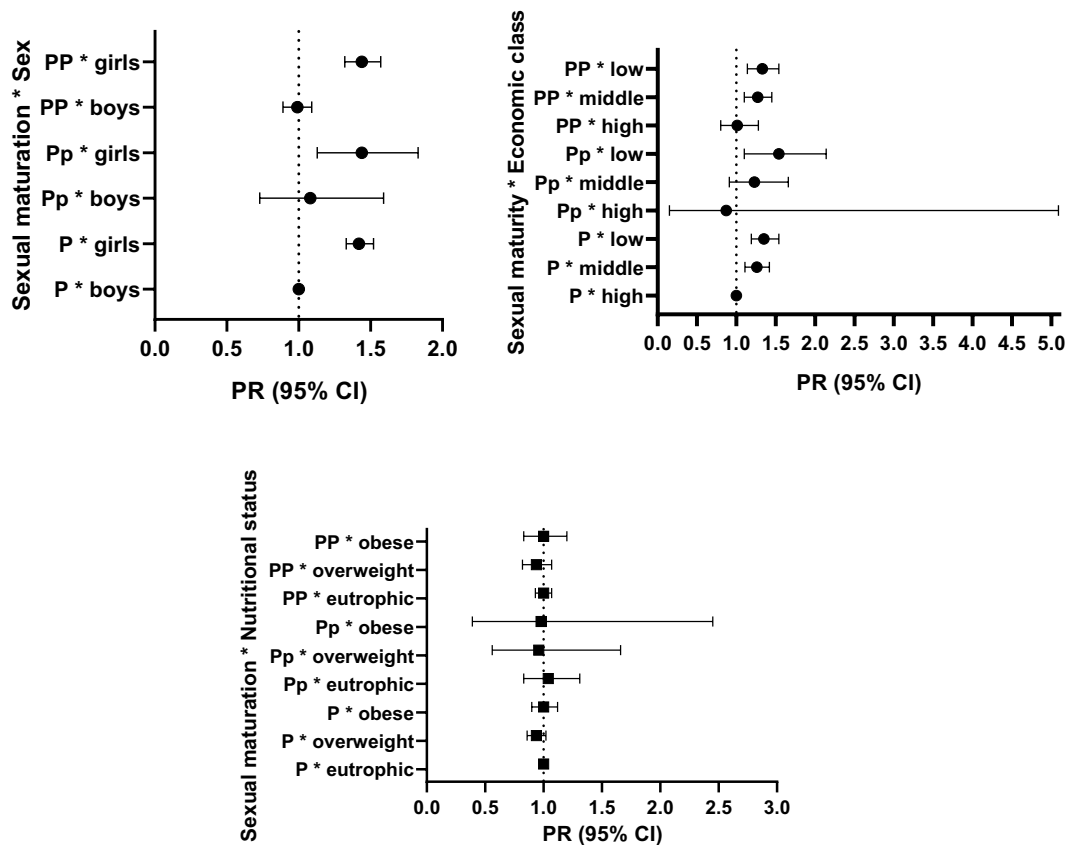


Fig. 1 Sexual maturation interaction with sex, economic class, and nutritional status associated with insufficient physical activity of students of both sexes from 11 to 19 years old from two Brazilian cities. *P* pubescent, *Pp* prepubertal, *PP* postpubertal

95% CI) = 1.19–1.54), prepubertal (*Pp*) students of low economic class (PR = 1.54; 95% CI = 1.10–2.14), and postpubertal (*PP*) students of middle (PR = 1.27; 95% CI = 1.10–1.45) and low economic classes (PR = 1.33; 95% CI = 1.14–1.54) were more likely to be insufficiently active.

Discussion

The results showed that adolescents aged 14–19 years were more likely to be insufficiently active. The literature confirms these findings showing that the proportion of active individuals declines significantly in adolescence [1, 8]. The lower engagement in physical activity during adolescence may be a result of the increase in school, family, and professional commitments, such as increased study time, preparatory courses, internships, and work favor the decrease in the practice of physical activity at this stage. Besides, the adolescents change their interest with age based on social interactions. Adolescents are more prone to engage in behaviors that are endorsed by their social groups, and physical activity practice may not be one of their daily activities [22].

The probability of being insufficiently active was 43% higher in girls than boys (PR = 1.43; 95% CI = 1.35–1.51). Studies with adolescents Brazilian [23, 24] and from other nationalities [25, 26], support our results and may reflect the different social roles imposed by society that influence the interests and different behavior between boys and girls [27]. Girls are encouraged from an early age to perform activities with little energy and use their free time with more sedentary activities, which can lead to being less active in their daily lives. On the other hand, boys are culturally motivated to play sports and participate in sports competitions, which usually involve vigorous physical activity [26, 28].

The interaction of sexual maturation with sex showed that the probability of girls being insufficiently active increases with the pubertal stage. Evidences indicates that pubertally advanced girls tend to have a lower level of physical activity [6]. Advanced puberty is associated with depression and anxiety, increased use of tobacco and alcohol, and the adoption of other risky behaviors, including insufficient physical activity [13, 29]. Girls who are advanced in maturation may have less perception of body attractiveness,

sports competence, physical conditioning, and physical self-esteem, which makes them less engaged in physical activity [29].

The interaction of sexual maturation with the economic class showed that, regardless of the maturation stage, the economic class was a significant predictor of the practice of physical activity. Students from the middle and lower economic classes were more likely to be insufficiently active. Evidences show that the influence of economic disparities in physical activity behaviors is consistent among students. Students of lower economic class perform less physical activity [30, 31], and students of high economic class are more physically active [32, 33]. High-income adolescents have a higher practice of structured physical activity in clubs and sports associations. These practices increase the bonds of friendship and, therefore, the dissemination of more physically active behaviors among friends [22]. Students of lower economic classes might be less physically active due not have access equipment and sports facilities to safe and appropriate due to their cost constraints, due to lack of time due to lack of time for needing to work or study, or due to the lack of social support from parents that could provide transportation and opportunities to engage structured physical activity [34].

Overweight is usually associated with lower levels of physical activity [7, 35]; however, our study showed that overweight girls were less likely to be insufficiently active. In the study by Curry et al. [36] with 1260 adolescents aged 11–13 years in East London, girls with high BMI practiced less physical activity. The constant concern with the current aesthetic standards imposed by society might explain these results. Overweight girls might engage in physical activity to reduce body weight.

This study shows as its major strength the association of sexual maturation with physical activity and the interaction of several variables in a representative sample of students from public schools from two Brazilian cities. The sample size offered enough statistical power to test several interactions and better understand the factors associated with adolescents' engagement in physical activity. The present study is not without limitations. The use of self-reported measures of physical activity and sexual maturation could be affected by the recall and social desirability bias. However, both instruments have adequate validity for Brazilian children and adolescents.

Conclusions

Our results showed that were associated with insufficient physical activity: girls, students aged 14–19 years, and those of middle and low economic classes. Were less likely to be insufficiently active: overweight girls. The interaction of

sexual maturation with the variables sex, nutritional status, and economic class showed that girls regardless of the maturation stage and students from low and middle economic classes were more likely to be insufficiently active. The probability of girls being insufficiently active increased with the pubertal stage. Our results reinforce the need to promote intervention programs to increase physical activity practice, especially in girls and students of middle and low economic classes. Based on the research results, schools participating in the study can be informed of the research findings and disseminate them or even promote intervention programs focusing on education and health promotion to increase the physical activity practice especially in girls and students of middle and low economic class. More studies are needed that incorporate prospective longitudinal study designs, objective methods for assessing physical activity such as accelerometers, and analyses of mediation and moderation of psychosocial factors, such as social support, self-esteem, self-efficacy, self-concept, and motivation in the relationship between sexual maturation and physical activity.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection, and analysis were performed by EDAB, TSP, ABP, JGC, and MPdaS. The teacher WdeC performed the orientation and the correction of the final manuscript. The first draft of the manuscript was written by EDAB and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All the procedures followed the research standards involving human beings established by the National Health Council (resolution n^o. 466/2012) and the Research Ethics Committee of the Federal University of Paraná (Protocol No. 722.529; CAAE: 30350514.3.0000.0102) approved the present study.

Consent to participate Informed consent was obtained from all adolescents' participants included in the study.

Informed consent All participants provided informed consent prior to their participation.

Human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the

1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Ethical standards The study was approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

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