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Original research

Physical activity patterns in a representative sample of adolescents from the largest city in Latin America: a cross-sectional study in Sao Paulo

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Abstract

Objectives We examined the patterns of total and domain-specific physical activity (PA) by sex, socioeconomic and maternal education level in adolescents from Sao Paulo city, Brazil.

Design Cross-sectional study including a representative sample.

Participants A representative sample included 2,682 (52.2% boys) adolescents aged 14-15 years from public and private schools in Sao Paulo. Socioeconomic level was assessed using wealth index derived from principal component analysis. Descriptive analyses evaluated differences in total and domain-specific PA by sex, socioeconomic and maternal educational level.

Outcome measures We collected data on frequency and time spent in each domain of PA (active transportation, leisure and physical education classes) through a self-reported questionnaire.

Results On average, adolescents spent 197.7 min/week (95% CI: 190.6-204.8) on total PA. The proportion of adolescents achieving at least 60 min/day was 12.7% (95%CI 11.4-14.1), with a higher prevalence in boys (18.3%) and those with higher socioeconomic level (17.4%). Similar patterns were observed for leisure PA and physical education classes. Active transportation was higher in girls (46.0 min/week; 95%CI: 42.6-49.6) than boys (43.4 min/week, 95%CI: 39.9-46.6). Boys with higher socioeconomic and maternal education level had higher amount of total PA.

Conclusions We found a variation in patterns of total and domain-specific PA by sex, socioeconomic and education level in adolescents from Sao Paulo. Initiatives for promoting PA in adolescents may take into account these findings.

Keywords: Epidemiology, physical activity, active transportation, leisure physical activity, physical education classes.

Strengths and limitations of this study

- Use of a large representative sample of adolescents living in a megacity, Sao Paulo; therefore, increasing generalizability.
- Use of total and domain-specific physical activity data to describe patterns of adolescent's physical activity by sex, socioeconomic level, and maternal education level.
- Physical activity was collected through a self-report questionnaire; thus, measurement error is likely to have occurred.
- Out-of-school adolescents were not included in our study.
- Around one in ten of adolescents did not report maternal education level, which may lead to biased patterns of physical activity.

Introduction

The benefits of physical activity (PA) during childhood and adolescence are well-established. PA decreases the risk of cardiovascular disease, adiposity and improves cognitive development, cardiorespiratory and muscular fitness.[1] In addition, PA during adolescence has been linked with lower risk of non-communicable diseases during adulthood.[2] To achieve these health benefits, the World Health Organization (WHO) recommends adolescents to accumulate at least 60 min/day of moderate- to-vigorous intensity physical activity (MVPA). In Brazil and the city of Sao Paulo, only 29% of adolescents meet the PA guidelines, a scenario which is slightly better than the worldwide average (19%)[3 4] The reasons for this low level of PA in adolescents are not yet fully understood.[5]

Due to the complexity and the large number of correlates and determinants of PA, evidence has shown that some population strata have greater opportunities to practice PA.[6] A systematic review showed that young people with socioeconomic vulnerability have lower levels of PA.[7] In Brazil, the National School-Based Health Survey showed that boys and children of mothers with more years of schooling are more active in the leisure domain compared to girls and adolescents of mothers with incomplete elementary school.[8]

One area of emerging research interest is the context in which PA occurs, also known as domains or modes of PA.[1] PA includes a diversity of organized (e.g. sport activities, physical education classes) and non-organized activities (e.g. active play or non-organized sport), as well as active transport (e.g. cycling to school).[1] To evaluate the pattern of total and domain-specific PA may provide a more nuanced understanding of this complex behavior. For instance, perceived traffic and access to recreational and leisure facilities has been positively related to sports, while the presence of adequate walking and cycling infrastructure, accessibility to these practices, street connectivity and proximity to public

spaces to active transportation.[9] These findings reinforce the possibility that environmental characteristics that most likely favor PA in various domains, such as displacement, may differ from those required for leisure PA. In this sense, leisure PA may require specific characteristics, such as multi-sport courts, playgrounds and parks with different sports equipment.[10 11]

Promoting PA for adolescents living in megacities is additionally challenging. Sao Paulo is among the 10 most urbanized and populous cities worldwide,[12] characterized by diverse cultural and socioeconomic backgrounds, as well as a wide variation in disease distribution and lifestyle behaviors. In recent years, Sao Paulo has undergone an accelerated urbanization process, along with a demographic, epidemiological, and socioeconomic transition.[13]. Meanwhile, highly disorganized and heavy traffic, air and noise pollution, rising crime rates, and high income inequality persist in this megacity.[13] Few studies have showed the pattern of total and domain-specific PA in adolescents living in Sao Paulo. Therefore, understanding the patterns of total and domain-specific PA by sex, socioeconomic level, and maternal education may provide new insights for and enable future research on how policies and interventions are affecting adolescents' PA. To describe the pattern of PA in adolescents from Sao Paulo, we utilized data from a large representative sample of students, the Sao Paulo Project for the Social Development of Children and Adolescents (*São Paulo para o desenvolvimento social de crianças e adolescentes - SP-PROSO*)

Methods

Study design, sample, and data collection

SP-PROSO is a cross-sectional study including a representative sample of 9th grade students from public and private schools in Sao Paulo.[14] The target population of SP-

PROSO was adolescents (14-15 years old) enrolled in the 9th grade in public and private schools in São Paulo city in 2017. The sampling strategy considered stratification by school type (state public, municipal public and private schools) and clustering by taking each class as a draw unit. SP-PROSO was approved by the Ethics and Research Committee of the University of Sao Paulo School of Medicine and the National Commission for Research Ethics. The schools' principal, responsible guardian and the adolescents themselves signed a consent form to participate in the study.

The estimated calculated sample size for SP-PROSO was 2,849 students.[14] In total, 156 classes from 119 schools accepted to participate in the study. Of the 61 private schools drawn, 26 refused and 3 did not respond and were excluded. Among public schools, the number of losses were only one among the state schools and seven among the municipal ones. Regarding the students, considering the number presented in class on the day of data collection (n=2.816), 96 were not authorized by their parents or refused to participate in the research, and 18 students could not participate due to health-related and/or reading/comprehension issues. The final sample size included 2.702 participants, which represented 94.8% of the calculated sample size.

Adolescents filled out a self-reported structured questionnaire available in their school classrooms during regular school hours. The questionnaire was based on two validated questionnaires - Global School-Based Student Health Survey[15] and the Youth Risk Behaviour Surveillance System.[16]

Physical activity assessment

PA was assessed by weekly frequency and duration of active transportation (walking or bicycle) to and from school, leisure-time PA, and participation in physical education classes during the past week. We calculated total PA by summing-up minutes per week

(min/week) across domains of PA. Adolescents were categorized as "meeting" (≥420 min/week) or "not meeting" (<420 min/week) the WHO recommendation of PA for adolescents.[17] PA in each domain was expressed as continuous (min/week) and categorical (participation in at least 2 days a week). Finally, we estimated the distribution of total PA according to the domains of PA (i.e., to estimate the share of each domain of PA).

Sociodemographic variables

As previously suggested by Barros and Victoria, we calculated the socioeconomic level through principal component analysis (PCA).[18] We ran PCA adding into the model: maternal educational level (incomplete middle school, complete middle school, complete high school, complete higher education); type of school (public or private); landline (yes or no), mobile phone (yes or no), internet computer in room (yes or no), car (yes or no), and number of bathrooms inside the house. We obtained the first component of the PCA and estimated coefficients using the following equation: coefficient=loading/SDx100. The individual value were calculated from the $\sum c_i v_i$, where c_i is the coefficient and v_i is the score for the ith variable. The socioeconomic level was categorized as terciles of the total wealth scores, being the first tercile (T1) the poorest group and the third tercile (T3) the wealthiest group. We also presented PA separately by sex and maternal education.

Patient and public involvement

This cross-sectional study among adolescents did not involve patients in the design, recruitment, conduct or planning of this study.

Statistical analysis

We described total and domain-specific PA using absolute frequencies, mean (and it 95% confidence intervals - 95% CI), and median (and its interquatile range). Analyses were then carried out according to sex, socioeconomic level, and maternal education level. Mann-Whitney and Kruskal-Wallis tests were used to compare means and variances, and Chi-Square test was used to compare categorical variables. All analyses were performed using IBM SPSS (v 22 IBM Corp, Armonk, New York, NY, USA).[19]

Results

Adolescents spent 197.7 minutes (95% CI: 190.6 to 204.8) of total PA per week; the median value was 140 min/week (interquartile range: 55.0-280.0) (Figure 1). Boys, those with higher socioeconomic level, and maternal education level presented higher levels of total PA. Mean differences in total PA were: 83 min/week higher in boys than girls; 87 min/week higher among those in the high socioeconomic level, compared to those in the low socioeconomic level; 21 min/week higher among those whose mothers had complete higher education than those who mother's did not complete middle-school. The proportion of individuals reaching ≥420 min/week of total PA was 12.7% (95%CI 11.4-14.1), with higher proportion in boys (18.3%) than girls (6.8%), in the high socioeconomic group (17.4%) than in the low socioeconomic group (9%), and for mothers having complete higher education (16%) than mothers who did not complete middle-school (14.5%) (Table 1).

Figure 1

Table 1

Figure 2 shows the proportion of adolescents participating at least 2 days/week in each of the three PA domains investigated: 65.2% for active transportation, 63.7% for leisure-PA, and 81.2% for participation in physical education classes.

Figure 2

Figure 3 and 4 display the proportion and min/week of total PA according to domains of PA by sex, socioeconomic level, maternal educational level, and PA guidelines. The relative contribution of leisure PA was higher among adolescents presenting higher levels of PA. For instance, leisure PA contributed to 46% of total PA in boys, 49.5% in adolescents with high socioeconomic level, 46% in adolescents whom mother's completed the high school, and 56% in adolescents reaching the WHO recommendation (Figure 3). In absolute terms, leisure PA contributed most to total PA in boys (113 min/week), in adolescents with high socioeconomic level (116 min/week) and those whose mothers completed high school (106 min/week). On the other hand, active transportation contributed most to total PA in girls (46 min/week). Physical education classes had a higher participation in total PA in boys (92 min/week), in adolescents with high socioeconomic level (77 min/week) and those whose mothers did not complete high school (84 min/week).

Figure 3

Figure 4

Discussion

The aim of this study was to describe the pattern of total and domain-specific PA by sex, socioeconomic level, and maternal education level in adolescents from Sao Paulo. On average, adolescents spent 197.7 min/week of total PA. The proportion of adolescents reaching the WHO recommendation (≥420 min/week) for PA was 12.7% and was higher in boys and adolescents with higher socioeconomic level. Active transportation contributed most to total PA in girls than in boys (28% versus 18%). Leisure PA and physical education classes were higher in boys and adolescents with high socioeconomic level. Boys with higher socioeconomic level and maternal education had higher level of total PA.

Children and young people aged 5–17 years are recommended to accumulate at least 60 minutes of MVPA daily (420 min/week).[17] Comparing our results with high-income countries, we found a higher prevalence of insufficient PA in Sao Paulo (87.3%) than adolescents from Australia (83.5%), the United States (70.9%), Denmark (80.4%) and Spain (74.4%). Worldwide, 81% of adolescents aged between 11 and 17 years did not achieve this target.[20] In other states in Brazil, the proportions of adolescents not meeting current PA guidelines were 60% for Distrito Federal, 63.2% for Rio de Janeiro, and 64.1% for Rio Grande do Sul.[21]

In our study, patterns of domain-specific PA were different between boys and girls. Active transportation showed to be higher, in absolute and relative terms, in girls than boys. On the other hand, boys were more active than girls in the domains of leisure and physical education classes. These findings are similar to previous studies conducted worldwide.[4 22] In addition, the contribution of leisure PA and physical education classes to total PA was found to be 46.1% and 36.3% in boys and 36.6% and 34.9% in girls, respectively. Boys tend to participate more in PA of higher intensity (e.g., soccer, basketball, volleyball), while female adolescents are more involved in light to moderate intensity activities, such as walking, water activities and ice skating.[23] In addition, boys report greater social support from parents and friends to practice in physical activities, have fewer barriers to getting involved with PA and greater perception of self-efficacy. Girls show more negative attitudes regarding the practice of physical activities, refer to more barriers for PA and perceive environments more adversely (less favorable to PA practice).[24] PA interventions, especially in the leisure time, are important to increase total PA in girl adolescents in Sao Paulo. For this matter, it is imperative to identify girls' preferences, reasons for and barriers to engaging in PA.

Adolescents with high socioeconomic level showed the highest level of PA in our analysis. Previous studies also have shown that adolescents with higher socioeconomic level tend to be more active than those with lower socioeconomic level. Higher socioeconomic level has been associated with more opportunities at school and community settings.[7] Similarly, our results showed that adolescents with higher maternal education level tend to have higher levels of total PA, especially in the domain of leisure PA, possibly reflecting higher socioeconomic level. Several methods have been used to determine socioeconomic level (e.g., family income, professional occupation, schooling of parents, place of residence), which has shown to influence adolescents PA in particular ways.[7] For example, while the poorer walk more to go to school or work and develop more household care-related activities, their richer pairs engage in more leisure PA, explained by differences in access to financial and material resources. Different mechanisms may explain the relationship between parents' education and PA found.[7] First, participation in many PAs has financial costs (e.g., purchasing equipment, monthly fees and transportation) that cannot always be met by the poorest families.[25] Families with higher socioeconomic level usually live in neighborhoods with better infrastructure for PA (e.g., parks, squares, running / walking tracks, cycle paths or cycle lanes). In addition, adults with higher education level have PA levels, particularly during leisure [26 27], which may positively influence adolescents' PA [1 17]. Another plausible explanation for this association is that physically active parents are more likely to provide greater social support for adolescent's PA.[1 28]

Physical education classes is a fundamental opportunity for promoting PA.[10 29] Physical education classes may contribute considerably to adolescent PA levels, both directly - from the offer PA during class; and indirectly - by stimulating this practice, favoring access to knowledge and providing positive experiences with physical activities [29]. In a systematic review that estimated the PA level during physical education classes showed

that, on average, youth spend 37% of their physical education time in MVPA.[30] Adolescents who participate in physical education classes are more likely to be physically active.[29 31] Physical education classes showed to be an important opportunity for adolescent's PA, especially for those with lower socioeconomic and maternal education level. Policies aimed to promote PA should ensure, among other recommendations, that quality physical education classes helps youth to develop standards of behaviors that keep them physically active throughout their lives.[32]

Patterns of total and domain-specific PA may be useful for governments and decision makers to plan and promote PA interventions. Decisions can be made to construct appropriate PA leisure environments, such as outdoor park courts,[33] and improve the ability to walk the streets[34] and cycle paths. Our results indicate that adolescents participating in leisure PA are more likely to achieve the PA guidelines. In this sense, schools and government agencies may prioritize PA programs focused on leisure activities in order to increase total PA in adolescents from Sao Paulo.

Our study has some limitations. Of the 61 private schools drawn, 26 refused and three did not respond, and were excluded. Among public schools, the number of losses were only one for the state schools and seven for the municipal ones. Out-of-school adolescents were not included in our study. PA was collected through a self-report questionnaire, and thus measurement error is inevitable. However, this PA questionnaire have showed high accuracy.[34] Maternal education variable had substantial missing data (30%). However, missing data was not related to sex and socioeconomic level. Adolescents with maternal education missing data showed similar active transportation and participation in physical education classes. However, they tend to present higher levels of leisure PA (mean: 179.2 min/week; $p<0.001$) and total PA (mean: 75.2 min/week; $p<0.001$) compared to those whom responded the maternal education level (data not shown).

Conclusions

In this study, we found different patterns of total and domain-specific PA by sex, socioeconomic leve, and maternal education level in adolescents from Sao Paulo. Subgroups of adolescents with higher levels of PA (boys, high socioeconomic level, and maternal education) tend to have more engagement in leisure PA. Future studies should seek to better understand the challenges of implementing and promoting PA considering these patterns.

Appendix

Figure 1: Distribution of total physical activity (min/week).

Figure 2. Proportion (%) of adolescents practicing physical activity at least 2 days per week by domain.

Figure 3. Proportion (%) of domain physical activity by sex, socioeconomic, and education level and physical activity guidelines.

Figure 4: Minutes/week (means and 95% confidence intervals) of domain physical activity by sex, socioeconomic and education level.

*p<0.05

Author contributions

GLMF and LFMR had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. The corresponding author had final responsibility for the decision to submit for publication. MFTP was the PI responsible for study concept, design, and data collection. GLMF and LFMR prepared the

first draft. GLMF, LFMR, GAW, AAF and MFTP drafted and critically revised the manuscript for important intellectual content and gave final approval of the version to be published.

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Conflict of interest

None declared.

Patient consent for publication

Not required.

Ethics approval

The protocol was approved by the Ethics and Research Committee of the University of Sao Paulo School of Medicine (Comitê de Ética e Pesquisa da Faculdade de Medicina da Universidade de São Paulo, records no. 1.719.856) and the National Commission for Research Ethics (Comissão Nacional de Ética em Pesquisa [CONEP], records no. 2.014.816).

Data sharing statement

Data are available upon reasonable request from the corresponding author.

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Table 1. Adolescent's sociodemographic characteristics associated with total physical activity.

Variables	N	%	Mean (95%CI)	Median (25-75)	p[a]	≥420 min/week (95%CI)	p[b]
Total	2,682		197.7 (190.6-204.8)	140.0 (55.0-280.0)		12.7 (11.4-14.1)	
Sex	2,61				<0.0001		<0.0001
Boys	1,363	52.2	238.2 (227.6-248.8)	180.5 (25.0-343.7)		18.3 (16.4-20.5)	
Girls	1,247	47.8	155.8 (146.2-164.9)	105.0 (30.0-225.0)		6.8 (5.2-8.1)	
Socioeconomic level	2,682						
Low	893	33.3	173.0 (161.7-185.3)	120.0 (45.0-255.0)	<0.0001	9.0 (7.3-10.8)	<0.0001
Middle	890	33.2	197.8 (185.2-210.8)	140.0 (70.0-275.0)		12.5 (10.3-14.7)	
High	899	33.5	230.1 (217.2-243.9)	190.0 (85.0-330.0)		17.4 (15.0-19.9)	
Maternal education level	1,855						
Did not complete middle school	462	24.9	206.5 (187.4-226.7)	140.0 (50.0-303.7)	<0.0001	14.5 (11.4-17.9)	0.093
Complete middle school	366	19.7	186.6 (167.8-206.0)	130.0 (60.0-240.0)		9.8 (6.7-13.0)	
Complete high school	715	38.5	208.1 (194.1-221.3)	165.0 (75.0-305.0)		14.1 (11.5-16.8)	
Complete higher education	312	16.8	227.9 (205.9-250.9)	175.0 (76.2-340.0)		16.0 (12.4-20.4)	

[a] Mann-Whitney or Kruskal-Wallis test for the comparison of medians; [b] chi-square for heterogeneity.

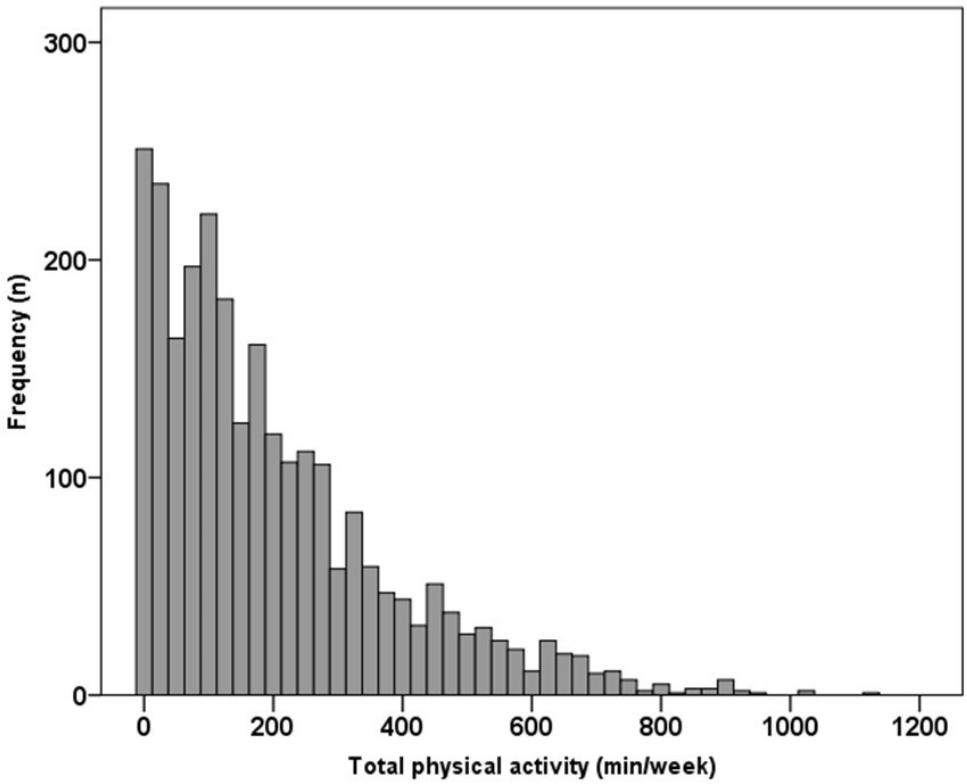

Figure 1: Distribution of total physical activity (min/week).

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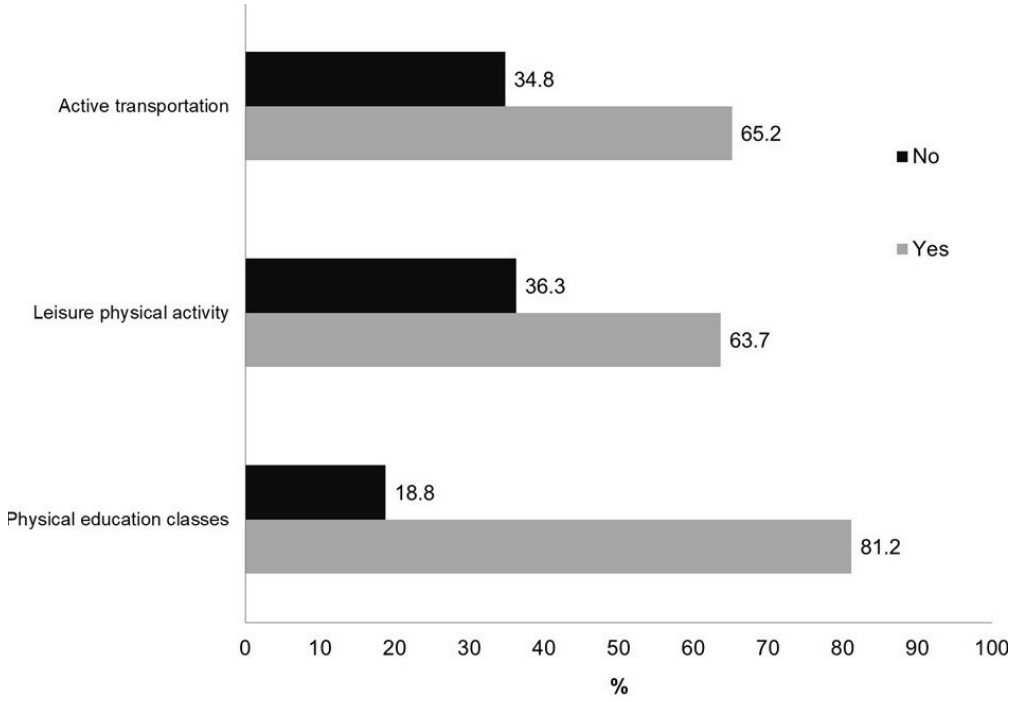

Figure 2. Proportion (%) of adolescents practicing physical activity at least 2 days per week by domain.

249x172mm (96 x 96 DPI)

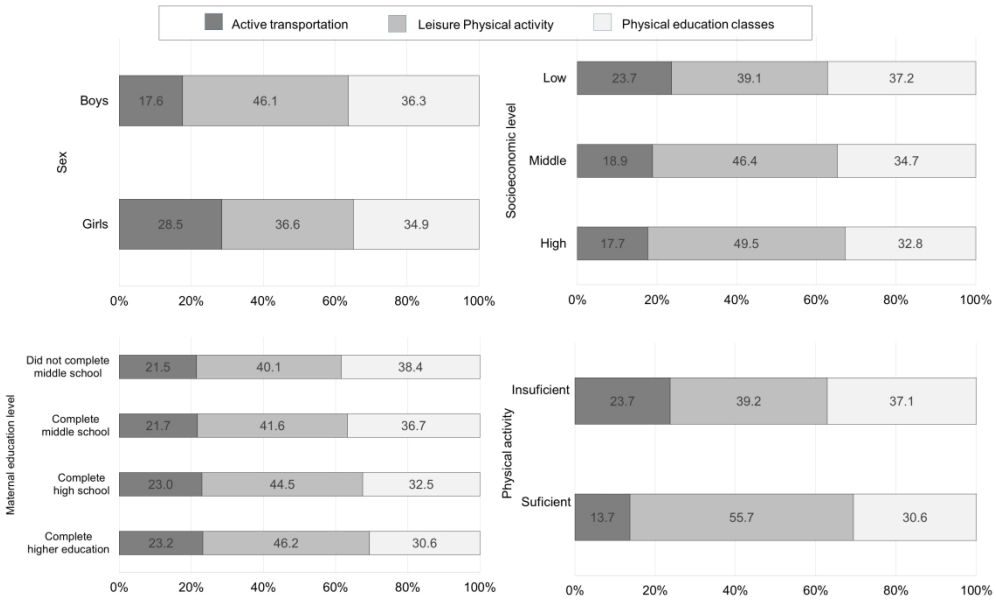

Figure 3. Proportion (%) of domain physical activity by sex, socioeconomic, and education level and physical activity guidelines.

889x529mm (96 x 96 DPI)

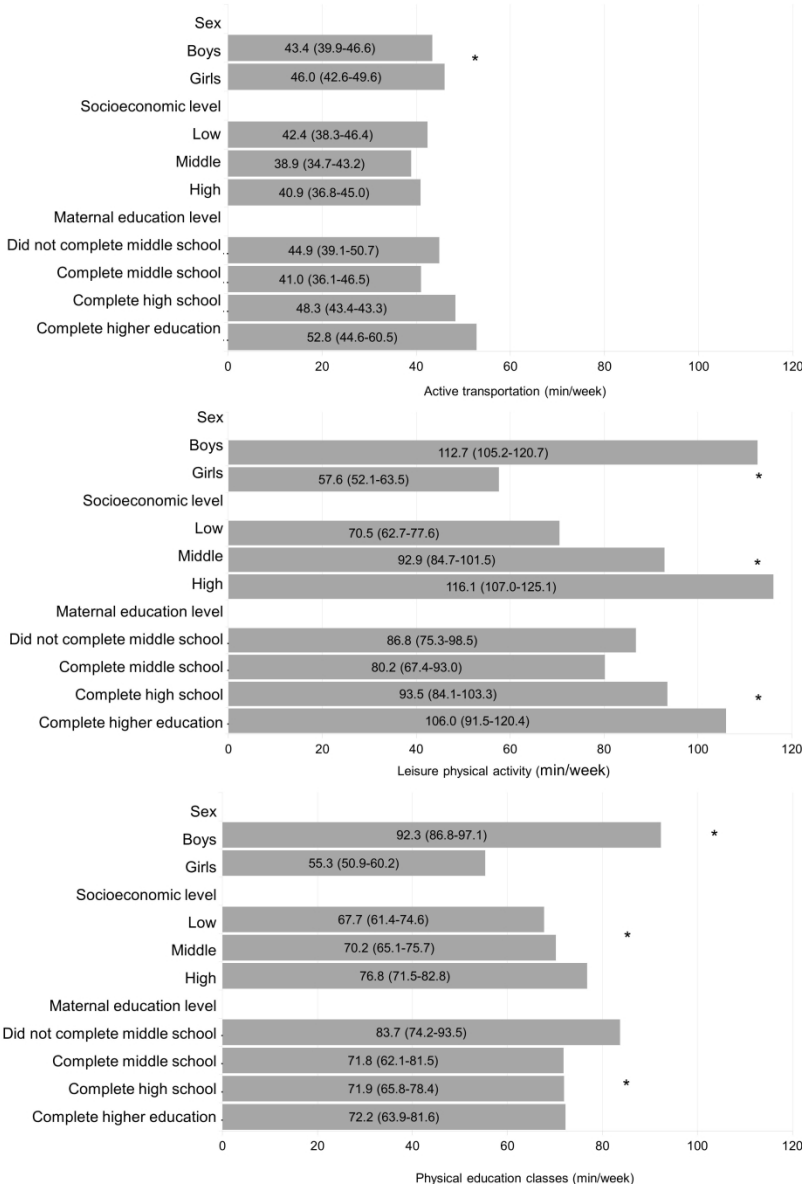

Figure 4: Minutes/week (means and 95% confidence intervals) of domain physical activity by sex, socioeconomic and education level.
*p<0.05

885x1319mm (96 x 96 DPI)

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Physical activity patterns in a representative sample of adolescents from the largest city in Latin America: a cross-sectional study in Sao Paulo

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Original research

Physical activity patterns in a representative sample of adolescents from the largest city in Latin America: a cross-sectional study in Sao Paulo

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Abstract

Objectives We examined the patterns of total and domain-specific physical activity (PA) by sex, socioeconomic status and maternal education level in adolescents from Sao Paulo city, Brazil.

Design Cross-sectional study.

Participants We included a representative sample of 2,682 (52.2% boys) adolescents aged 14-15 years from public and private schools in Sao Paulo. Socioeconomic status was assessed using wealth index derived from principal component analysis. Descriptive analyses evaluated differences in total and domain-specific PA by sex, socioeconomic status and maternal education level.

Outcome measures We collected data on the frequency and time that adolescents spent in each PA domain (active transportation, leisure and physical education classes) through a self-report questionnaire.

Results On average, adolescents spent 197.7 min/week (95% CI: 190.6-204.8) in total PA. The proportion of adolescents achieving at least 60 min/day was 12.7% (95%CI 11.4-14.1), with a higher prevalence in boys (18.3%) and in those with higher socioeconomic status (17.4%). Similar patterns were observed for leisure PA and physical education classes. Active transportation was higher in girls (46.0 min/week; 95%CI: 42.6-49.6) than in boys (43.4 min/week, 95%CI: 39.9-46.6). Boys with higher socioeconomic status and higher maternal education level had higher levels of total PA.

Conclusions We found a variation in patterns of total and domain-specific PA by sex, socioeconomic status and maternal education level in adolescents from Sao Paulo. Initiatives for promoting PA in adolescents should take these findings into account.

Keywords: Epidemiology, physical activity, active transportation, leisure physical activity, physical education classes.

Strengths and limitations of this study

- Use of a large sample of adolescents living in a megacity, Sao Paulo; therefore, the representativeness is high.
- Use of total and domain-specific physical activity data to describe adolescent´s physical activity patterns by sex, socioeconomic status, and maternal education level.
- Physical activity was collected through a self-report questionnaire; therefore, measurement error is likely to have occurred.
- Out-of-school adolescents were not included in our study.
- About one out of ten adolescents did not report maternal education level, which may have led to biased patterns of physical activity.

Introduction

The benefits of physical activity (PA) during childhood and adolescence are well known. PA decreases the risk of cardiovascular disease and adiposity, improves cognitive development, and cardiorespiratory and muscular fitness.[1] In addition, PA during adolescence has been linked to a lower risk of non-communicable diseases during adulthood.[2] To achieve these health benefits, the World Health Organization (WHO) recommends that adolescents accumulate at least 60 min/day of moderate to vigorous intensity PA (MVPA).[3] In Brazil, only 29% of adolescents meet these PA guidelines, a scenario that is slightly better than the world average (19%).[4] The reasons for this low PA level in adolescents are not yet fully understood.[5]

In relation to the large number of correlates and determinants of PA, evidence has shown that some population strata have greater opportunities to achieve the recommended PA guidelines.[6] A systematic review showed that young people with socioeconomic vulnerability have lower levels of PA.[7] In Brazil, the National School-Based Health Survey showed that boys and children of mothers with more years of schooling are more active in their leisure time than girls and adolescents of mothers with incomplete elementary school.[8]

An emerging area of research is the context in which PA occurs, also known as domains or modes of PA.[1] PA includes a diversity of organized (e.g. sports activities, physical education classes) and unorganized activities (e.g. active play or unorganized sport), as well as active transportation (e.g., cycling to school).[1] Assessing the patterns of total and domain-specific PA could provide a more complete understanding of this complex behavior. For instance, perceived traffic and access to recreational and leisure facilities have been positively associated with engagement in sports. On the other hand, the presence of adequate walking and cycling infrastructure, street connectivity and

proximity to public spaces have been associated with increased active transportation.[9] These findings suggest that PA determinants may differ according to PA domains.[10 11]

Promoting PA in adolescents living in megacities is an even greater challenge. Sao Paulo is among the ten most urbanized and populous cities in the world,[12] characterized by diverse cultural and socioeconomic backgrounds, as well as wide variation in disease distribution and lifestyles. In the last years, Sao Paulo has undergone an accelerated urbanization process, along with a demographic, epidemiological, and socioeconomic transition.[13] Meanwhile, highly disorganized and heavy traffic, air and noise pollution, rising crime rates, and high-income inequality persist in this megacity.[13] These changes have produced changes in PA patterns in all age groups.[14 15] Systematic literature reviews indicated that most studies have been conducted in high-income countries.[16 17] In Brazil, previous studies have suggested that socioeconomic inequalities in access to leisure PA have decreased between 2009 and 2015, although they remain high.[18] In addition, few studies have showed the pattern of total and domain-specific PA in adolescents living in megacities in low- to middle-income countries.[19]

In the urban context of Sao Paulo, characterized by social fragmentation and inequalities in opportunities to engage in PA, the New Master Plan has emerged as an effective initiative to promote active life.[20] This initiative improved an extensive network of bike paths created in Sao Paulo in 2014. In the last five years, the number of bike lanes has increased particularly in this city. This can be partly explained by the fact that bike lanes allow the temporary and regular use of public open spaces in urban contexts where there is a relatively low availability of public recreation facilities and public spaces. Furthermore, bike lanes represent an opportunity to encourage the equitable and sustainable use of public spaces, as they have the potential to change

transportation behaviors.[21] Therefore, understanding the patterns of total and domain-specific PA by sex, socioeconomic status, and maternal education can provide new insights and enable future research on how policies and interventions impact PA in adolescents. To describe the PA pattern in adolescents in Sao Paulo, we used data from a large representative sample of students, the Sao Paulo Project for the Social Development of Children and Adolescents (*São Paulo para o desenvolvimento social de crianças e adolescentes - SP-PROSO*)

Methods

Study design, sample, and data collection

SP-PROSO is a cross-sectional study including a representative sample of 9th grade students from public and private schools in Sao Paulo.[22] SP-PROSO was approved by the Ethics and Research Committee of the University of Sao Paulo School of Medicine and the National Commission for Research Ethics. The schools' principal, responsible guardian and the adolescents themselves signed a consent form to participate in the study.

The target population were 9th grade adolescents formally enrolled in schools in the city of Sao Paulo. According to the 2015 School Census, a total of 175,854 students were enrolled in the 9th grade of 2,086 private and public schools in Sao Paulo. Minimum sample size was determined to obtain estimates of population groups of at least 15% of the population ($n=n_o/0,15$), with an accuracy of (d) 0.06 and a sampling design effect of 1.7. The estimated minimum sample size was 2,849 students. Considering a possible loss of 10%, this number was increased to 3,300. The sampling strategy considered stratification by school type (state public, municipal public and private) and clustering by considering each class as a drawing unit. In total, 156 classes were randomly selected

and 119 schools agreed to participate in the study. Of the 61 private schools drawn, 26 refused to participate and 3 did not respond to our invitation and were excluded. Of the public schools, there was only one loss among the state schools and seven among the municipal schools. Regarding the students, considering the number that attended classes on the day of data collection (n=2.816), 96 were not authorized by their parents or refused to participate in the study, and 18 could not participate due to health-related and/or reading/comprehension issues. The final sample size was 2,702 participants, which represented 94.8% of the calculated minimum sample size.

Adolescents filled out a self-report structured questionnaire available in their classrooms during regular school hours. The questionnaire was based on two validated questionnaires from the Global School-Based Student Health Survey[23] and the Youth Risk Behaviour Surveillance System.[24]

Physical activity assessment

The PA questionnaire asked participants about the weekly frequency and duration of active transportation (walking or cycling) to and from school, leisure PA, and participation in physical education classes during the past week. This questionnaire has been used by the National Survey of School Health (*Pesquisa Nacional de Saúde do Escolar* - PeNSE).[25] Measures of PA have been validated previously and showed satisfactory relative validity (sensitivity: 77.9%; specificity: 69.1%; accuracy index: 73.1%).[26]

We calculated total PA by adding the minutes per week (min/week) of each PA domain. Adolescents were categorized as “meeting” (≥420 min/week) or “not meeting” (<420 min/week) PA guidelines according to WHO’s recommendations for adolescents.[3] PA in each domain was expressed as continuous (min/week) and categorical

(participation in at least two days a week). Finally, we estimated the distribution of total PA according to PA domains (i.e., to estimate the share of each PA domain).

Sociodemographic variables

The socioeconomic status was determined based on maternal education level and a series of questions that explored the possession of goods and the presence of a maid in the home. These questions were derived from the PeNSE. The PeNSE questionnaire included questions about the presence of goods in the home (the home where the adolescents actually lived). This questionnaire and method of measuring socioeconomic status has been widely used in Brazil in school surveys. [27]

As previously suggested by Barros and Victoria (2005), the socioeconomic status was calculated through principal component analysis (PCA).[27] PCA was ran adding to the model: maternal educational level (incomplete middle school, complete middle school, complete high school, complete higher education); school type (public or private); landline (yes or no), mobile phone (yes or no), internet computer in the room (yes or no), car (yes or no), and number of bathrooms inside the house. The first component of the PCA and estimated coefficients were obtained using the following equation: coefficient=loading/SDx100. The individual value was calculated from $\sum c_i v_i$, where c_i is the coefficient and v_i is the score for the ith variable. Socioeconomic status was categorized as terciles of the total wealth scores, being the first tercile (T1) the poorest group and the third tercile (T3) the wealthiest group. Total and domain-specific PA were also presented separately by sex and maternal education level.

Patient and public involvement

This cross-sectional study with adolescents did not involve patients in the design, recruitment, implementation or planning.

Statistical analysis

Total and domain-specific PA were described using absolute frequencies, mean (and its 95% confidence intervals - 95% CI), and median (and its interquartile range). Analyses were carried out according to sex, socioeconomic status, and maternal education level. Mann-Whitney and Kruskal-Wallis tests were used to compare means and variances, and Chi-Square test was used to compare categorical variables. All analyses were performed using IBM SPSS (v 22 IBM Corp, Armonk, New York, NY, USA).[28]

Results

On average, adolescents spent 197.7 minutes (95% CI: 190.6 to 204.8) in total PA per week; with a median value of 140 min/week (interquartile range: 55.0-280.0) (Figure 1). Boys, adolescents with higher socioeconomic status and higher maternal education level presented higher levels of total PA. Mean differences in total PA were: 83 min/week higher in boys than girls; 87 min/week higher in those of high socioeconomic status compared to those of low socioeconomic status; 21 min/week higher in those whose mothers had complete higher education compared to those whose mothers did not complete middle-school. The proportion of individuals achieving ≥420 min/week of total PA was 12.7% (95%CI 11.4-14.1), with a higher proportion in boys (18.3%) than in girls (6.8%), in the high socioeconomic group (17.4%) than in the low socioeconomic group (9%), and in those whose mothers completed higher education (16%) than in those whose mothers did not complete middle-school (14.5%) (Table 1).

Figure 1

Table 1

Figure 2 shows the proportion of adolescents participating in at least two days/week in each of the three PA domains investigated: 65.2% for active transportation, 63.7% for leisure PA, and 81.2% for participation in physical education classes.

Figure 2

Figure 3 display the proportion and min/week of total and domain-specific PA by sex, socioeconomic status, maternal education level, and PA guidelines. The relative contribution of leisure PA was higher among adolescents with higher levels of PA. For instance, leisure PA contributed to 46% of total PA in boys, 49.5% in adolescents with high socioeconomic status, 46% in adolescents whose mothers completed high school, and 56% in adolescents achieving PA guidelines.

Figure 3

In absolute terms, leisure PA contributed more to total PA in boys (113 min/week), in adolescents with high socioeconomic status (116 min/week) and in those whose mothers completed high school (106 min/week). On the other hand, active transportation contributed more to total PA in girls (46 min/week). Physical education classes had a higher share of total PA in boys (92 min/week), in adolescents with high socioeconomic status (77 min/week) and in those whose mothers did not complete high school (84 min/week) (Figure 4).

Figure 4

Discussion

The aim of this study was to describe the pattern of total and domain-specific PA by sex, socioeconomic status, and maternal education level in adolescents from the largest city of Latin America, Sao Paulo. On average, adolescents spent 197.7 min/week in total PA. The proportion of adolescents who met the WHO PA recommendations (≥420 min/week) was 12.7%, and was higher in boys and adolescents with higher socioeconomic status. Active transport contributed more to total PA in girls than in boys (28% versus 18%). Leisure PA and physical education classes were higher in boys and adolescents with high socioeconomic status. Boys with higher socioeconomic status and maternal education had higher levels of total PA.

Children and young people aged 5 to 17 years are advised to accumulate at least 60 minutes of daily MVPA (420 min/week).[3] Compared with high-income countries, we found a higher prevalence of insufficient PA in adolescents in Sao Paulo (87.3%) than in adolescents in Australia (83.5%), United States (70.9%), Denmark (80.4%) and Spain (74.4%). Worldwide, 81% of adolescents aged 11 to 17 years did not achieve this goal.[29] In other Brazilian cities, the proportion of adolescents who do not meet the PA guidelines is lower than in Sao Paulo; for example, it is 60% in Distrito Federal, 63.2% in Rio de Janeiro, and 64.1% in Rio Grande do Sul.[30] These differences in PA across countries and cities are not well characterized. Heterogeneity across countries in terms of socioeconomic and environmental determinants of PA domains could certainly play a role.[4] Intervention programs should consider PA patterns to encourage PA practice among adolescents in the city of Sao Paulo.

Sao Paulo has been described as a city with a large disorganized urban sprawl. In the past 70 years, there has been an increase in violence and a decrease in public open spaces in peripheral regions and in low socioeconomic areas. These facts may explain the higher prevalence of physical inactivity among adolescents in Sao Paulo compared

to other cities. However, in the last ten years, different interventions have aimed to change this scenario. The New Master Plan to reduce environmental inequities was implemented in 2014.[20] Thereafter, programs such as “ruas de lazer” were implemented, where streets are closed to cars and open to the population on weekends. There was also an increase in bike paths and programs such as “ciclofaixas de lazer”, where part of the streets and avenues are open to cyclists on weekends. Finally, green areas such as squares and parks around the city have also been expanded and valued as important public spaces for PA.[21]

In our study, patterns of domain-specific PA were different between boys and girls. Active transport was higher, in absolute and relative terms, in girls than in boys. On the other hand, boys were more active than girls in the domains of leisure and physical education classes. These findings are similar to previous studies conducted worldwide.[4] [31] In addition, the contribution of leisure PA and physical education classes to total PA was found to be 46.1% and 36.3% in boys and 36.6% and 34.9% in girls, respectively. Boys tend to participate more frequently in high-intensity PA (e.g., soccer, basketball, volleyball), while girls tend to engage in light to moderate-intensity activities, such as walking, water activities and ice skating.[32] In addition, boys report greater social support from parents and friends, have fewer barriers to getting involved in, and a greater perception of self-efficacy for PA. On the other hand, girls show more negative attitudes towards PA, refer to more barriers and perceive less favorable environments for PA.[33] PA interventions, especially in leisure time, are important to increase total PA of adolescent girls in Sao Paulo. For this reason, it is imperative to identify girls’ preferences, reasons and barriers to participate in these activities.

Adolescents with a high socioeconomic status showed a higher PA level than the lower socioeconomic groups. Higher socioeconomic status has been associated with

more opportunities at school and in the community for PA.[7] Similarly, our results showed that adolescents with a higher maternal education level tend to have higher levels of total PA, especially in the leisure PA domain, possibly reflecting a higher socioeconomic status. Several methods have been used to determine socioeconomic status (e.g., family income, professional occupation, parental education, place of residence), which have been shown to influence adolescent PA in particular ways.[7] For example, while poorest groups walk more to and from school or work and develop more household activities, wealthiest groups engage more frequently in leisure PA, which could be explained by differences in access to financial and material resources. Different mechanisms may explain the relationship between parental education and PA.[7] First, participation in many types of PA has financial costs (e.g., purchasing equipment, monthly fees and transportation) that may not be affordable by the poorest families.[34] Families with higher socioeconomic status usually live in neighborhoods with better infrastructure for PA (e.g., parks, squares, running/walking tracks or cycle paths). In addition, adults with higher education levels have higher PA levels, particularly during leisure time,[35 36] which may positively influence adolescents' PA.[1 3] Another plausible explanation for this association is that physically active parents are more likely to provide greater social support for adolescent PA.[1 37]

In our study, adolescents spent relatively little time on leisure PA and active transportation. Participants did, on average, 26 min/week of leisure PA and 44 min/week of active transportation. These domains accounted for only 23% and 41% of total PA, respectively. Active transportation to school is an important source of PA and has been associated to higher PA levels in adolescents.[38-40] As only 65% of the participants engage in active transportation, school-based interventions aiming to promote walking or cycling to and from school are needed. Prevalences of active transportation in Latin

American countries have been associated with different socioenvironmental characteristics.[41] Safety, social support for commuting, and the built environment have been reported to be important determinants of active transportation in adolescents.[42]

Physical education classes are a fundamental opportunity to promote PA.[10 43] Physical education classes may contribute considerably to adolescent PA, both directly – by offering PA in the class; and indirectly - by stimulating PA practice, favoring access to knowledge and positive experiences with PA.[43] A systematic review that estimated PA levels during physical education classes showed that, on average, youth spend 37% of their physical education time in MVPA.[44] In another study, physical education classes contributed 30% to total PA.[39] Adolescents who participate in physical education classes are more likely to be physically active.[43 45] Physical education classes showed to be an important opportunity for adolescents' PA, especially for those with lower socioeconomic status and lower maternal education level. Policies aimed to promote PA should ensure, among other things, that frequency and quality physical education classes contribute to adolescents develop standards of behaviors that keep them physically active throughout their lives.[46]

Patterns of total and domain-specific PA may be useful for decision makers to plan and promote PA interventions. Decisions can be made to construct appropriate PA leisure environments, such as outdoor park courts,[47] and improve the walkability of streets[26] and cycle paths. Our results indicate that adolescents participating in leisure PA are more likely to achieve PA guidelines. In this sense, schools and decision makers should prioritize PA programs focused on leisure activities to increase total PA in adolescents in Sao Paulo.

Our study has some limitations. Of the 61 private schools drawn, 26 refused and three did not respond, so they were excluded. Of the public schools, one state school

and seven municipal schools were lost. Out-of-school adolescents were not included in our study. PA information was collected through a self-report questionnaire, and therefore measurement error probably occurred. Although participants were asked about the frequency and duration of each PA domain in a typical week, the questionnaire did not include information on the intensity of activities.[48] However, this PA questionnaire has shown high relative accuracy.[26] The maternal education variable had substantial missing data (30%). However, missing data was not related to sex and socioeconomic status. Adolescents with missing maternal education data showed similar active transportation and participation in physical education classes. However, they tended to present higher levels of leisure PA (mean: 179.2 min/week; $p<0.001$) and total PA (mean: 75.2 min/week; $p<0.001$) compared to those who did answered a questionnaire about maternal education level (data not shown).

Conclusions

In this study, we found different patterns of total and domain-specific PA by sex, socioeconomic status, and maternal education level in adolescents from Sao Paulo, which should be considered by PA interventions. Subgroups of adolescents with higher PA levels (boys and adolescents with high socioeconomic status and high maternal education level) tended to have more engagement in leisure PA. Routine PA transportation should also be highly encouraged to increase PA in adolescents. Future studies should seek to better understand the challenges of implementing and promoting PA by considering total and domain-specific PA patterns.

Appendix

Figure 1: Distribution of total physical activity (min/week).

Figure 2. Proportion (%) of adolescents practicing physical activity at least two days per week by domain.

Figure 3. Proportion (%) of domains of physical activity by sex, socioeconomic status, maternal education level and physical activity guidelines.

Figure 4: Minutes/week (means and 95% confidence intervals) of domain of physical activity by sex, socioeconomic status and maternal education level.

*p<0.05

Author contributions

GLMF and LFMR had full access to all study data and were responsible for the integrity of the data and the accuracy of the data analysis. The corresponding author had final responsibility for the decision to submit for publication. MFTP was the PI responsible for study concept, design, and data collection. GLMF and LFMR prepared the first draft. GLMF, LFMR, GAW, AAF and MFTP drafted and critically revised the manuscript for important intellectual content and gave final approval of the version to be published.

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Conflict of interest

None declared.

Patient consent for publication

Not required.

Ethics approval

The protocol was approved by the Ethics and Research Committee of the University of Sao Paulo, School of Medicine (Comitê de Ética e Pesquisa da Faculdade de Medicina da Universidade de São Paulo, records no. 1.719.856) and the National Commission for Research Ethics (Comissão Nacional de Ética em Pesquisa [CONEP], records no. 2.014.816).

Data sharing statement

Data are available upon reasonable request from the corresponding author.

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Table 1. Adolescent's sociodemographic characteristics associated with total physical activity.

Variables	N	%	Mean (95%CI)	Median (25-75)	≥420 min/week (95%CI)	p[b]
Total	2,682		197.7 (190.6-204.8)	140.0 (55.0-280.0)	12.7 (11.4-14.1)	
Sex	2,61					<0.0001
Boys	1,363	52.2	238.2 (227.6-248.8)	180.5 (25.0-343.7)	18.3 (16.4-20.5)	
Girls	1,247	47.8	155.8 (146.2-164.9)	105.0 (30.0-225.0)	6.8 (5.2-8.1)	
Socioeconomic status	2,682					
Low	893	33.3	173.0 (161.7-185.3)	120.0 (45.0-255.0)	9.0 (7.3-10.8)	<0.0001
Middle	890	33.2	197.8 (185.2-210.8)	140.0 (70.0-275.0)	12.5 (10.3-14.7)	
High	899	33.5	230.1 (217.2-243.9)	190.0 (85.0-330.0)	17.4 (15.0-19.9)	
Maternal education level	1,855					
Did not complete middle school	462	24.9	206.5 (187.4-226.7)	140.0 (50.0-303.7)	14.5 (11.4-17.9)	0.093
Complete middle school	366	19.7	186.6 (167.8-206.0)	130.0 (60.0-240.0)	9.8 (6.7-13.0)	
Complete high school	715	38.5	208.1 (194.1-221.3)	165.0 (75.0-305.0)	14.1 (11.5-16.8)	
Complete higher education	312	16.8	227.9 (205.9-250.9)	175.0 (76.2-340.0)	16.0 (12.4-20.4)	

[a] Mann-Whitney or Kruskal-Wallis test for the comparison of medians; [b] chi-square for heterogeneity.

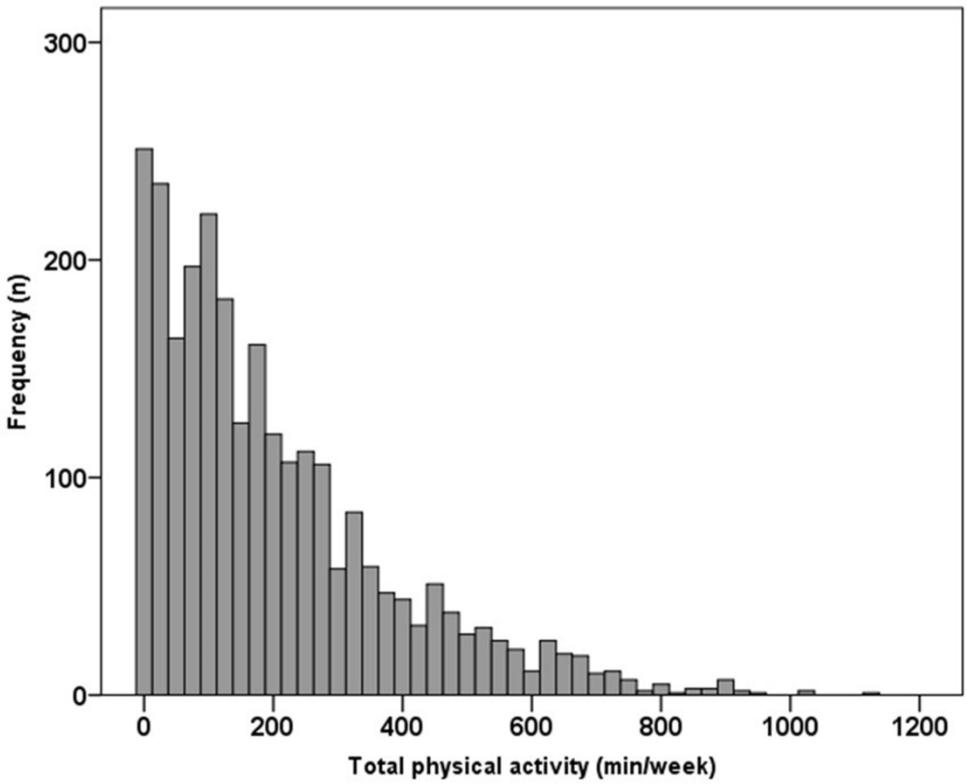

Figure 1: Distribution of total physical activity (min/week).

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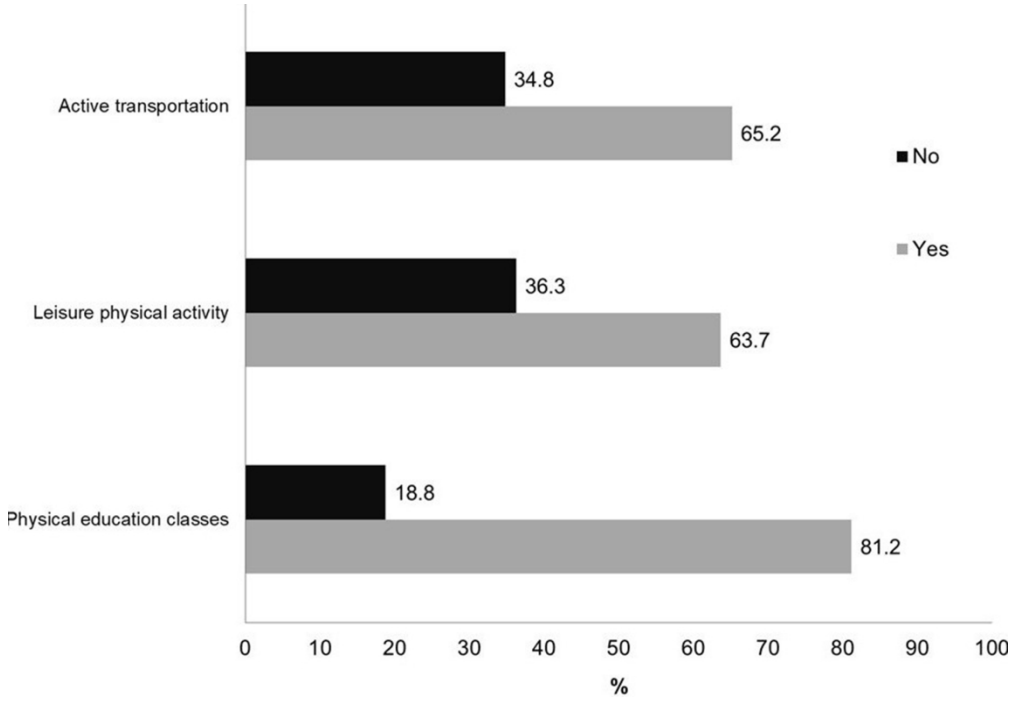

Figure 2. Proportion (%) of adolescents practicing physical activity at least two days per week by domain.

249x172mm (300 x 300 DPI)

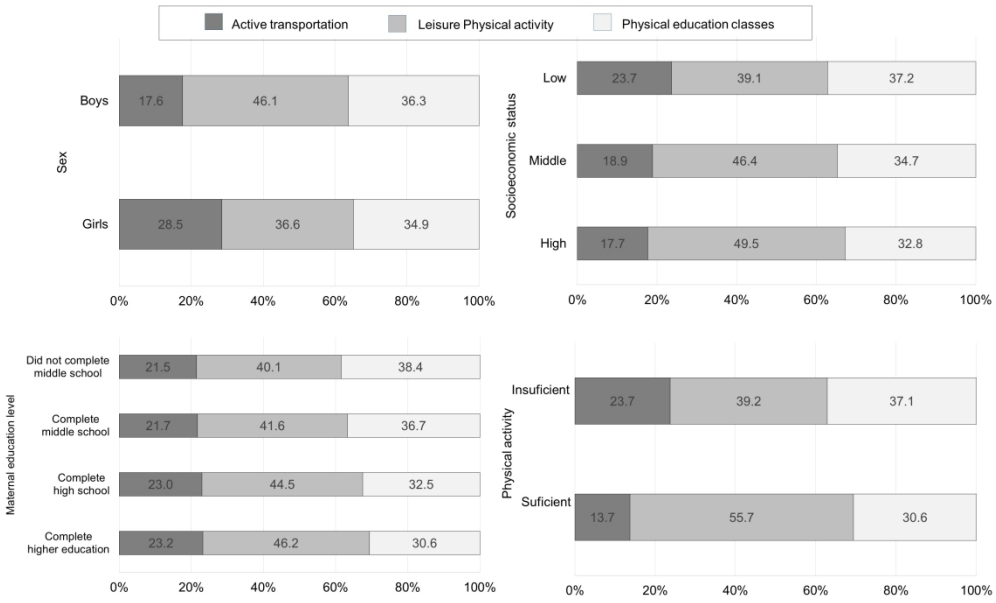

Figure 3. Proportion (%) of domains of physical activity by sex, socioeconomic status, maternal education level and physical activity guidelines.

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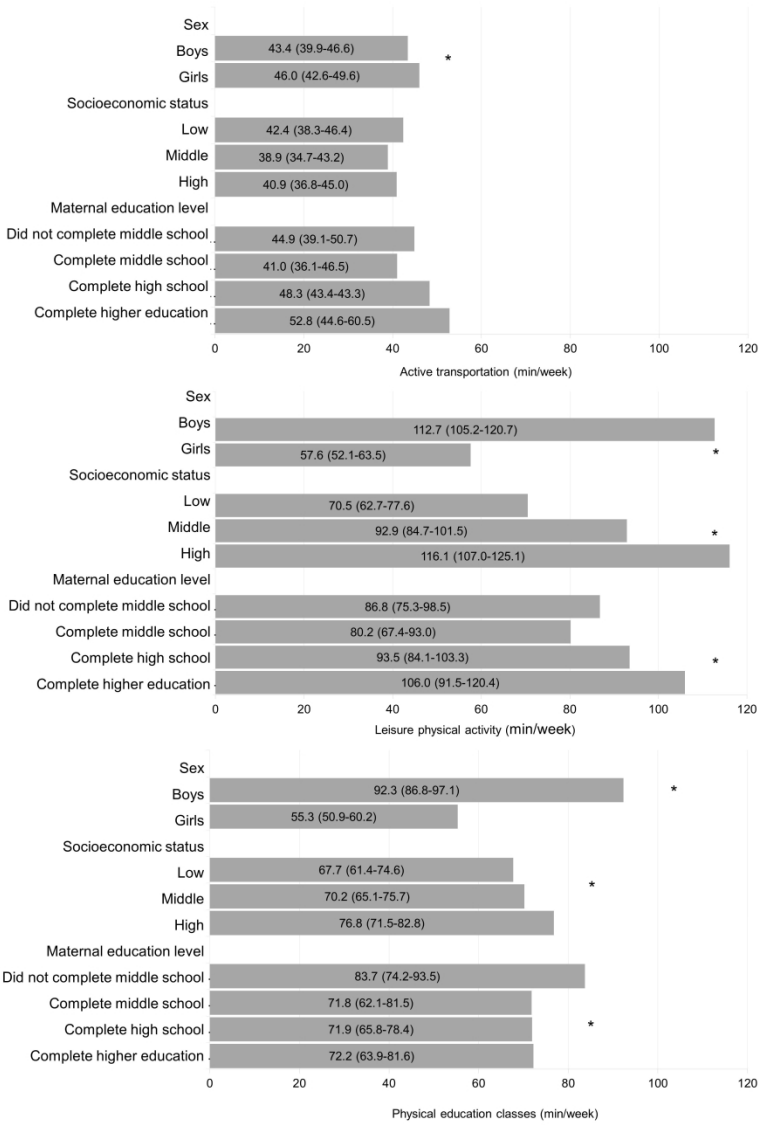

Figure 4: Minutes/week (means and 95% confidence intervals) of domain of physical activity by sex, socioeconomic status and maternal education level.
*p<0.05

284x447mm (300 x 300 DPI)

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Physical activity patterns in a representative sample of adolescents from the largest city in Latin America: a cross-sectional study in Sao Paulo

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Original research

Physical activity patterns in a representative sample of adolescents from the largest city in Latin America: a cross-sectional study in Sao Paulo

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Abstract

Objectives We examined the patterns of total and domain-specific physical activity (PA) by sex, socioeconomic status and maternal education level in adolescents from Sao Paulo city, Brazil.

Design Cross-sectional study.

Participants We included a representative sample of 2,682 (52.2% boys) adolescents aged 14-15 years from public and private schools in Sao Paulo. Socioeconomic status was assessed using wealth index derived from principal component analysis. Descriptive analyses evaluated differences in total and domain-specific PA by sex, socioeconomic status and maternal education level.

Outcome measures We collected data on the frequency and time that adolescents spent in each PA domain (active transportation, leisure and physical education classes) through a self-report questionnaire.

Results On average, adolescents spent 197.7 min/week (95% CI: 190.6-204.8) in total PA. The proportion of adolescents achieving at least 60 min/day was 12.7% (95%CI 11.4-14.1), with a higher prevalence in boys (18.3%) and in those with higher socioeconomic status (17.4%). Similar patterns were observed for leisure PA and physical education classes. Active transportation was higher in girls (46.0 min/week; 95%CI: 42.6-49.6) than in boys (43.4 min/week, 95%CI: 39.9-46.6). Boys with higher socioeconomic status and higher maternal education level had higher levels of total PA.

Conclusions We found a variation in patterns of total and domain-specific PA by sex, socioeconomic status and maternal education level in adolescents from Sao Paulo. Initiatives for promoting PA in adolescents should take these findings into account.

Keywords: Epidemiology, physical activity, active transportation, leisure physical activity, physical education classes.

Strengths and limitations of this study

- Use of a large sample of adolescents living in a megacity, Sao Paulo; therefore, the representativeness is high.
- Use of total and domain-specific physical activity data to describe adolescent´s physical activity patterns by sex, socioeconomic status, and maternal education level.
- Physical activity was collected through a self-report questionnaire; therefore, measurement error is likely to have occurred.
- Out-of-school adolescents were not included in our study.
- About one out of ten adolescents did not report maternal education level, which may have led to biased patterns of physical activity.

Introduction

The benefits of physical activity (PA) during childhood and adolescence are well known. PA decreases the risk of cardiovascular disease and adiposity, improves cognitive development, and cardiorespiratory and muscular fitness.[1] In addition, PA during adolescence has been linked to a lower risk of non-communicable diseases during adulthood.[2] To achieve these health benefits, the World Health Organization (WHO) recommends that adolescents accumulate at least 60 min/day of moderate to vigorous intensity PA (MVPA).[3] In Brazil, only 29% of adolescents meet these PA guidelines, a scenario that is slightly better than the world average (19%).[4] The reasons for this low PA level in adolescents are not yet fully understood.[5]

In relation to the large number of correlates and determinants of PA, evidence has shown that some population strata have greater opportunities to achieve the recommended PA guidelines.[6] A systematic review showed that young people with socioeconomic vulnerability have lower levels of PA.[7] In Brazil, the National School-Based Health Survey showed that boys and children of mothers with more years of schooling are more active in their leisure time than girls and adolescents of mothers with incomplete elementary school.[8]

An emerging area of research is the context in which PA occurs, also known as domains or modes of PA.[1] PA includes a diversity of organized (e.g. sports activities, physical education classes) and unorganized activities (e.g. active play or unorganized sport), as well as active transportation (e.g., cycling to school).[1] Assessing the patterns of total and domain-specific PA may provide a more complete understanding of this complex behavior. For instance, perceived traffic and access to recreational and leisure facilities have been positively associated with engagement in sports. On the other hand, the presence of adequate walking and cycling infrastructure, street connectivity and

proximity to public spaces have been associated with increased active transportation.[9] These findings suggest that PA determinants may differ according to PA domains.[10 11]

Promoting PA in adolescents living in megacities is an even greater challenge. Sao Paulo is among the ten most urbanized and populous cities in the world,[12] characterized by diverse cultural and socioeconomic backgrounds, as well as wide variation in disease distribution and lifestyles. In the last years, Sao Paulo has undergone an accelerated urbanization process, along with a demographic, epidemiological, and socioeconomic transition.[13] Meanwhile, highly disorganized and heavy traffic, air and noise pollution, rising crime rates, and high-income inequality persist in this megacity.[13] These changes have produced changes in PA patterns in all age groups.[14 15] Systematic literature reviews indicated that most studies have been conducted in high-income countries.[16 17] In Brazil, previous studies have suggested that socioeconomic inequalities in access to leisure PA have decreased between 2009 and 2015, although it remain high.[18] In addition, few studies have showed the pattern of total and domain-specific PA in adolescents living in megacities in low- to middle-income countries.[19]

In the urban context of Sao Paulo, characterized by social fragmentation and inequalities in opportunities to engage in PA, the New Master Plan has emerged as an effective initiative to promote active life.[20] This initiative improved an extensive network of bike paths created in Sao Paulo in 2014. In the last five years, the number of bike lanes has increased particularly in this city. This can be partly explained by the fact that bike lanes allow the temporary and regular use of public open spaces in urban contexts where there is a relatively low availability of public recreation facilities and public spaces. Furthermore, bike lanes represent an opportunity to encourage the equitable and sustainable use of public spaces, as they have the potential to change

transportation behaviors.[21] Therefore, understanding the patterns of total and domain-specific PA by sex, socioeconomic status, and maternal education can provide new insights and enable future research on how policies and interventions impact PA in adolescents. To describe the PA pattern in adolescents in Sao Paulo, we used data from a large representative sample of students, the Sao Paulo Project for the Social Development of Children and Adolescents (*São Paulo para o desenvolvimento social de crianças e adolescentes - SP-PROSO*)

Methods

Study design, sample, and data collection

SP-PROSO is a cross-sectional study including a representative sample of 9th grade students from public and private schools in Sao Paulo.[22] SP-PROSO was approved by the Ethics and Research Committee of the University of Sao Paulo School of Medicine and the National Commission for Research Ethics. The schools' principal, responsible guardian and the adolescents themselves signed a consent form to participate in the study.

The target population were 9th grade adolescents formally enrolled in schools in the city of Sao Paulo. According to the 2015 School Census, a total of 175,854 students were enrolled in the 9th grade of 2,086 private and public schools in Sao Paulo. Minimum sample size was determined to obtain estimates of population groups of at least 15% of the population ($n=n_o/0,15$), with an accuracy of (d) 0.06 and a sampling design effect of 1.7. The estimated minimum sample size was 2,849 students. Considering a possible loss of 10%, this number was increased to 3,300. The sampling strategy considered stratification by school type (state public, municipal public and private) and clustering by considering each class as a drawing unit. In total, 156 classes were randomly selected

and 119 schools agreed to participate in the study. Of the 61 private schools drawn, 26 refused to participate and 3 did not respond to our invitation and were excluded. Of the public schools, there was only one loss among the state schools and seven among the municipal schools. Regarding the students, considering the number that attended classes on the day of data collection (n=2.816), 96 were not authorized by their parents or refused to participate in the study, and 18 could not participate due to health-related and/or reading/comprehension issues. The final sample size was 2,702 participants, which represented 94.8% of the calculated minimum sample size.

Adolescents filled out a self-report structured questionnaire available in their classrooms during regular school hours. The questionnaire was based on two validated questionnaires from the Global School-Based Student Health Survey[23] and the Youth Risk Behaviour Surveillance System.[24]

Physical activity assessment

The PA questionnaire asked participants about the weekly frequency and duration of active transportation (walking or cycling) to and from school, leisure PA, and participation in physical education classes during the past week. This questionnaire has been used by the National Survey of School Health (*Pesquisa Nacional de Saúde do Escolar* - PeNSE).[25] Measures of PA have been validated previously and showed satisfactory relative validity (sensitivity: 77.9%; specificity: 69.1%; accuracy index: 73.1%).[26]

We calculated total PA by adding the minutes per week (min/week) of each PA domain. Adolescents were categorized as “meeting” (≥420 min/week) or “not meeting” (<420 min/week) PA guidelines according to WHO’s recommendations for adolescents.[3] PA in each domain was expressed as continuous (min/week) and categorical

(participation in at least two days a week). Finally, we estimated the distribution of total PA according to PA domains (i.e., to estimate the share of each PA domain in total physical activity).

Sociodemographic variables

The socioeconomic status was determined based on maternal education level and a series of questions that explored the possession of goods and the presence of a maid in the home. These questions were derived from the PeNSE. The PeNSE questionnaire included questions about the presence of goods in the home (the home where the adolescents actually lived). This questionnaire and method of measuring socioeconomic status has been widely used in Brazil in school surveys. [27]

As previously suggested by Barros and Victoria (2005), the socioeconomic status was calculated through principal component analysis (PCA).[27] PCA was ran adding to the model: maternal educational level (incomplete middle school, complete middle school, complete high school, complete higher education); school type (public or private); landline (yes or no), mobile phone (yes or no), internet computer in the room (yes or no), car (yes or no), and number of bathrooms inside the house. The first component of the PCA and estimated coefficients were obtained using the following equation: coefficient=loading/SDx100. The individual value was calculated from $\sum c_i v_i$, where c_i is the coefficient and v_i is the score for the ith variable. Socioeconomic status was categorized as terciles of the total wealth scores, being the first tercile (T1) the poorest group and the third tercile (T3) the wealthiest group. Total and domain-specific PA were also presented separately by sex and maternal education level.

Patient and public involvement

This cross-sectional study with adolescents did not involve patients in the design, recruitment, implementation or planning.

Statistical analysis

Total and domain-specific PA were described using absolute frequencies, mean (and its 95% confidence intervals - 95% CI), and median (and its interquartile range). Analyses were carried out according to sex, socioeconomic status, and maternal education level. Mann-Whitney and Kruskal-Wallis tests were used to compare means and variances, and Chi-Square test was used to compare categorical variables. All analyses were performed using IBM SPSS (v 22 IBM Corp, Armonk, New York, NY, USA).[28]

Results

On average, adolescents spent 197.7 minutes (95% CI: 190.6 to 204.8) in total PA per week; with a median value of 140 min/week (interquartile range: 55.0-280.0) (Figure 1). Boys, adolescents with higher socioeconomic status and higher maternal education level presented higher levels of total PA. Mean differences in total PA were: 83 min/week higher in boys than girls; 87 min/week higher in those of high socioeconomic status compared to those of low socioeconomic status; 21 min/week higher in those whose mothers had complete higher education compared to those whose mothers did not complete middle-school. The proportion of adolescents achieving ≥420 min/week of total PA was 12.7% (95%CI 11.4-14.1), with a higher proportion in boys (18.3%) than in girls (6.8%), in the high socioeconomic group (17.4%) than in the low socioeconomic

group (9%), and in those whose mothers completed higher education (16%) than in those whose mothers did not complete middle-school (14.5%) (Table 1).

Figure 1

Table 1

Figure 2 shows the proportion of adolescents participating in at least two days/week in each of the three PA domains investigated: 65.2% for active transportation, 63.7% for leisure PA, and 81.2% for participation in physical education classes.

Figure 2

Figure 3 display the proportion and min/week of total and domain-specific PA by sex, socioeconomic status, maternal education level, and PA guidelines. The relative contribution of leisure PA was higher among adolescents with higher levels of PA. For instance, leisure PA contributed to 46% of total PA in boys, 49.5% in adolescents with high socioeconomic status, 46% in adolescents whose mothers completed high school, and 56% in adolescents achieving PA guidelines.

Figure 3

In absolute terms, leisure PA contributed more to total PA in boys (113 min/week), in adolescents with high socioeconomic status (116 min/week) and in those whose mothers completed high school (106 min/week). On the other hand, active transportation contributed more to total PA in girls (46 min/week). Physical education classes had a higher share of total PA in boys (92 min/week), in adolescents with high socioeconomic status (77 min/week) and in those whose mothers did not complete high school (84 min/week) (Figure 4).

Figure 4

Discussion

The aim of this study was to describe the pattern of total and domain-specific PA by sex, socioeconomic status, and maternal education level in adolescents from the largest city of Latin America, Sao Paulo. On average, adolescents spent 197.7 min/week in total PA. The proportion of adolescents who met the WHO PA recommendations (≥420 min/week) was 12.7%, and was higher in boys and adolescents with higher socioeconomic status. Active transport contributed more to total PA in girls than in boys (28% versus 18%). Leisure PA and physical education classes were higher in boys and adolescents with high socioeconomic status. Boys with higher socioeconomic status and maternal education had higher levels of total PA.

Children and young people aged 5 to 17 years are advised to accumulate at least 60 minutes of daily MVPA (420 min/week).[3] Compared with high-income countries, we found a higher prevalence of insufficient PA in adolescents in Sao Paulo (87.3%) than in adolescents in Australia (83.5%), United States (70.9%), Denmark (80.4%) and Spain (74.4%). Worldwide, 81% of adolescents aged 11 to 17 years did not achieve this goal.[29] In other Brazilian cities, the proportion of adolescents who do not meet the PA guidelines is lower than in Sao Paulo; for example, it is 60% in Distrito Federal, 63.2% in Rio de Janeiro, and 64.1% in Rio Grande do Sul.[30] These differences in PA across countries and cities are not well characterized. Heterogeneity across countries in terms of socioeconomic and environmental determinants of PA domains could certainly play a role.[4] Intervention programs should consider PA patterns to encourage PA practice among adolescents in the city of Sao Paulo.

Sao Paulo has been described as a city with a large disorganized urban sprawl. In the past 70 years, there has been an increase in violence and a decrease in public open spaces in peripheral regions and in low socioeconomic areas. These facts may explain

the higher prevalence of physical inactivity among adolescents in Sao Paulo compared to other cities. However, in the last ten years, different interventions have aimed to change this scenario. The New Master Plan to reduce environmental inequities was implemented in 2014.[20] Thereafter, programs such as "*ruas de lazer*" were implemented, where streets are closed to cars and open to the population on weekends. There was also an increase in bike paths and programs such as "*ciclofaixas de lazer*", where part of the streets and avenues are open to cyclists on weekends. Finally, green areas such as squares and parks around the city have also been expanded and valued as important public spaces for PA.[21]

In our study, patterns of domain-specific PA were different between boys and girls. Active transport was higher, in absolute and relative terms, in girls than in boys. On the other hand, boys were more active than girls in the domains of leisure and physical education classes. These findings are similar to previous studies conducted worldwide.[4] [31] In addition, the contribution of leisure PA and physical education classes to total PA was found to be 46.1% and 36.3% in boys and 36.6% and 34.9% in girls, respectively. Boys tend to participate more frequently in high-intensity PA (e.g., soccer, basketball, volleyball), while girls tend to engage in light to moderate-intensity activities, such as walking, water activities and ice skating.[32] In addition, boys report greater social support from parents and friends, have fewer barriers to getting involved in, and a greater perception of self-efficacy for PA. On the other hand, girls show more negative attitudes towards PA, refer to more barriers and perceive less favorable environments for PA.[33] PA interventions, especially in leisure time, are important to increase total PA of adolescent girls in Sao Paulo. For this reason, it is imperative to identify girls' preferences, reasons and barriers to participate in these activities.

Adolescents with a high socioeconomic status showed a higher PA level than the lower socioeconomic groups. Higher socioeconomic status has been associated with more opportunities at school and in the community for PA.[7] Similarly, our results showed that adolescents with a higher maternal education level tend to have higher levels of total PA, especially in the leisure PA domain, possibly reflecting a higher socioeconomic status. Several methods have been used to determine socioeconomic status (e.g., family income, professional occupation, parental education, place of residence), which have been shown to influence adolescent PA in particular ways.[7] For example, while poorest groups walk more to and from school or work and develop more household activities, wealthiest groups engage more frequently in leisure PA, which could be explained by differences in access to financial and material resources. Different mechanisms may explain the relationship between parental education and PA.[7] First, participation in many types of PA has financial costs (e.g., purchasing equipment, monthly fees and transportation) that may not be affordable by the poorest families.[34] Families with higher socioeconomic status usually live in neighborhoods with better infrastructure for PA (e.g., parks, squares, running/walking tracks or cycle paths). In addition, adults with higher education levels have higher PA levels, particularly during leisure time,[35 36] which may positively influence adolescents' PA.[1 3] Another plausible explanation for this association is that physically active parents are more likely to provide greater social support for adolescent PA.[1 37]

In our study, adolescents spent relatively little time on leisure PA and active transportation. Participants did, on average, 26 min/week of leisure PA and 44 min/week of active transportation. These domains accounted for only 23% and 41% of total PA, respectively. Active transportation to school is an important source of PA and has been associated to higher PA levels in adolescents.[38-40] As only 65% of the participants

engage in active transportation, school-based interventions aiming to promote walking or cycling to and from school are needed. Prevalences of active transportation in Latin American countries have been associated with different socioenvironmental characteristics.[41] Safety, social support for commuting, and the built environment have been reported to be important determinants of active transportation in adolescents.[42]

Physical education classes are a fundamental opportunity to promote PA.[10 43] Physical education classes may contribute considerably to adolescent PA, both directly – by offering PA in the class; and indirectly - by stimulating PA practice, favoring access to knowledge and positive experiences with PA.[43] A systematic review that estimated PA levels during physical education classes showed that, on average, youth spend 37% of their physical education time in MVPA.[44] In another study, physical education classes contributed 30% to total PA.[39] Adolescents who participate in physical education classes are more likely to be physically active.[43 45] Physical education classes showed to be an important opportunity for adolescents' PA, especially for those with lower socioeconomic status and lower maternal education level. Policies aimed to promote PA should ensure, among other things, that frequency and quality physical education classes contribute to adolescents develop standards of behaviors that keep them physically active throughout their lives.[46]

Patterns of total and domain-specific PA may be useful for decision makers to plan and promote PA interventions. Decisions can be made to construct appropriate PA leisure environments, such as outdoor park courts,[47] and improve the walkability of streets[26] and cycle paths. Our results indicate that adolescents participating in leisure PA are more likely to achieve PA guidelines. In this sense, schools and decision makers should prioritize PA programs focused on leisure activities to increase total PA in adolescents in Sao Paulo.

Our study has some limitations. Of the 61 private schools drawn, 26 refused and three did not respond, so they were excluded. Of the public schools, one state school and seven municipal schools were lost. Out-of-school adolescents were not included in our study. PA information was collected through a self-report questionnaire, and therefore measurement error probably occurred. Although participants were asked about the frequency and duration of each PA domain in a typical week, the questionnaire did not include information on the intensity of activities.[48] However, this PA questionnaire has shown high relative accuracy.[26] The maternal education variable had substantial missing data (30%). However, missing data was not related to sex and socioeconomic status. Adolescents with missing maternal education data showed similar active transportation and participation in physical education classes. However, they tended to present higher levels of leisure PA (mean: 179.2 min/week; $p<0.001$) and total PA (mean: 75.2 min/week; $p<0.001$) compared to those who did answered a questionnaire about maternal education level (data not shown).

Conclusions

In this study, we found different patterns of total and domain-specific PA by sex, socioeconomic status, and maternal education level in adolescents from Sao Paulo, which should be considered by PA interventions. Subgroups of adolescents with higher PA levels (boys and adolescents with high socioeconomic status and high maternal education level) tended to have more engagement in leisure PA. Routine PA transportation should also be highly encouraged to increase PA in adolescents. Future studies should seek to better understand the challenges of implementing and promoting PA by considering total and domain-specific PA patterns.

Appendix

Figure 1: Distribution of total physical activity (min/week).

Figure 2. Proportion (%) of adolescents practicing physical activity at least two days per week by domain.

Figure 3. Proportion (%) of domains of physical activity by sex, socioeconomic status, maternal education level and physical activity guidelines.

Figure 4: Minutes/week (means and 95% confidence intervals) of domain of physical activity by sex, socioeconomic status and maternal education level.

*p<0.05

Author contributions

GLMF and LFMR had full access to all study data and were responsible for the integrity of the data and the accuracy of the data analysis. The corresponding author had final responsibility for the decision to submit for publication. MFTP was the PI responsible for study concept, design, and data collection. GLMF and LFMR prepared the first draft. GLMF, LFMR, GAW, AAF and MFTP drafted and critically revised the manuscript for important intellectual content and gave final approval of the version to be published.

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Conflict of interest

None declared.

Patient consent for publication

Not required.

Ethics approval

The protocol was approved by the Ethics and Research Committee of the University of Sao Paulo, School of Medicine (Comitê de Ética e Pesquisa da Faculdade de Medicina da Universidade de São Paulo, records no. 1.719.856) and the National Commission for Research Ethics (Comissão Nacional de Ética em Pesquisa [CONEP], records no. 2.014.816).

Data sharing statement

Data are available upon reasonable request from the corresponding author.

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Table 1. Adolescent's sociodemographic characteristics associated with total physical activity.

Variables	N	%	Mean (95%CI)	Median (25-75)	≥420 min/week (95%CI)	P[b]
Total	2,682		197.7 (190.6-204.8)	140.0 (55.0-280.0)	12.7 (11.4-14.1)	
Sex	2,61					<0.001
Boys	1,363	52.2	238.2 (227.6-248.8)	180.5 (25.0-343.7)	18.3 (16.4-20.5)	
Girls	1,247	47.8	155.8 (146.2-164.9)	105.0 (30.0-225.0)	6.8 (5.2-8.1)	
Socioeconomic status	2,682					
Low	893	33.3	173.0 (161.7-185.3)	120.0 (45.0-255.0)	9.0 (7.3-10.8)	<0.001
Middle	890	33.2	197.8 (185.2-210.8)	140.0 (70.0-275.0)	12.5 (10.3-14.7)	
High	899	33.5	230.1 (217.2-243.9)	190.0 (85.0-330.0)	17.4 (15.0-19.9)	
Maternal education level	1,855					
Did not complete middle school	462	24.9	206.5 (187.4-226.7)	140.0 (50.0-303.7)	14.5 (11.4-17.9)	0.093
Complete middle school	366	19.7	186.6 (167.8-206.0)	130.0 (60.0-240.0)	9.8 (6.7-13.0)	
Complete high school	715	38.5	208.1 (194.1-221.3)	165.0 (75.0-305.0)	14.1 (11.5-16.8)	
Complete higher education	312	16.8	227.9 (205.9-250.9)	175.0 (76.2-340.0)	16.0 (12.4-20.4)	

[a] Mann-Whitney or Kruskal-Wallis test for the comparison of medians; [b] chi-square for heterogeneity.

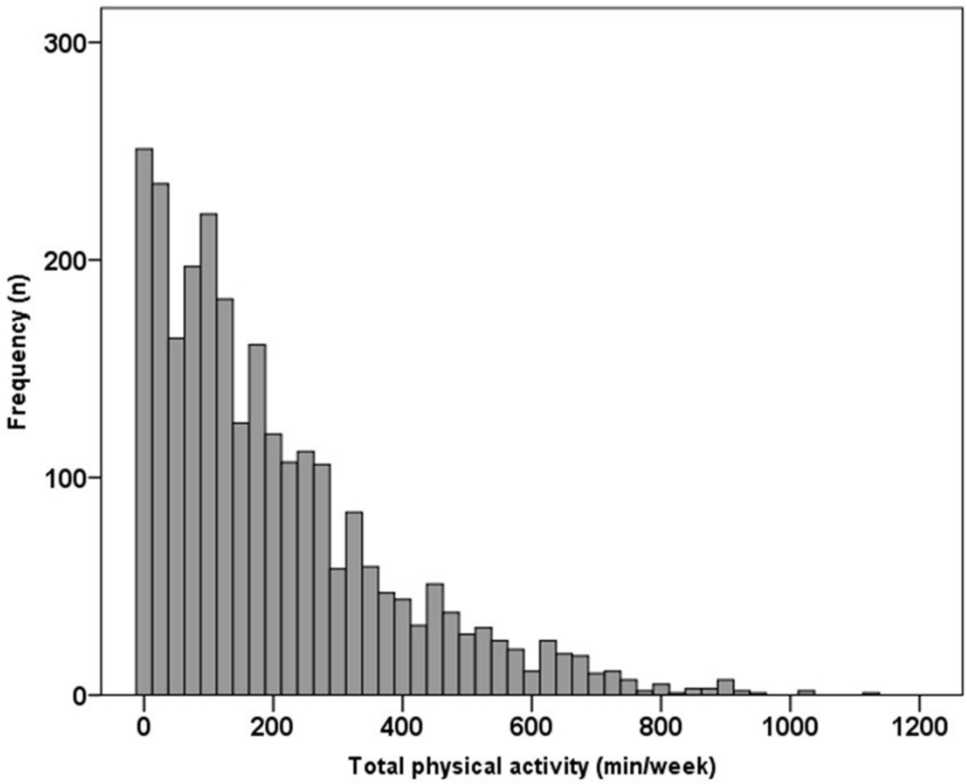

Figure 1: Distribution of total physical activity (min/week).

232x184mm (300 x 300 DPI)

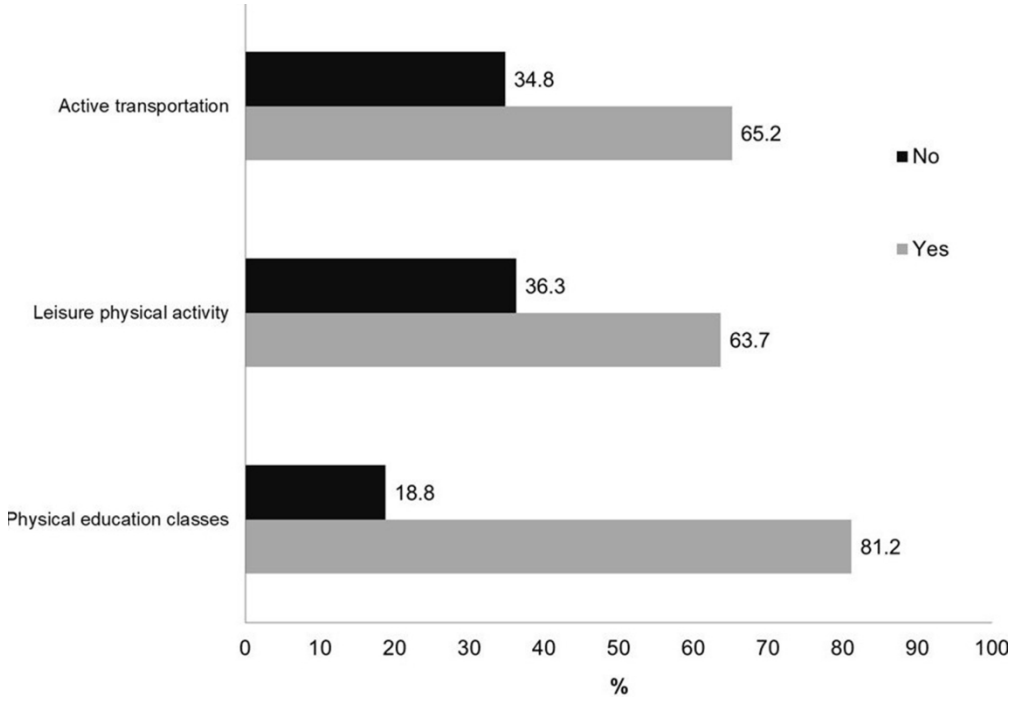

Figure 2. Proportion (%) of adolescents practicing physical activity at least two days per week by domain.

249x172mm (300 x 300 DPI)

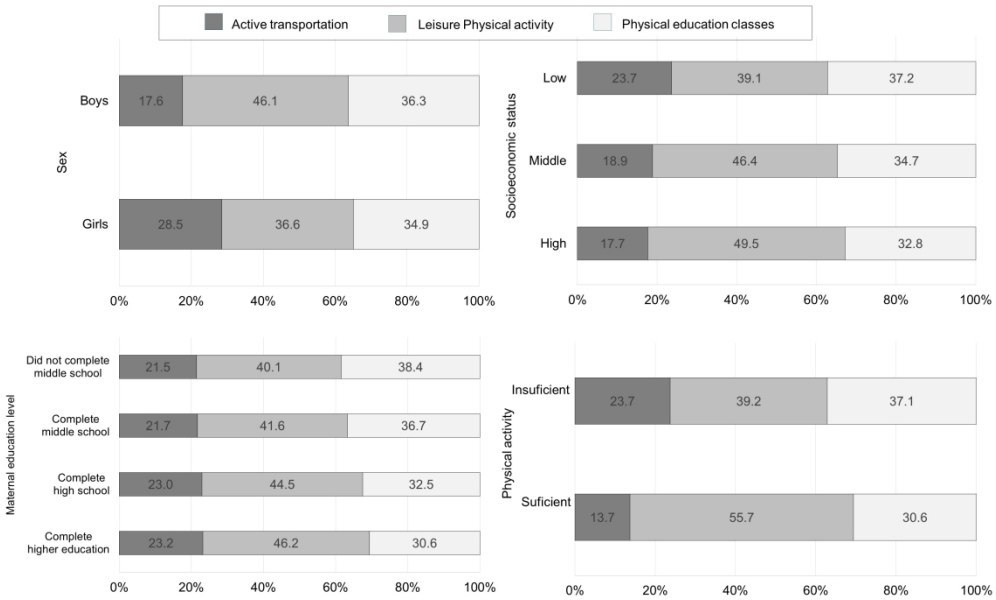

Figure 3. Proportion (%) of domains of physical activity by sex, socioeconomic status, maternal education level and physical activity guidelines.

284x169mm (300 x 300 DPI)

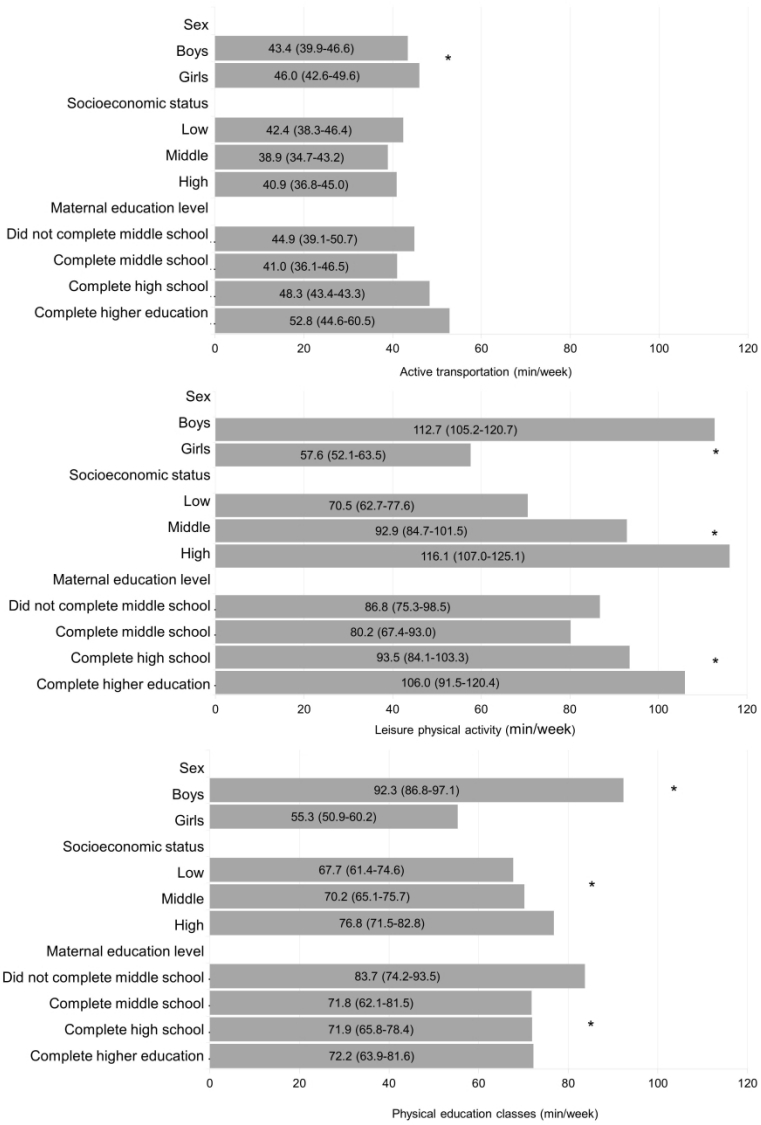

Figure 4: Minutes/week (means and 95% confidence intervals) of domain of physical activity by sex, socioeconomic status and maternal education level.
*p<0.05

284x447mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4, 5, 6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6, 7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7,8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7,8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	7
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7, 8, 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	6, 7
		(*e*) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6, 7
		(b) Give reasons for non-participation at each stage	6, 7
		(c) Consider use of a flow diagram	6, 7
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	NA
		(b) Indicate number of participants with missing data for each variable of interest	24
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	7, 8, 9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14, 15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14, 15
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.