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Is physical activity associated with resting heart rate in boys and girls? A representative study controlled for confounders☆

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Abstract
Objective: Investigate the relationship between different domains of physical activity and resting heart rate (RHR) in boys and girls.
Method: The sample included 1011 adolescents, aged between 10 and 17 years. RHR was measured by a heart rate monitor and physical activity was assessed in total and in three different domains (school, occupational, and sports practice) by a questionnaire. Anthropometry was directly obtained for body mass index and central fat. Ethnicity, sedentary behavior, and smoking habits were self-reported and used to adjust the analysis, through hierarchical linear regression.
Results: Total physical activity was associated with low RHR in boys ($\beta = -0.52$; 95% CI: -0.92, -0.12) and girls ($\beta = -0.67$; 95% CI: -1.07, -0.28). Although sporting physical activities were associated with low RHR in both boys ($\beta = -0.58$; 95% CI: -1.05, -0.11) and girls ($\beta = -0.87$; 95% CI: -1.34, -0.39), occupational physical activity was related to low RHR only in boys ($\beta = -1.56$; 95% CI: -2.99, -0.14).

Conclusion: The practice of physical activity in the sport practice domain and total physical activity were related to low RHR in both sexes, while occupational physical activities were associated with RHR only in boys.

A atividade física está associada à frequência cardíaca de repouso em meninos e meninas? Estudo representativo controlado para fatores de confusão

Resumo
Objetivo: Investigar a relação entre diferentes domínios de atividade física e frequência cardíaca de repouso (FCRep) em meninos e meninas.
Método: A amostra incluiu 1.011 adolescentes, com idade entre 10 e 17 anos. A FCRep foi medida por um monitor de frequência cardíaca e a atividade física foi avaliada no total e em três diferentes domínios (escolar, ocupacional e prática esportiva) através de um questionário. A antropometria foi obtida diretamente para o índice de massa corporal e gordura central. Etnia, comportamento sedentário e tabagismo foram autorrelatados e usados para ajustar a análise, através da regressão linear hierárquica.
Resultados: A atividade física total foi associada à baixa FCRep nos meninos (β = -0,52; IC95% -0,92; -0,12) e meninas (β = -0,67; IC95% -1,07; -0,28). Embora as atividades físicas esportivas estivessem associadas à baixa FCRep em ambos meninos (β = -0,58; IC95% -1,05, -0,11) e meninas (β = -0,87; IC95% -1,34, -0,39), a atividade física ocupacional estava relacionada à baixa FCRep apenas em meninos (β = -1,56; IC95% -2,99; - 0,14).
Conclusão: A prática de atividade física no domínio da prática esportiva e a atividade física total foram relacionadas à baixa FCRep em ambos os sexos, enquanto as atividades físicas ocupacionais foram associadas à FCRep apenas em meninos.

Introduction

Resting heart rate (RHR) is an important marker of cardiovascular risk.[1] Representing an easy to perform measurement, it is useful for screening cardiovascular disorders in several populations, including children and adolescents.[2]

In youth, the RHR is affected by several factors, including obesity, ethnicity, sex, and physical inactivity.[3] In turn, the practice of sports activities outside the school environment is related to low RHR.[4] Cayres et al.,[4] in a study of 120 adolescents, observed that adolescents who practiced sports outside the school environment demonstrated better heart rate variability. Other domains of physical activity, such as leisure time and active commuting activities, were associated with better parameters of heart rate variability in adolescents who were physically active for more than six months, although RHR values were not compared.[5] Mild leisure-time physical activity was associated with cardiometabolic risk in adolescents when compared to intense leisure-time physical activity, and this association was stronger among overweight and obese adolescents.[6]

Different types of physical activities can be performed at different volumes and intensities by adolescents, even according to age, gender, body weight, and socioeconomic level[7]; the intensity of physical activity has been considered a main determinant of alterations in RHR, since it was related with cardiorespiratory fitness and fatness.[8] In

this sense, it is conceivable that different types of physical activity could be differently associated with RHR in youth.

With regard to physical activity, gender differences have been observed among patterns of practice, where girls were about 20% less physically active than boys and presented lower participation in extracurricular sports, with influence from school and family environments.[9] In this sense, boys achieved a higher level of moderate-to-vigorous physical activity than girls, and younger boys and girls were more active and less sedentary than older adolescents. Different patterns of physical activity were also observed regarding ethnicity in youth, where black adolescents were less physically active and more sedentary when compared to white adolescents.[10] These factors that influence the amount and intensity of physical activity, as well as those which may also mediate the effect of physical activity on RHR, such as tobacco,[11] are important to be considered as confounding factors in the statistical analysis.

Therefore, the aim of this study was investigate the relationship between different domains of physical activity and resting heart rate (RHR) in boys and girls.

Methods

The present study is derived from a larger School-based Research Project, which was funded by the National Council for Scientific and Technological Development, aiming to

verify the relationship of elevated heart rate with lifestyle, eating habits, and cardiovascular risk factors in adolescents (process: 442395/2014-0).

Sample selection and inclusion criteria

According to the Education Secretary of Presidente Prudente, a city in southeastern region of Brazil, there are approximately 37,000 students enrolled in state and private school systems. Of this total, 27,860 students are enrolled in primary school and 9105 in high school, and a small proportion, up to 20%, of these students are enrolled in private schools. The study sample consisted of students aged between 10 and 17 years, all regularly enrolled in public or private teaching networks of the city.

According to previous information,[12] Presidente Prudente contains 36 schools serving the specific population of this study. In order to contemplate students from different areas of the city (north, south, east, west, and central) a public school was chosen randomly from each region, and all classrooms in these schools were invited to participate. As private schools are not present in all regions of the city, two private schools were selected randomly to meet the proportionality of students in this segment.

Study participants were: (i) children and adolescents aged 10–17 years; (ii) enrolled in basic or middle public and private schools; (iii) not taking medicines to control heart rate; (iv) had not performed strenuous exercise for at least 24 h prior to evaluation; (v) had not consumed caffeinated drinks in the 24 h prior to evaluation, and (vi) returned the consent form allowing the teenager to participate, signed by a parent or guardian. The study was approved by the Research Ethics Committee of the Universidade Estadual Paulista (UNESP), under protocol (21600613.4.0000.5402).

Sample size

The sample size calculation was performed according to the Fisher and Belle[13] equation for a finite population $n = (z^2_{\alpha/2}N(1-P))/(\varepsilon^2_r P(N-1) + z^2_{\alpha/2}(1-P))$. A prevalence of elevated heart rate of 50%, used in epidemiological studies,[14] a school population of Presidente Prudente city of approximately 37,000 students, a 95% confidence interval, and a maximum tolerable error of 4% were considered, giving a simple random sample of 591 adolescents. However, as the study was carried out by conglomerates, a correction of 1.5 for design effect gave a minimum size of 886 subjects. Anticipating possible sample losses of 10%, the total sample required for the survey was 975 subjects.

Organization of data collection

The questionnaire was carried out by researchers (previously trained) in the classroom of the students so that any questions could be resolved beforehand. The anthropometric measurements (weight, height, and waist circumference) and evaluation of resting heart rate were performed in a dedicated room, previously provided by the schools participating in the study. To avoid possible constraints on anthropometric variables, boys were evaluated by a male researcher and girls by a female researcher.

Resting heart rate

Heart rate was measured with the adolescent in the sitting position after a five-minute rest, using a heart rate monitor, Polar brand. This device is light, weighing 230 g, and has a transmitter that transmits the pulse to a clock on one of the user's arms. The heart rate transmitter was placed on the xiphoid process of the adolescents and values of heartbeat obtained while they were at rest. The evaluations were performed in the morning and evening. Temperature and humidity were not controlled, as the assessments were carried out in locations previously provided by the participating educational institutions.

Anthropometry

For anthropometric measurements all participants in the sample were measured barefoot and wearing light clothes. Body mass was measured using a digital scale (Plenna, São Paulo, Brazil) with a graduation of 0.1 kg. Height was measured by a portable stadiometer with a maximum length of two meters and twenty centimeters, with a precision of 0.1 cm. Thus, the body mass index (BMI) was calculated by means of the body mass divided by the square of height (BMI = kg/m^2).

Waist circumference was determined by measurements in duplicate of the minimum circumference between the iliac crest and the last rib, using a non-elastic tape in millimeters (Sanny, Paraná, Brazil). The final value of waist circumference was determined through the average of the two values. This measurement was adjusted by height, through calculation of the waist-to-height ratio.

Sedentary behavior

Sedentary behavior was composed of the number of hours in a week that the adolescents reported watching television, using the computer, playing video games, and using a mobile phone/tablet. This measure was considered in continuous form and the questionnaire has been previously used.[15]

Habitual physical activity

The practice of physical activity was assessed by the Baecke questionnaire,[16] an instrument validated for use in Brazilian adolescents.[17] This questionnaire evaluates the usual practice of physical activities through three different domains: (i) physical activity at school: the sum of the frequency of time spent in the school environment carrying out activities standing, sitting, walking, carrying loads; (ii) occupational physical activity: time spent and mode used for locomotion to school and/or work, walking, cycling; (iii) leisure and sports activities outside school: related to sports practice (training/gym) taking into account the intensity, weekly time, and how long the adolescent had carried out the activity (months/years). This instrument provides a dimensionless score for each of the three assessed domains. At

the end, the sum of these three domains indicated the total practice of physical activity.

Smoking habits

Tobacco use was verified by questions adapted from the Global School-based Student Health Survey[18] (Centers for Disease Control and Prevention, 2004). This instrument provides the frequency of use of tobacco in the previous month. Those adolescents who reported having smoked in the previous 30 days were considered as presenting risk behavior, regardless of the number of cigarettes smoked in the period.

Statistical analysis

The *t*-test for independent samples was used to characterize the sample, with the results expressed as mean and standard deviation. The association between RHR and physical activity in the various domains and in total was analyzed by simple linear regression. A multiple linear regression model was created to analyze this relationship, adjusted simultaneously for independent variables (age, ethnicity, waist-to-height ratio, smoking, and sedentary behavior). For data analysis SPSS (SPSS for Windows, version 16.0, Chicago, USA) software was used. The statistical significance adopted was 5%, with a 95% confidence interval.

Results

The study included 1011 adolescents: 454 boys (44.9%) and 557 girls (55.1%). The male adolescents were significantly younger than the female adolescents (12.9 [±2.3] vs. 13.3 [±2.3], respectively [*p* = 0.002]). Boys were more physically active than girls in sports (4.6 [±2.2] vs. 4.0 [±2.1], respectively [*p* < 0.001]), occupational physical activities (2.6 [±0.8] vs. 2.4 [±0.7], respectively [*p* = 0.005]), and total physical activity (9.4 [±2.6] vs. 8.8 [±2.7], respectively [*p* < 0.001]). No differences were observed according to sex regarding mean values of body weight (*p* = 0.506), height (*p* = 0.552), BMI (*p* = 0.486), waist circumference (*p* = 0.181), waist-to-height ratio (*p* = 0.061), cigarettes/day (*p* = 0.127), hours/day of sedentary behavior (*p* = 0.601), heart rate/minute (*p* = 0.445), and physical activity score in the school domain (*p* = 0.737). This information is presented in Table 1.

Fig. 1 contains the RHR in raw data, according to quartiles of physical activity score in boys and girls. No significant differences were observed.

Table 2 presents the simple and multiple analyses between RHR and the scores of physical activity at school and in occupational domains. No significant relationship was observed for boys or girls.

The analysis of the relationship between RHR and sports physical activity practiced demonstrated an inverse relationship, i.e., the higher the physical activity of adolescents, the lower the RHR values. The total physical activity also presented a significant inverse relationship with RHR. These relationships remained significant in both sexes, even in the fully adjusted multiple regression model (Table 3).

Discussion

The results of this study show that in children and adolescents, regardless of sex, increased sports activities outside the school environment and the practice of total physical activity promote lower RHR values. This occurred in both sexes even when the analysis was adjusted for various confounders. However, this relationship was not observed for the school and occupational physical activity domain.

In a study with Brazilian adolescents, the authors observed that sports practice was related to a decrease in RHR values, independent of body fat.[8] In another study conducted in the southern region of Brazil, it was observed that sports practice was also associated with lower RHR in adolescents, however in the cited study,[19] sex was used only as an adjustment variable and stratified results were not presented as in the present study. The results of the present study showed that sports activity outside the school environment is an important variable related to the behavior of RHR. Considering the effects of physical activity on RHR, this decrease could provide three mechanisms of action, namely: (i) neural mechanism: through the action of muscle afferent nerves (chemoreceptors and mechanoreceptors) that possess the function of informing peripheral changes (cardiovascular control center), regulating the necessary stimuli according to exercise intensity[20]; (ii) baroreflex mechanism: PA acts as a behavior regulator every beat, maintaining BP values within a fluctuation limit, and also exerting an interaction on the variation in vasomotor tone[21]; (iii) central mechanism: activities related to the autonomic nervous system (ANS), which respectively control the changes in sympathetic and parasympathetic efferent activity over the completion of exercise.[22]
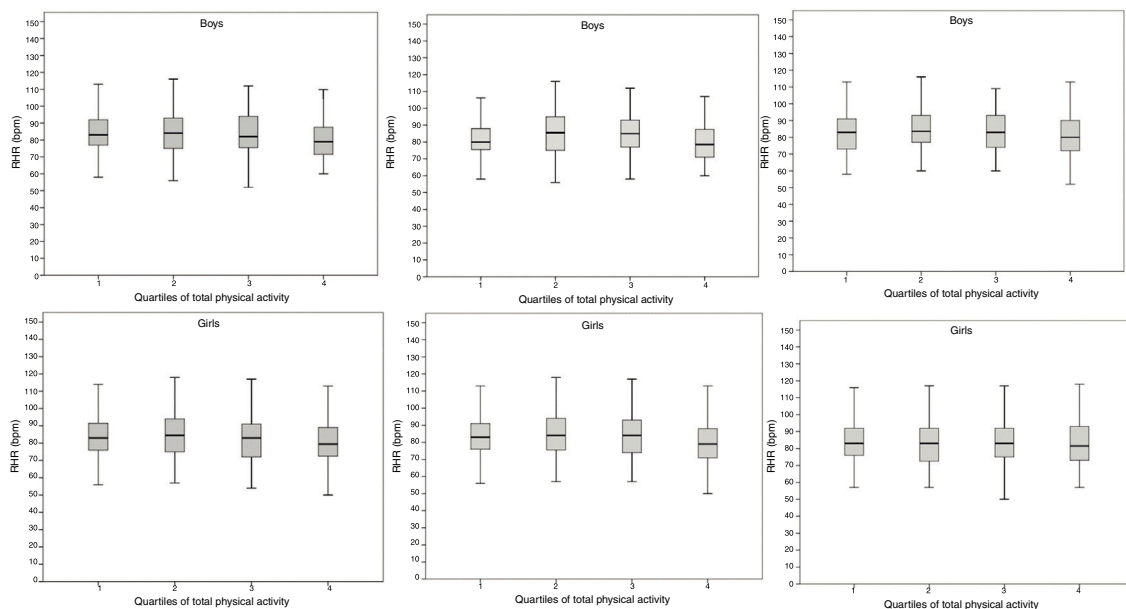
It should be noted that there is full disclosure of the amount by which moderate-to-high physical activities promote health benefits, which occur through physiological changes in the cardiovascular, pulmonary, and metabolic systems; these improvements in health arise as acute and subacute responses during/or after a session of exercise.[23] The intensity of physical activities in adolescents is an important factor for physiological responses, since it was observed that 15 min of vigorous intensity physical activity for three days per week in a 12 week intervention was already able to improve the cardiovascular health of 12–15-year old adolescents.[24]

The study showed that male adolescents were more active when compared to their peers of the opposite sex. These findings are convergent with other findings in the literature, where it has been observed that boys showed a higher prevalence of reaching recommended global levels of physical activity than girls, although schoolchildren presented a prevalence of only 33% of sufficient levels of habitual physical activity.[25] Considering occupational physical activity, which may be related to decreased RHR in the male population, boys tend to have more freedom to leave home to perform physical activity when compared to the female population, perhaps for cultural reasons, and thus present greater displacement compared to girls, given that leisure activities among boys tend to be more active than those carried out by girls.[26]

Table 1 Sample characterization.

	Boys Mean (SD)	Girls Mean (SD)	p-Value
Age (years)	12.9 (2.3)	13.3 (2.3)	0.002
Weight (kg)	49.8 (15.0)	50.4 (14.5)	0.506
Height (cm)	155.4 (13.4)	155.9 (12.1)	0.556
BMI (kg/m^2)	20.2 (4.3)	20.4 (4.2)	0.487
Waist-to-height ratio	0.44 (0.06)	0.44 (0.06)	0.061
Smoking (cigars/day)	1.1 (0.6)	1.0 (0.4)	0.145
Sedentary behavior (hours/day)	11.9 (6.2)	11.7 (6.0)	0.203
Resting heart rate (beats/minute)	82.6 (12.3)	83.2 (13.6)	0.445
School physical activity	2.3 (0.5)	2.3 (0.4)	0.739
Sports physical activity	4.6 (2.2)	4.0 (2.1)	0.001
Occupational physical activity	2.6 (0.8)	2.4 (0.7)	0.005
Total PA (Baecke's score)	9.4 (2.6)	8.8 (2.7)	0.001

BMI, body mass index; PA, physical activity; SD, standard deviation.

Figure 1 Resting heart rate (RHR) in different domains of physical activity in adolescents.

These influences can soften the sympathetic activity and/or lead to more activity of the parasympathetic tone, exerting a cardioprotective function both during exercise, after the completion of exercise, and during rest.[21,27] Something that should be considered important in sex differences is the waist-to-height ratio, considered as a confounding factor in the present study, since it was observed that the relationship between abdominal obesity and RHR was positive among boys.[28] A 12-week vigorous intensity physical activity intervention of 15 min for three days per week showed significant decreases in fatness of adolescents[29] and these findings consolidate the role of physical activity in cardiovascular risk prevention from early ages.

In turn, the absence of significant results in school and occupational physical activity practices for both sexes may occur due to insufficient time of practice during the week, which in the studied population usually represents going to school, generally in motor vehicles (public or private

transport). When the authors aimed to analyze the school physical activity, it was observed that much improvement is still required in the education system in Brazilian schools, especially regarding duration of the classes. Kremer et al.[30] point out the considerable amount of time spent on the organization and transport of students to the space where the physical education class will be carried out, as well as the low intensity of activities during the classes.

Finally, an inverse relationship was found between total physical activity (referring to the sum of the three domains analyzed) and RHR. One hypothesis for this is that this relationship exists on account of the intensity of the activities (low, moderate, and high) and the time spent carrying out these activities; the time and intensity spent on sports activities outside the school environment may be considered as a determining factor in this association.

Some limitations of this study need to be mentioned. The cross-sectional design does not allow investigation of causal

Table 2 Relationship between resting heart rate and domains of school and occupational physical activity in adolescents.

	School PA				Occupational PA			
	β	SE	95% CI	p-Value	β	SE	95% CI	p-Value
Boys								
Simple regression	1.14	1.081	−0.99; 3.26	0.294	−1.38	0.768	−2.89; 0.13	0.072
Multiple regression[a]	R squared = 0.145				R squared = 0.152			
PA score	0.32	1.017	−1.68; 2.32	0.752	−1.41	0.723	−2.84; 0.01	0.051
Age	**−1.67**	**0.243**	**−2.14; −1.19**	**0.001**	**−1.65**	**0.242**	**−2.12; −1.17**	**0.001**
Ethnicity	−0.50	0.393	−1.27; 0.27	0.205	−0.50	0.392	−1.27; 0.27	0.201
Waist-to-height ratio	**20.39**	**9.417**	**1.88; 38.89**	**0.031**	**22.97**	**9.406**	**4.49; 41.46**	**0.015**
Smoking	0.22	0.794	−1.34; 1.78	0.779	0.16	0.790	−1.39; 1.72	0.836
Sedentary behavior	**1.95**	**0.777**	**0.43; 3.48**	**0.012**	**1.82**	**0.775**	**0.29; 3.34**	**0.020**
Girls								
Simple regression	−0.52	1.190	−2.85; 1.82	0.664	−0.66	0.810	−2.25; 0.93	0.413
Multiple regression[a]	R squared = 0.073				R squared = 0.075			
PA score	0.15	1.179	−2.16; 2.47	0.897	−0.79	0.791	−2.35; 0.76	0.317
Age	**−1.28**	**0.249**	**−1.77; −0.79**	**0.001**	**−1.27**	**0.249**	**−1.76; −0.79**	**0.001**
Ethnicity	−0.01	0.395	−0.78; 0.77	0.982	−0.03	0.395	−0.80; 0.75	0.947
Waist-to-height ratio	**25.06**	**9.732**	**5.94; 44.18**	**0.010**	**25.74**	**9.743**	**6.60; 44.88**	**0.008**
Smoking	−0.85	1.314	−3.43; 1.73	0.517	−0.89	1.311	−3.46; 1.69	0.500
Sedentary behavior	−0.67	0.761	−2.17; 0.82	0.377	−0.69	0.748	−2.16; 0.78	0.354

Bold highlighted values were statistically significant.
PA, physical activity; SE, standard error; CI, confidence interval.
[a] All variables inserted simultaneously in the model.

Table 3 Relationship between resting heart rate and domains of sports and total physical activity in adolescents.

	Sports PA				Total PA			
	β	SE	95% CI	p-Value	β	SE	95% CI	p-Value
Boys								
Simple regression	**−0.58**	**0.255**	**−1.08; −0.08**	**0.023**	**−0.49**	**0.218**	**−0.92; −0.06**	**0.025**
Multiple regression[a]	R squared = 0.155				R squared = 0.157			
PA score	**−0.55**	**0.237**	**−1.02; −0.09**	**0.021**	**−0.51**	**0.203**	**−0.91; −0.11**	**0.013**
Age	**−1.64**	**0.241**	**−2.11; −1.16**	**0.001**	**−1.63**	**0.241**	**−2.11; −1.16**	**0.001**
Ethnicity	−0.53	0.391	−1.30; 0.24	0.177	−0.53	0.391	−1.30; 0.24	0.176
Waist-to-height ratio	**21.61**	**9.324**	**3.28; 39.94**	**0.021**	**22.81**	**9.347**	**4.44; 41.18**	**0.015**
Smoking	0.13	0.789	−1.42; 1.68	0.867	0.11	0.789	−1.44; 1.66	0.892
Sedentary behavior	**1.97**	**0.770**	**0.46; 3.49**	**0.011**	**1.95**	**0.769**	**0.44; 3.46**	**0.012**
Girls								
Simple regression	**−0.72**	**0.247**	**−1.20; −0.23**	**0.004**	**−0.57**	**0.209**	**−0.98; −0.16**	**0.006**
Multiple regression[a]	R squared = 0.094				R squared = 0.091			
PA score	**−0.86**	**0.240**	**−1.34; −0.39**	**0.001**	**−0.66**	**0.203**	**−1.06; −0.26**	**0.001**
Age	**−1.34**	**0.247**	**−1.83; −0.86**	**0.001**	**−1.32**	**0.247**	**−1.80; −0.83**	**0.001**
Ethnicity	−0.04	0.390	−0.81; 0.73	0.919	−0.04	0.391	−0.81; 0.73	0.921
Waist-to-height ratio	**25.28**	**9.617**	**6.39; 44.17**	**0.009**	**25.89**	**9.640**	**6.95; 44.82**	**0.007**
Smoking	−1.19	1.300	−3.75; 1.36	0.359	−1.10	1.301	−3.66; 1.45	0.397
Sedentary behavior	−0.73	0.739	−2.19; 0.72	0.321	−0.67	0.740	−2.12; 0.79	0.368

Bold highlighted values were statistically significant.
PA, physical activity; SE, standard error; CI, confidence interval.
[a] All variables inserted simultaneously in the model.

relationship between the results presented. Furthermore, the authors emphasize the subjective analysis of physical activity through a questionnaire as a limitation when compared to more sophisticated methods of assessment such as an accelerometer. The lack of temperature control in the RHR assessment is another important limitation, since the evaluations were performed in a single specific room, previously granted by the school, and Brazilian public schools rarely have availability of acclimatized rooms. Although the assessments were conducted in the same period in which the students had class, adjustment for the assessment period was not performed due to lack of this information. However,

the difficulty should be noted of using such tools in epidemiological studies a with large sample size in low-middle income countries. As strengths, as well as analysis of different domains of physical activity; the multiple model in the analysis of this relationship should be considered another positive aspect. The sample selection should also be highlighted, as it was representative, offering all teenagers from public and private schools similar chances to participate in the study through the randomization process. It is worth noting the organization of the study according to sex, to verify whether the possible relationships between RHR and physical activity occurred in a similar way between boys and girls.

Conclusion

By analyzing these results, it is concluded that the practice of physical activity in the sports domain and total physical activity in both sexes were associated with lower values of resting heart rate even after adjustment for different confounders. These types of physical activities are worth the time involved, even outside the school environment, with involvement of parents, society, and public policies, aiming to encourage sports practice or even higher global levels of physical activity, and consequently improve cardiovascular health from early ages.

Conflicts of interest

The authors declare no conflicts of interest.

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