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Article

A gender analysis of the impact of physical education on the mental health of brazilian schoolchildren

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ABSTRACT

This paper investigates the effect of attending physical education classes on mental health indicators – loneliness and insomnia – of Brazilian schoolchildren. The identification strategy consists of separating the sample into two parts: people who practice physical activity and who attend physical education classes at school and people who, despite not attending physical education classes, practice physical activities. The data are from the 2015 National Adolescent School-based Health Survey (PeNSE), and the sample pairing method is the Propensity Score Matching with robustness analysis using the Bivariate Probit method and the sensitivity is tested using the method developed by Ichino, Mealli, and Nannicini (2008). For both girls and boys the results showed that physical education exerts a negative effect, reducing the probability of reporting problems of insomnia and loneliness among schoolchildren who attend the discipline. Although they show similar magnitudes, the observed effects are greater for boys, in both measures. The study investigates – in a rigorous and unprecedented way in the literature – the effect of physical education classes on the insomnia and loneliness of Brazilian school children. The results are important for the formulation of discipline maintenance policies in the curriculum of schoolchildren in Brazil.

1. Introduction

The benefits of physical activity are well-documented in the literature. Physical inactivity is considered one of the leading risk factors for death worldwide, increasing the incidence of noncommunicable diseases such as cardiovascular disease, cancer and diabetes (WHO, 2016). However, although it is a problem that affects all age groups, it can be even more critical in periods of growth and development, such as in adolescence. Among the various changes that occur in this period, the development of healthy/unhealthy habits and behaviors requires attention, since those behaviors tend to prevail in adulthood (Ortega et al., 2008).

Children and adolescents have increasingly presented poor physical and mental health thanks to their current lifestyle, which reduces physical activity and increases sedentary behaviors (Hills et al., 2015). According to the World Health Organization (WHO, 2016), more than 80% of the world's adolescents do not get the recommended level of physical activity.

In the late 20th century, scientific studies recommended the inclusion physical education in the school curriculum, emphasizing the need for it to provide opportunities for practice and lifelong engagement (Marshall and Hardman, 2000). According to Monica (2014), physical education – which is practiced in an organized manner and controlled by a specialist – is a useful way to reduce sedentary lifestyles and stress levels, in addition, the discipline plays a fundamental role in the social integration of children, who spend a good part of their days on computers and using the internet.

Although many studies analyze the relationship between physical activity and health in children and adolescents, the existing literature still has little to say about the causal effects of physical education over health. The vast majority of studies show evidence of positive associations of physical activity in physical and mental health measures (Bailey, 2005, 2006; Bailey et al., 2009; Hallal, Victora, Azevedo, & Wells, 2006). The effects of physical activity on adolescent physical health are well documented. Evidence shows beneficial effects on minimizing the risk of suffering from various chronic diseases, on skeletal health, on blood pressure control and pulmonary function (Hallal et al., 2006; Hu et al., 2004; Padilla, Wallace, & Park, 2005; Slattery, Edwards, Boucher, Anderson, & Caan, 1999; Srivastava & Kreiger, 2000). In addition, physical activity in adolescence prevents

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overweight and obesity and increases the likelihood of practicing physical activity in adulthood, generating an indirect effect on future health (Azevedo, Araújo, Silva, & Hallal, 2007; Black, Johnston, Propper, & Shields, 2019; Gutin et al., 2002; Jakicic & Otto, 2005; Rippe & Hess, 1998).

Regarding mental health, the evidence demonstrates that there is a protective effect. Practicing physical activity in adolescence reduces the probability of presenting episodes of depression, difficulty sleeping, anxiety, loneliness, antisocial behavior, emotional problems and hyperactivity (Biddle & Asare, 2011; Felfe, Lechner, & Steinmayr, 2016; Harvey et al., 2018; Janssen & LeBlanc, 2010; McMahon et al., 2016).

Although there is a vast literature analyzing the relationship between physical activity and health in adolescence, there are few studies that focus on the effect of the physical education discipline itself and the existing studies only seek to analyze possible associations. Kremer et al. (2013) test the reasons that make students depressed. The authors note that depressive problems are negatively associated with active physical education practice. Santos et al. (2015) observe, for students of the Pernambuco state education system, that the feeling of loneliness in young females is negatively correlated with participation in physical education. For the variable of having no friends or having only one friend, participation in physical education is negatively correlated in both genders. Lang et al. (2016) analyze the effect of a specific physical education program on students' social skills, stress, and sleep quality. The results showed a significant increase in the social skills of the program's participants, while the variables of stress and sleep quality remained stable in the analysis.

Physical education in schools is an opportunity for adolescents to develop and strengthen behaviors that will keep them physically active throughout adult life (WHO, 2016). Thus, it becomes important to understand the benefits of physical education in school on health indicators. In this sense, the present study seeks to test the causal effect of physical activity developed in the discipline of physical education on the insomnia and loneliness of schoolchildren. The study uses data from a sample of Brazilian students and contributes with the existing evidence in the literature when analyzing the importance of physical education on loneliness and sleep problems.

2. Method

2.1. Data

The data used are from the 2015 PeNSE (National Adolescent School-based Health Survey). The research is the result of a joint effort of the Brazilian Ministries of Education and Health and aims to provide information for adolescents to the Surveillance System of Risk and Factors for Chronic Non-Communicable Diseases. The 2015 edition of PeNSE is the third edition, with the previous ones occurring in 2009 and in 2012.

The 2015 PeNSE has approximately 113 thousand observations of individuals who were between the sixth year of elementary school and the third year of high school in the reference year of the research. The database has two samples, but this study will focus on the first sample, which has 102.301 thousand observations from 3160 schools. The data are representative at the national level, consisting of the five large regions and the federal units – the sample 2 has a different sampling process, considering students aged 13 to 17 who are at different learning stages, while sample 1 considers students of the ninth grade. Sample cuts refer to people who did not practice physical activities outside school - physical activity outside school means walking or cycling on the way between home and school and other activities such as bodybuilding, gymnastics, dance, martial arts, among others - and people who did not answer any of the variables used in this study - the final sample is 40.876 students.

The sampling process of sample 1 - used in this study - is carried out through geographic stratification in the Federative Units (FU) and Federal District capitals and in other municipalities, forming 56 strata. Within the geographic strata we included allocation strata, considering whether the school was public or private and the size of the school (according to the number of ninth grade classes, schools with more than two classes are considered large). After the selection of schools, the classes were randomly selected and all the students present were invited to answer the questionnaire (IBGE, 2016).

Table 1
- Mean of the variables among schoolchildren who do and do not attend the physical education discipline.
Source: Prepared by the authors based on the 2015 PeNSE.

Variable	Boys			Girls		
	Attends	Does not attend	t	Attends	Does not attend	t
Attends Physical Education	0.80	0.20	***	0.72	0.28	***
Feels lonely	0.08	0.13	***	0.20	0.25	***
Difficulty sleeping	0.06	0.08	***	0.15	0.18	***
Age	14.37	14.47	***	14.13	14.18	***
Health	0.78	0.74	***	0.71	0.65	***
Lives with the mother	0.90	0.89	**	0.91	0.90	**
Whites	0.41	0.35	***	0.41	0.35	***
Lives with the father	0.66	0.64	***	0.62	0.60	***
Employment	0.10	0.18	*	0.09	0.09	
Mother smokes	0.06	0.06		0.07	0.07	
Father smokes	0.12	0.12		0.12	0.12	
Additional Time	216.48	210.21	***	154.87	142.79	***
Four or more days of Physical Activity	0.56	0.54	**	0.41	0.38	***
Socioeconomic Level	0.07	−0.18	***	0.04	−0.18	***
Risk behavior	0.00	−0.01		0.00	0.08	***
Capital city	0.53	0.51	***	0.53	0.49	***
Urban	0.93	0.91	***	0.93	0.93	
Private school	0.27	0.21	***	0.28	0.22	***
Full-time	0.23	0.22	***	0.24	0.21	***
Mother's education						
No education	0.05	0.06	***	0.06	0.07	***
Did not finish elementary school	0.20	0.24	***	0.23	0.26	***
Finished elementary school	0.08	0.09		0.07	0.08	
Did not finish high school	0.08	0.08		0.08	0.09	**
Finished high school	0.24	0.25		0.22	0.23	*
Did not finish undergraduate school	0.08	0.07		0.08	0.07	
Finished undergraduate school	0.27	0.21	***	0.26	0.20	***
Observations	17,922	4567		13,293	5094	

Note: ***p < 0.01, **p < 0.05, *p < 0.1.

2.1.1. Variables

Two dependent variables are used, as proxies, to measure mental health: difficulty sleeping and feeling lonely. Both measures are self-reported and in the research they are classified in 5 categories: never, rarely, sometimes, most of the time and always. These variables have been transformed into dichotomies (difficulty sleeping = 1 if they have difficulty sleeping always or most of the time and feeling lonely = 1 if they always feel lonely or most of the time).

Table 1 presents the descriptive statistics of the sample, showing the mean of the variables separated by gender and in subgroups of practitioners and non-practitioners of physical education. The column named *t* in each group represents the *t*-test of mean difference. The description of all the variables used can be seen in Table A1 of the appendix.

2.2. Empirical strategy

Ideally the same individuals would be compared in two situations, attending the discipline of physical education, called the treatment group, and not attending, called the counterfactual group. Since it is not

possible (to attend and not attend physical education classes at the same time), the proposed identification strategy is to compare individuals who practice physical activities and additionally attend physical education with those who practice physical activities but do not attend physical education classes. The goal is to reduce the bias of unobservable characteristics by comparing individuals with different motivations for practicing sports, since choosing to participate in physical education classes is not a random process.

Firstly, the aim of the pairing is to construct a control group that is as close as possible to the treatment group. When the selection is randomized, the means of the observable and unobservable variables of each group should be statistically equal. By assumption, since there is a statistically identical pair in the treatment and control groups, the only difference in the dependent variable between the groups is the participation or not in the program (in this case, physical education class). This hypothesis considers that all the characteristics that determine participation in the program are controlled in vector X (observed variables). This hypothesis is called exogeneity and can be described as follows:

$$Y_i(0) \perp T_i|X_i \tag{1}$$

where Y_i is the variable to be explained, T_i is the treatment, and X_i is the vector of explanatory variables.

This hypothesis suggests that the individual in the control group who pairs with the individual in the treatment group is a good predictor of how the treated individual would be if he/she chose not to participate in the treatment. Mathematically speaking, the explained variable is independent of the treatment, given the control of observable characteristics.

Another important hypothesis about pairing is that of overlap: it is necessary that for each treatment individual there is a non-treatment individual of similar observable characteristics. In other words, the vector region of observable variables need not only represent the treated group, but also characteristics of the treatment group. Mathematically, it is possible to formalize such a hypothesis:

$$pr[T_i = 1|X_i] < 1 \tag{2}$$

Given such hypotheses, the mean effect of treatment on the treated (ATT) is calculated by means of the difference of the individual receiving the treatment or not, as follows:

$$ATT = E[Y_i(1)|T_i = 1, X] - E[Y_i(0)|T_i = 1, X] \tag{3}$$

where $E[Y_i(1)|T_i = 1, X]$ is the mean of Y for the treated population, given a vector of observable characteristics X and $E[Y_i(0)|T_i = 1, X]$ is the mean of Y for the treated group if treatment were not available.

As the second part of equation (3) is unknown due to the counterfactual, $E[Y_i(0)|T_i = 1, X]$, not being not observable, and given the hypothesis of independence, we can write:

$$E[Y_i(0)|T_i = 1, X] = E[Y_i(0)|X] = E[Y_i(0)|T_i = 0, X] = E[Y_i|T_i = 0, X] \tag{4}$$

Thus, ATT is calculated by:

$$ATT = E[Y_i|T_i = 1, X] - E[Y_i|T_i = 0, X] \tag{5}$$

In order to obtain the mean effect of the treatment on the treated, the mean difference in Y between the groups is calculated by means of the expectation of this difference, conditioned to the treatment ($T_i = 1$), that is, the equation (5) is rewritten by removing the expectation, given that there was treatment.

$$ATT = E[E[Y_i|T_i = 1, X] - E[Y_i|T_i = 0, X]|T_i = 1] \tag{6}$$

To avoid the so-called Curse of Dimensionality (when the number of covariates is too high and exact pairing is practically impossible), Rosenbaum and Rubin (1983) suggest a model known as Propensity Score Matching in which the vector X is no longer used for the pairing, but a function of X, which synthesizes all the information in this vector. Thus, the function of probability of receiving the treatment is given by:

$$p(X) = pr[T = 1|X] \tag{7}$$

Thus, the orthogonality hypothesis is given by:

$$Y_i(0) \perp T_i|p(X_i) \tag{8}$$

To estimate such propensity, the Logit method will be used. The probability of participation in the treatment is given by:

$$\Pr[T_i = 1|X] = \frac{\exp(x\beta)}{1 + \exp(x\beta)} \tag{9}$$

And the estimator:

$$\hat{p}(x) = \frac{\exp(x\hat{\beta})}{1 + \exp(x\hat{\beta})} \tag{10}$$

Finally, the mean effect of treatment on the treated (ATT), using the estimator shown in (10), is given by:

$$ATT = E_{p(x)|T=1}E[Y_i(1)|T = 1, p(x)] - E[Y_i(0)|T = 0, p(x)] \tag{11}$$

The variables used for pairing through propensity score matching include personal variables such as race, age, whether the individual lives with the mother and/or the father, whether the individual has a job, self-reported health, risk behaviors (tobacco, alcohol and illicit drugs), the socioeconomic level and the amount of physical activity done outside the school. Other characteristics – the mother's educational level, whether the individual lives in a capital city, urban area and whether he/she studies full-time and/or in a private school – have also been added to the pairing. Although the high number of explanatory variables may be a problem – since it makes it difficult to match the groups and this may lead to the exclusion of a considerable part of the sample – the maximum sample loss in the models used here is 5 boys and 18 girls.

Thus, the selected methods are most diverse, avoiding that the result be biased by the method choice: one nearest neighbor and five nearest neighbors with replacement, which enables an individual from the control group to be compared with more than one treated individual; radius, in which each observation of the treated group is compared with observations within a radius of distance (the calliper used is 0.01); and Kernel, in which the individual in the treatment group is compared with several individuals in the control group, but weighs more heavily the controls closest to the treatment.

To check whether the omission of any relevant variable may cause bias in the chance of being part of the treatment group (attending physical education class), sensitivity tests are required. Thus, Ichino et al. (2008) propose a method that tests the independence hypothesis of the dependent variable of treatment (conditioned to the regression controls). The hypothesis behind the test is that there is an unobservable variable υ, binary, which affects independence. If the variable were observed, the ATT would be calculated given that:

$$E(Y_0|T = 1, X, \upsilon) = E(Y_0|T = 0, X, \upsilon) \tag{12}$$

That is, the expectation for the dependent variable before treatment is the same for the treated and untreated groups. Next, the characterization of υ is done through four parameters:

$$p_{ij} = \Pr(\upsilon = 1|\mathrm{T} = \mathrm{i},\ \mathrm{Y}=\mathrm{j}) = \Pr(\upsilon = 1|\mathrm{T} = \mathrm{i},\ \mathrm{Y}= \mathrm{j},\mathrm{X}) \tag{13}$$

where the subscripts i and j range from 0 to 1, given the chance that υ is equal to 1 for each of the groups defined by the result and treatment.

To obtain the ATT estimate through the PSM method with υ, the estimation is repeated several times (500 in this work, following Santos and Jacinto (2017)), and the estimates are averaged. The value of υ is assigned individually to each observation, given the parameters p_{ij}, considering that it belongs to any of the four possible categories of combinations of i and j.

2.2.1. Robustness analysis

Finally, in order to guarantee the consistency of the result, we use the model known as Bivariate Probit, which simultaneously estimates two equations in which the dependent variable is binary. In the current research problem, the Bivariate Probit simultaneously considers the probability of declaring feeling lonely (Y_1^*) and the probability of reporting insomnia (Y_2^*), considering the possible correlation of the errors of the two equations in the estimation of both (Cunha & Vasconcelos, 2016; Guimarães, Santos, & dos, 2010; Monte, Ramalho, & Pereira, 2011).

$$\begin{cases} Y_1^* = X_1^1\beta_1 + \varepsilon_{1i} \\ Y_2^* = X_2^2\beta_2 + \varepsilon_{2i} \end{cases} \quad (14)$$

Where X_g^1 is the set of covariates that affect the variable Y_g^*, β_g is the set of coefficients associated with the variables X and ε_{gi} is the error. g assumes 1 or 2. Note, however, that Y_1^* assumes 1 if, and only if, $Y_1^* > 0$, otherwise it assumes 0. Similarly, Y_2^* assumes 1 if, and only if, $Y_2^* > 0$, otherwise it assumes 0. The error can be described according to equation (15):

$$\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} | X_1, X_2 \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix}\right] \quad (15)$$

According to Guimarães et al. (2010), the two equations in (14) are estimated by means of the so-called Seemingly Unrelated Regressions (SUR) model and must respect the fact that the residual expectation is zero with normal bivariate distribution, constant variance and error covariance equal to ρ. The final model is a Seemingly Unrelated Bivariate Probit, in which the probability of reporting loneliness is estimated in the first equation in (14) and the probability of feeling insomnia - second equation in (14).

The estimates made with the methods presented in this section did not take into account the sample design of PeNSE. Only recently has the international literature devoted efforts to analyze the most appropriate way to implement PSM in complex samples, but there is still no consensus, so we chose to present the estimates without incorporating the sample design, which is usually done in the literature.

3. Results

The results obtained to verify the quality of the pairing are presented in the appendix. In figure A1 we can graphically verify the density function of the propensity score for the unpaired and paired sample, respectively, for the groups of boys and girls. Note that the distributions for both sexes were quite different before the pairing and were almost identical after this procedure. In Table A2 we observed that the means of the variables are statistically identical after the pairing for all covariates in the sample of girls and in only three covariates there is difference for the sample of boys, and these differences are only significant at the 10% level.

Table A3 shows decrease in the Pseudo-R^2 and the mean and median biases for the paired sample. The likelihood ratio (LR) test shows that there are no more statistical differences between the groups after the pairing, the same is true for Pseudo-R^2. These results suggest that, from a vector of observable variables, the groups are similar.

The effects of physical education classes on the feeling of loneliness are presented in Table 2. They are obtained from the mean treatment effect on the treated (ATT). Each of the columns refers to the results for each gender, and the results are arranged in the rows according to the different pairing methods. As we can see, the results are all negative and significant at the 1% level. This means that the effect of physical education class on loneliness goes in the direction of reducing that feeling for boys and girls.

Although descriptive statistics show that girls feel more alone than boys, the effect is stronger for male adolescents. For example, considering the nearest neighbor method (NR 1) with replacement, the proportion of boys reporting loneliness is 4.7 percentage points (p.p) lower in those who attend physical education classes than those who do not. For girls this effect is lower, of 2.7 p. p.

Table 2
- Effects of Physical Education on the feeling of loneliness.
Source: Prepared by the authors.

	Boys	Girls
NR (1) with replacement	−0.0477*** (0.007)	−0.0274*** (0.009)
NR (5) with replacement	−0.0404*** (0.006)	−0.0408*** (0.007)
Radius	−0.0404*** (0.007)	−0.0404*** (0.007)
Kernel	−0.0417*** (0.007)	−0.0418*** (0.007)

Note: ***p < 0.01, **p < 0.05, *p < 0.1. Standard error in parentheses. NR (1) with replacement. Nearest neighbor with one neighbor matching with replacement. NR (5) with replacement. Nearest neighbor with 5 neighbors matching with replacement.

Table 3
Effects of physical education on insomnia.
Note: ***p < 0.01, **p < 0.05, *p < 0.1significance. Standard error in parentheses. NR (1) with replacement. Nearest neighbor with one neighbor matching with replacement. NR (5) with replacement. Nearest neighbor with 5 neighbors matching with replacement.

	Boys	Girls
NR (1) with replacement	−0.0212*** (0.006)	−0.0162** (0,008)
NR (5) with replacement	−0.0245*** (0.005)	−0.0188*** (0.007)
Radius	−0.0243*** (0.005)	−0.0181*** (0.006)
Kernel	−0.0238*** (0.005)	−0.0194*** (0.006)

Source: Prepared by the authors.

Table 3 presents the effects of the physical education discipline on the reports of not sleeping at night (insomnia). Again, the effects are in the sense of improving the quality of sleep. As with the feeling of loneliness, insomnia affects, on average, more girls in the sample, but the estimated effects of physical education show to be greater for boys. According to estimates of the nearest neighbor method (NR 1) with replacement, in the sample of girls the proportion of treated patients reporting insomnia problems is 1.6 p. p lower compared to the control group. For boys, this proportion is higher in comparison to girls, of 2.1 p. p.

Both results presented in Tables 2 and 3 show that attending physical education reduces the feeling of loneliness and the sleep difficulty, demonstrating that it has a positive effect on the mental health of students. However, we cannot rule out the hypothesis that this effect is not of the discipline, but of the presence of omitted variables relevant to the specification. In this case, the control group would not be an adequate counterfactual because, in the presence of unobserved variables, the difference between treated and control could not be fully credited to the observable variables. Although such a hypothesis is not testable, we can analyze the robustness of our estimates through sensitivity analyzes.

The sensitivity test proposed by Ichino et al. (2008) seeks to find variables that may affect treatment, that is, unobserved variables that affect the independence of treatment. For the result to be considered satisfactory, the ATT with the confounder must maintain the signal and the significance. This ATT is generated by the nearest neighbor method, with the incorporation of the variable “confounder”, and represents the mean of the effect in a process of 500 repetitions.

The results presented in Tables 4 and 5 show that any unobserved factor correlated with each covariate used in the analysis would not be sufficient to bring the ATT estimates to zero. The confounders included in the analysis cause little or no interference to the estimated ATTs. The

Table 4
- Sensitivity of Ichino et al. (2008) for loneliness.

	P11	P10	P01	P00	Γ	Λ	ATT	SE
Boys								
Private School	0.29	0.27	0.23	0.20	1.258	1.512	−0.042	0.009
Full-time	0.24	0.23	0.24	0.21	1.180	1.112	−0.041	0.008
Employment	0.22	0.18	0.21	0.17	1.368	1.081	−0.041	0.008
White	0.38	0.37	0.32	0.31	1.075	1.304	−0.041	0.008
Mother's education 1	0.05	0.05	0.06	0.06	0.972	0.816	−0.039	0.008
Mother's education 2	0.18	0.20	0.22	0.24	0.904	0.806	−0.041	0.008
Mother's education 3	0.09	0.08	0.09	0.09	1.076	0.985	−0.039	0.008
Mother's education 4	0.08	0.08	0.10	0.08	1.294	0.953	−0.039	0.008
Mother's education 5	0.23	0.24	0.25	0.25	1.037	0.954	−0.040	0.008
Mother's education 6	0.09	0.08	0.07	0.07	0.944	1.104	−0.039	0.008
Lives with mother	0.86	0.91	0.83	0.90	0.553	1.117	−0.039	0.008
Lives with father	0.60	0.67	0.54	0.66	0.624	1.090	−0.039	0.008
Capital city	0.59	0.53	0.52	0.50	1.076	1.109	−0.040	0.008
Urban	0.96	0.93	0.94	0.91	1.579	1.357	−0.041	0.008
Girls								
Private School	0.29	0.28	0.22	0.22	1.012	1.408	−0.040	0.011
Full-time	0.23	0.24	0.21	0.21	1.013	1.168	−0.041	0.011
Employment	0.12	0.09	0.11	0.08	1.414	1.087	−0.039	0.011
White	0.36	0.36	0.30	0.29	1.037	1.353	−0.041	0.011
Mother's education 1	0.05	0.06	0.06	0.07	0.905	0.797	−0.040	0.011
Mother's education 2	0.23	0.24	0.27	0.26	1.064	0.874	−0.040	0.011
Mother's education 3	0.07	0.07	0.06	0.08	0.766	0.954	−0.037	0.011
Mother's education 4	0.09	0.08	0.10	0.09	1.088	0.888	−0.039	0.011
Mother's education 5	0.22	0.22	0.23	0.23	0.997	0.937	−0.039	0.011
Mother's education 6	0.08	0.07	0.08	0.07	1.112	1.048	−0.037	0.011
Lives with mother	0.88	0.92	0.87	0.91	0.648	1.142	−0.038	0.011
Lives with father	0.56	0.64	0.54	0.62	0.713	1.096	−0.040	0.011
Capital city	0.57	0.52	0.53	0.48	1.227	1.153	−0.042	0.011
Urban	0.95	0.92	0.95	0.92	1.533	1.021	−0.037	0.011

Note: The first columns present the values p_{ij} used to simulate the binary variable (U) for each case. Γ are the odds ratios, for the untreated, of the outcome variable considering the U effect and controlling the observed covariates (X). Λ represents the treatment odds ratio (T), considering the U effect and controlling the observed covariates (X). ATT generated by NN (1) with replacement after repeating the process 500 times.

Table 5
- Sensitivity of Ichino et al. (2008) for insomnia.

	P11	P10	P01	P00	Γ	Λ	ATT	SE
Boys								
Private School	0.27	0.27	0.22	0.19	1.208	1.513	−0.025	0.007
Full-time	0.25	0.23	0.24	0.21	1.200	1.113	−0.024	0.007
Employment	0.25	0.18	0.22	0.17	1.417	1.081	−0.024	0.007
White	0.37	0.37	0.33	0.31	1.108	1.303	−0.024	0.007
Mother's education 1	0.06	0.05	0.06	0.06	0.937	0.813	−0.024	0.007
Mother's education 2	0.20	0.20	0.21	0.24	0.842	0.807	−0.024	0.007
Mother's education 3	0.09	0.08	0.11	0.08	1.418	0.983	−0.024	0.007
Mother's education 4	0.08	0.08	0.07	0.08	0.885	0.955	−0.024	0.007
Mother's education 5	0.22	0.24	0.26	0.25	1.065	0.953	−0.024	0.007
Mother's education 6	0.09	0.08	0.06	0.07	0.914	1.106	−0.024	0.007
Lives with mother	0.87	0.91	0.86	0.90	0.743	1.118	−0.024	0.007
Lives with father	0.58	0.67	0.56	0.65	0.685	1.096	−0.023	0.007
Capital city	0.56	0.53	0.54	0.50	1.132	1.115	−0.025	0.007
Urban	0.94	0.93	0.95	0.93	1.933	1.365	−0.024	0.007
Girls								
Private School	0.27	0.29	0.21	0.22	0.926	1.406	−0.017	0.010
Full-time	0.26	0.23	0.22	0.21	1.069	1.173	−0.018	0.010
Employment	0.12	0.09	0.11	0.08	1.375	1.092	−0.018	0.010
White	0.35	0.36	0.30	0.39	1.052	1.361	−0.018	0.010
Mother's education 1	0.06	0.05	0.07	0.07	1.067	0.799	−0.018	0.010
Mother's education 2	0.23	0.23	0.27	0.26	1.101	0.876	−0.018	0.010
Mother's education 3	0.07	0.07	0.07	0.08	0.887	0.950	−0.017	0.010
Mother's education 4	0.09	0.08	0.09	0.09	0.976	0.889	−0.018	0.009
Mother's education 5	0.21	0.22	0.24	0.23	1.033	0.938	−0.017	0.010
Mother's education 6	0.09	0.07	0.08	0.07	1.057	1.046	−0.017	0.009
Lives with mother	0.88	0.92	0.88	0.91	0.712	1.137	−0.017	0.010
Lives with father	0.56	0.63	0.53	0.61	0.733	1.109	−0.017	0.010
Capital city	0.57	0.52	0.53	0.49	1.160	1.155	−0.019	0.010
Urban	0.95	0.93	0.95	0.92	1.506	1.022	−0.017	0.010

Note: The first columns present the values p_{ij} used to simulate the binary variable (U) for each case. Γ are the odds ratios, for the untreated, of the outcome variable considering the U effect and controlling the observed covariates (X). Λ represents the treatment odds ratio (T), considering the U effect and controlling the observed covariates (X). ATT generated by NN (1) with replacement after repeating the process 500 times.

Table 6
- Effects of physical education on loneliness and insomnia – probit bivariate apparently not related.

	Loneliness	Insomnia	ρ
Girls	−0,148***	−0,087***	0.535***
	(0,023)	(0,025)	(0.012)
Boys	−0,225***	−0,15***	0.564***
	(0,027)	(0,031)	(0.014)

Note: ***p < 0.01, **p < 0.05, *p < 0.1significance. Robust standard error in parentheses.

greatest deviations are observed in the analysis for the sample of girls when we consider loneliness as the dependent variable. The confounder that causes the largest deviation from the base value is the capital variable, increasing the estimated ATT by approximately 16.7%. The results of the sensitivity analysis of Ichino et al. (2008) prove to be robust for both measures of loneliness and insomnia, in the two analyzed samples, boys and girls.

The Seemingly Unrelated Bivariate Probit model allows us to do this analysis considering that the error terms between the regressions are correlated. Table 6 shows that the unobserved variables affecting loneliness and insomnia are positively correlated. Although there are other unobserved factors between loneliness and insomnia, the negative effect of physical education classes on these indicators remains significant in both genders.

4. Discussion

This study aimed to understand how the practice of physical education affects the mental health of students, comparing students who attend physical education classes with those who do not. In order to reduce the problem of endogeneity caused by comparing essentially different people (people who practice physical activity with people who do not), only those individuals who practice some extracurricular physical activity were selected, in addition, the duration of this activity is used to pair the groups.

The results show that boys and girls benefit from physical activity that comes from physical education classes. For both measures analyzed, the results showed that physical education exerts a negative effect, reducing the probability of reporting problems of insomnia and loneliness among schoolchildren who attend the discipline. Although they show similar magnitudes, the observed effects are greater for boys, for both measures. The results showed to be robust in the sensitivity analyzes and were maintained in the analysis with an alternative methodology.

The negative effect of physical education class on loneliness is also observed by Santos et al. (2015) and Moisescu (2014). According to Santos et al. (2015), participation in physical education classes is a factor associated with the indicator of social isolation “having few friends” in both genders, but the effects of physical education practice on the feeling of loneliness are only observed in girls. Moisescu (2014) has found evidence that sports and physical education play a prominent role in the prevention of loneliness and depression.

The evidence in the literature demonstrates that this relationship should be mediated through a psychosocial mechanism (Felfe et al., 2016; Fox, 1999; Pels & Kleinert, 2016). The opportunity for social interaction of physical education would provide the social support necessary to increase the well-being of students, affecting the feeling of loneliness. In addition, this interaction with colleagues would stimulate the development of personal skills, contributing to the quality of relationships (Felfe et al., 2016).

For insomnia, the results are also in agreement with those observed in the literature (Brand et al., 2010; Kalak et al., 2012). Matricciani Olds and Petko (2012) have been observing the existence of a positive association between physical activity and hours of sleep. According to Lang et al. (2013), self-reported sleep is strongly predicted by the amount of physical exercise, thus, adolescents with higher levels of physical activity have better sleep quality, with less waking up at night and fewer insomnia symptoms.

The results found here corroborate Vancampfort et al. (2018), who study sleep problems for 38 low- and middle-income countries and find that people who do not meet the international standard of physical activity (more than 150 min of physical activity per week) are 23% more likely to have sleep problems. The difference in the effect of physical activity by gender can be explained according to the findings of Werneck, Vancampfort, Oyeyemi, Stubbs, and Silva (2018), which show that physical activity reduces girls' insomnia only when practiced between 60 and 119 min per week. Boys, on the other hand, are less likely to report insomnia when practicing physical activity, regardless of the time spent on them per week. Pinto, Barbosa, dos, Nahas, and Pelegrini (2018) point out that the effect of physical activity on quality of sleep may be due to the physiological mechanisms provided by physical activity such as the release of endorphin, the consequence of which is the reduction of stress.

5. Conclusion

The results observed in this study follow the literature that shows that physical activity and physical education are important for the formation of adolescents. Thus, these results may have important implications for public policies, as the discipline of physical education offered in the basic education curriculum has a protective effect on the mental health of schoolchildren. A possible low-cost public policy may be to increase the participation of young people in physical education. According to Costa (2010), there are a number of factors that can promote the participation of young people in the discipline of physical education. The factor that stands out is the teacher's power of inclusion, contemplating and involving all the students in the definition of learning objectives. From the suggestions listed by the author it is possible to improve the students' perception of the importance of physical education in order to increase the participation of boys and girls.

The work has some limitations. The study uses data from a complex sample, but its sample design is not considered in the presented estimates. Only recently has the international literature devoted efforts to analyzing the most appropriate way to implement PSM in complex samples, but there is still no consensus over how best to use it or what advantages it offers. Nevertheless, we have tested some literature contributions in our estimates. These tests showed that the incorporation of the sampling design did not interfere with the observed results, so we chose to present the estimates without incorporating the sample design, which is usually done in the literature. In addition, the information on outcome, solitude and loneliness variables are self-reported, so they are subject to information bias.

It should be noted, however, that results presented here apply to young people who already practice some type of physical activity and, in addition, attend physical education. The coefficients may be higher when compared to sedentary adolescents or to young people who are not in school, since the database is representative for schoolchildren. Research into such effects of physical education is a gap that can be met in new studies.

Ethics statement

This paper is an empirical work using publicly available data. There are no relevant issues of ethics involved in the development of this work. No institutional or national ethical committees have reviewed this paper.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2019.100419.

Appendix

Table A1
Name and description of variables

Variable	Description
Dependent and Treatment Variables	
Feels lonely	1 = Reports loneliness most of the time or always in the last 12 months. 0 = c/c
Difficulty sleeping	1 = Reports insomnia most of the time or always in the last 12 months. 0 = c/c
Attends Physical Education	1 = person who attends physical education. 0 = c/c
Students' characteristics	
Age	Age at the time of the research
Health	1 = good or great reported health. 0 = c/c
Lives with the mother	1 = same residence as the mother. 0 = c/c
White	1 = self-declared white or yellow. 0 = c/c
Lives with the father	1 = same residence as the father. 0 = c/c
Mother's education	Mother's education
Employment	1 = has a job. 0 = c/c
Habits of the student or relatives	
Mother smokes	1 = mother smokes. 0 = c/c
Father smokes	1 = father smokes. 0 = c/c
Additional Time	Minutes that practices physical exercise aside from physical education
Physical Activity	1 = four days or more of physical activity a week. 0 = c/c
Socioeconomic Level	Socioeconomic Level estimated by Factor Analysis
Risk behavior	Indicator of estimated risk behaviors by Factor Analysis
School's characteristics	
Capital city	1 = school is located in the capital city. 0 = c/c
Urban	1 = school is located in an urban zone. 0 = c/c
Private school	1 = administrative unit: private school. 0 = c/c
Full-time	1 = studies full-time. 0 = c/c
Socioeconomic Level	
Landline phone	1 = has a landline phone at home. 0 = c/c
Cell phone	1 = has a cell phone. 0 = c/c
Computer	1 = has a computer at home. 0 = c/c
Internet	1 = has internet at home. 0 = c/c
Car	1 = has a car at home. 0 = c/c
Housekeeper	1 = has a housekeeper at home. 0 = c/c
Risk behavior	
Has ever smoked	1 = has ever smoked. 0 = c/c
Has ever drank	1 = has ever drank. 0 = c/c
Has ever used drugs	1 = has ever used illicit drugs. 0 = c/c
Friends Drink	How many friends drink: 1 = none and 5 = all of them
Friends Use Drugs	How many friends use illicit drugs: 1 = none and 5 = all of them

Source: Prepared by the authors based on the 2015 PeNSE. Note: c/c: if otherwise.

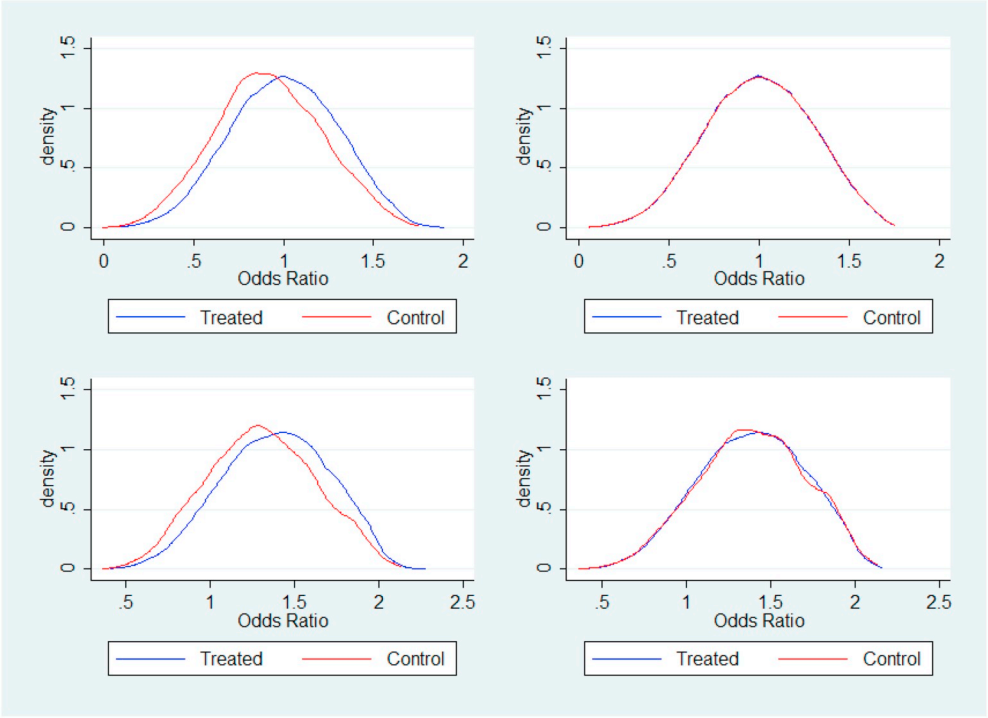

Fig. A1. Sampling distribution before and after pairing.

Table A2
Variable's means after pairing

Variable	Boys			Girls		
	Attends	Does not attend	t	Attends	Does not attend	t
Age	14.38	14.38		14.13	14.14	
Health	0.78	0.78		0.71	0.71	
Lives with the mother	0.90	0.90		0.91	0.91	
Whites	0.41	0.40		0.41	0.41	
Lives with the father	0.66	0.66		0.62	0.61	
Employment	0.18	0.19		0.09	0.09	
Mother smokes	0.6	0.06		0.07	0.07	
Father smokes	0.12	0.12		0.12	0.12	
Additional Time	216.5	216.88		154.68	155.06	
Physical Activity	0.56	0.56		0.41	0.41	
Socioeconomic Level	0.07	0.07		0.03	0.04	
Risk behavior	−0.11	−0.05		0.00	0.00	
Capital city	0.53	0.53		0.53	0.52	
Urban	0.93	0.93		0.92	0.93	
Private school	0.27	0.27		0.28	0.28	
Full-time	0.23	0.23		0.23	0.24	
Mother's education						
Did not finish elementary school	0.20	0.20		0.23	0.23	
Finished elementary school	0.08	0.09		0.07	0.07	
Did not finish high school	0.08	0.07		0.08	0.08	
Finished high school	0.24	0.27		0.22	0.22	
Did not finish undergraduate school	0.08	0.08		0.07	0.07	
Finished undergraduate school	0.26	0.27		0.26	0.26	

Table A3
Balancing before and after pairing

	Pseudo-R^2	LR chi^2	P-value	Mean Bias	Median Bias
Boys					
Unpaired	0.015	341.06	0.000	6.5	4.2
Paired	0.001	27.71	0.185	0.9	0.8
Girls					
Unpaired	0.015	314.06	0.000	6.5	4.2
Paired	0.000	10.98	0.975	0.5	0.4

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