# The relationship between school performance and physical health: A microdata approach using PISA tests

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**Abstract:**
**Background:** People who practice sports enjoy good health and physical and mental well-being. It has been scientifically proven that physical activity provides cognitive benefits. Therefore, the objective of this research is to determine if physical activity at least 60 minutes a day is related to school performance expressed in objective scores per subject.
**Material and methods:** We used 288,552 data from students, whose average age was 15 years, who participated in the 2018 OECD Program for International Student Assessment (PISA). We used a linear regression model, a formal test was also performed to rule out the presence of multicollinearity among our independent variables. In addition, we estimated the marginal impacts of the physical health variable.
**Results:** We observed that 33.22% of our sample reported not playing sports, while 66.78% reported that they did play sports. There is a positive correlation between physical activity and math, reading and science scores. Specifically, we observed that students who played sports scored 11. 18 (CI=10.502,11.861), 20.39 (CI=19.726,21.051) and 16.24 (CI=15.549,16.938) points higher in math, reading and science respectively, compared to those students who did not play sports. In addition, a linear regression analysis was performed where it was shown that for each day that 60 minutes of physical activity is performed, the math, reading and science averages increase by 4.47 (CI= 4.351,4.602), 3.65 (CI= 3.528,3.775) and 4.03 (CI= 3.911,4.167), respectively.
**Conclusions:** A significant correlation was found between the frequency and time spent in physical activity and academic performance. However, it is very common that the practice of physical activity decreases over time, so it is necessary to promote the implementation of the subject of Physical Education in the curriculum of educational institutions, since long-term physical exercise improves cognitive function and mental health of children and adolescents. In addition, it is necessary in the future to define the optimal parameters of each type of physical exercise to increase its effectiveness in cognitive improvement in this population group.

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## I. Introduction

Physical health is an important protective factor for the prevention and treatment of organic diseases such as cardiovascular disease, type 2 diabetes and several types of cancer. It is also a protective factor for mental health, as it prevents cognitive decline and the symptoms of depression and anxiety.[1]. In short, physical activity is fundamental in the different stages of development, both physically and emotionally, especially during childhood, which is when we are best able to acquire healthy habits that will accompany us throughout our lives[2]. Globally, it is estimated that 27.5% of adults and 81% of adolescents do not meet the adequate physical activity recommendations established by the World Health Organization (WHO)[3]. Latin America is where the highest levels of physical inactivity have been found, with 39% of its population being sedentary[4].

The recommended physical activity for children aged 5 to 17 years with the objective of improving their cardiorespiratory and muscular fitness, bone health, metabolic health markers, and reducing symptoms of anxiety and depression, consists of at least 60 minutes of daily physical activity of moderate to vigorous intensity, expressed through play, sport, walking, recreational activity, and physical education, in the context of family, school, and community activities.

Currently, the problem lies in the fact that most schoolchildren, in addition to their academic routine, have extracurricular activities, such as music education, language education or simply review academies: Music

Education, language education or simply review academies, and as a consequence reduce the time they devote to non-sedentary activities, thus aggravating the sedentary situation, if we add the low number of weekly hours of Physical Education that is taught in the curricular mesh of educational establishments[5]. More and more children devote their free time to sedentary activities such as watching television or playing video games. There is time for everything and sport can never be left aside. It is an essential physical activity. Children today are able to sit for hours in front of a screen (television, computer, mobile devices, tablets, etc.) and its use or rather abuse has been associated with a lower participation in physical-sports activities and chronic pathologies that were formerly associated almost exclusively to adults. In addition, recent research has associated long hours of playing video game consoles with attention and concentration problems[6].

The WHO recommends that children from 5 to 17 years of age should perform 60 minutes of physical activity daily, which can be divided into several sessions throughout the day. In addition, it suggests adding at least three times a week resistance exercises to improve muscular strength in the large muscles of the trunk and limbs and vigorous aerobic exercises to benefit cardiorespiratory functions and reduce cardiovascular risk factors[6].On the other hand, several authors agree that the practice of physical activity provides benefits at a cognitive level[7,] . In the study by Drobnic, et al. [8]observed that after performing two 3-minute runs at high intensity, a concentration of substances such as dopamine and adrenaline was produced, which resulted in an improvement in verbal learning and vocabulary retention in the long term. On the other hand, the Ramirez study [8] study provides information on the cognitive brain processes and abilities in older people who were physically active were better than those of individuals who were not physically active. The study consisted of observing a group of volunteers, who for 60 years had led a sedentary and inactive lifestyle, after running fast and steadily for 45 minutes, 3 times a week, had achieved an improvement in their mental abilities, which should decline with age. According to Ramirez (2001)[8] the cognitive processes in children who systematically perform moderate-high physical activity are better than those of children who practice a sedentary lifestyle.

Animal and human studies show that physical activity, and cardiovascular exercise in particular, produce profound functional and structural changes in the nervous system, and in the brain in particular. For example, intense exercise increases the concentration of neurotransmitters4 such as serotonin, dopamine, adrenaline and noradrenaline. Some of these neurotransmitters modulate cognitive processes such as memory consolidation.[9] For example, a very small number of studies have investigated the effects of physical activity on memory in children[10] . One such study compared the effects of a 40-minute session of circuit-type exercise or team games on long- and short-term verbal memory in 11- and 12-year-old children. The results showed that verbal short-term memory improved only with team games, while long-term memory improved after both circuit exercise and team games. These results demonstrate that, despite the undoubted benefits of physical activity on cognitive aspects, the relationship between physical activity and cognition is highly complex and that not all types of exercise clearly improve all aspects of cognition[10].

Some studies have investigated the relationship between cardiovascular fitness level and different aspects related to school performance in children and adolescents. In a paradigmatic study, Åberg et al.[11]. studied the relationship between cardiovascular fitness, intelligence and school performance in more than one million individuals at the age of 18 years. The results of this important study showed that the level of cardiovascular fitness was associated with academic performance and intelligence. In another study, Castelli et al.[12] demonstrated correlations between cardiovascular fitness level and overall school performance, particularly in mathematics and reading, in 259 school-aged children. Individually, the results of these and other studies suggest that young people who are cardiovascularly trained and who can use large amounts of oxygen (VO2 max) during exercise perform better academically. Considering the above and taking research as a reference, it seems logical to ratify that students who have performed physical exercise for a prolonged period of time obtain better academic results.

## II. Material And Methods

**Study Design and Population:** To achieve its objective, this study adopted a quantitative approach, with descriptive-correlational design with data obtained from the Organization for Economic Cooperation and Development's 2018 Program for International Student Assessment (PISA).

**Inclusion and Exclusion Criteria:** 288552 children whose mean age was 15 years were included.

**Data source: The** "PISA 2018 Database" was used for this study. This is a dataset provided by the OECD free of charge. Participants come from the 37 OECD member countries and 42 PISA partner countries and economies. The PISA 2018 database consists of responses to a collection of questions from ten different questionnaires. These questionnaires are intended for students and all other parties involved in the learning process of schoolchildren: parents, teachers and school principals.

**Study Variables.** Our dependent variable of interest is physical health, which was measured through the variables of whether or not the student practices any sport and the number of days a student exercises 60 minutes a day.

**Statistical Analysis.** The PISA 2018 Database was analyzed with the statistical package Stata v15 (Stata Corporation, College Station, Texas, USA). A value of p<0.05 was considered to determine statistical significance between variables. The Chi-square test was used to determine the overall correlation between the variables of interest. The association was evaluated by prevalence ratios with their respective 95% confidence intervals with an analysis for each of the variables included in the study. In addition, sociodemographic characteristics were reported as absolute frequencies; numerical variables were reported as means.

Finally, for the determination of the predictor variables, the ROC curve was applied with the probabilities estimated by applying logistic regression under the method of introducing their confidence intervals and their statistical significance p < 0.05.

In order to verify econometrically the different factors that affect the school performance of students in different countries, a linear regression model has been proposed to demonstrate these relationships. For this purpose we have:

$$SP_i = \beta_0 + \beta_1 X_i + \sum_{j=2}^{12} \beta_j Z_i + \varepsilon_i$$

Where $SP_i$ represents school performance, $X_i$ represents the physical health variable and $Z_i$ represents a set of control variables of the linear regression model. Finally, $\varepsilon_i$ represents the stochastic error term.

**Ethical considerations.** The present study did not require the approval of an institutional ethics committee for its execution, since it is an analysis of data freely available to the public and it was not necessary to use informed consent.

### III.    Result

**Table 1** shows the descriptive statistics of the data. Here we analyze all the variables used in this study and see that the sample is 288552 children. We observe that the average school performance (measured by objective scores) in mathematics is 463.24, while the average school performance in reading is 465.71 and the average school performance in science is 469.54. On the other hand, our physical health variables were captured through the variables of whether or not the student practices any sport and the number of days a student exercises 60 minutes a day. We observed that 33.22% of our sample reported not practicing sports, while 66.78% reported that they did practice sports. Likewise, the average number of days a student exercised 60 minutes a day was 4.57 days. Likewise, we observed that the average age of the students was 15.79 years old. On the other hand, 88.07% of the students reported that they are native speakers. Also, we observed that 89.51% reported that they have internet at home. 91.13% of students reported having a high family income. Likewise, 45.82% of students reported that the mother has a high education and 55.98% of students evidenced that they have science, arts and music books at home. Students in our sample also reported that they study an additional 18.95 minutes on average outside the home. On the other hand, the attitude and preference index on average was 0.09 and the percentage of students who reported never being bullied by the teacher was 73.30%, while the percentage of students who reported always being bullied by the teacher was 4.12%.

**Table N°1:** Descriptive statistics of the variables used in this study.

| Variable | N | Mean-percent | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| *School performance* | | | | | |
| Math scores | 288552 | 463.24 | 97.63 | 50.32 | 826.34 |
| Reading scores | 288552 | 465.71 | 100.49 | 54.31 | 812.03 |
| Science scores | 288552 | 469.54 | 98.85 | 101.47 | 835.62 |
| *Physical health* | | | | | |
| Practice sports (No=0) | 288552 | 33.22% | 0.47 | 0 | 1 |
| Practice sports (Yes=1) | 288552 | 66.78% | 0.47 | 0 | 1 |
| Days exercising 60 min per day | 288552 | 4.57 | 2.48 | 1 | |
| *Child's age* | | | | | |
| Age | 288552 | 15.79 | 0.29 | 15.17 | 16.42 |
| *Immigrant status* | | | | | |
| Native | 288552 | 88.07% | 0.32 | 0 | 1 |
| Second generation | 288552 | 5.89% | 0.24 | 0 | 1 |
| First generation | 288552 | 6.05% | 0.24 | 0 | 1 |

| | | | | | |
|---|---|---|---|---|---|
| ***Do you have internet?*** | | | | | |
| Internet (No=0) | 288552 | 10.49% | 0.31 | 0 | 1 |
| Internet (Yes=1) | 288552 | 89.51% | 0.31 | 0 | 1 |
| ***Family income*** | | | | | |
| Income (Low=0) | 288552 | 3.18% | 0.18 | 0 | 1 |
| Income (Average=1) | 288552 | 5.69% | 0.23 | 0 | 1 |
| Income (High=2) | 288552 | 91.13% | 0.28 | 0 | 1 |
| ***Mother's education*** | | | | | |
| Education (Low=0) | 288552 | 9.05% | 0.29 | 0 | 1 |
| Education (Mean=1) | 288552 | 45.13% | 0.50 | 0 | 1 |
| Education (High=2) | 288552 | 45.82% | 0.50 | 0 | 1 |
| ***Do you own books on science, art and music?*** | | | | | |
| Owns books (No=0) | 288552 | 44.02% | 0.50 | 0 | 1 |
| Owns books (Yes=1) | 288552 | 55.98% | 0.50 | 0 | 1 |
| ***Make friends easily?*** | | | | | |
| Friends (Strongly agree=0) | 288552 | 25.01% | 0.43 | 0 | 1 |
| Friends (Agree=1) | 288552 | 54.57% | 0.50 | 0 | 1 |
| | | | | | 1 |
| Friends (Disagree=2) | 288552 | 14.95% | 0.36 | 0 | |
| Friends (strongly disagree=3) | 288552 | 5.48% | 0.23 | 0 | 1 |
| ***International language at home?*** | | | | | |
| Language (test language=0) | 288552 | 86.64% | 0.34 | 0 | 1 |
| Language (International language=1) | 288552 | 13.36% | 0.34 | 0 | 1 |
| ***Additional study minutes per week*** | | | | | |
| Minutes studied outside of school | 288552 | 18.95 | 14.32 | 0 | |
| ***Attitudes, preferences*** | | | | | |
| Attitudes and preferences index | 288552 | 0.09 | 0.99 | -3.09 | 1.85 |
| ***Does your teacher ridicule you?*** | | | | | |
| Teacher bullying (Never=0) | 288552 | 73.30% | 0.44 | 0 | 1 |
| Teacher bullying (Almost never=1) | 288552 | 16.30% | 0.37 | 0 | 1 |
| Teacher Bulling (Sometimes =2) | 288552 | 6.29% | 0.24 | 0 | 1 |
| Teacher Bulling (Always =3) | 288552 | 4.12% | 0.20 | 0 | 1 |

Subsequently, we performed a correlation matrix to perform a detailed analysis of the correlation between the variables and to highlight possible multicollinearity problems. **Table 2** shows significant correlations between school performance and physical activity (both the dichotomous variable and the continuous variable). In addition, we observed some other variables with significant correlations. All these variables have an expected sign that is correct. In addition, we observed that some correlations between the independent variables are greater than 50%. This shows that there are probably multicollinearity problems among the variables. Below we perform a formal test to test for multicollinearity among the variables.

**Table N°2:** Correlation matrix of the variables

| | var1 | var2 | var3 | var4 | var5 | var6 | var7 | var8 | var9 | var10 | var11 | var12 | var13 | var14 | var15 | var16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| var1 | 1 | | | | | | | | | | | | | | | |
| var2 | 0.886* | 1 | | | | | | | | | | | | | | |
| var3 | 0.937* | 0.927* | 1 | | | | | | | | | | | | | |
| var4 | -0.052* | 0.109* | 0.076* | 1 | | | | | | | | | | | | |
| var5 | 0.153* | 0.118* | 0.139* | 0.229* | 1 | | | | | | | | | | | |
| var6 | 0.015* | 0.0261* | 0.022* | 0.009 | -0.070* | 1 | | | | | | | | | | |
| var7 | 0.019* | 0.017* | 0.007* | 0.066* | -0.008* | 0.008* | 1 | | | | | | | | | |
| var8 | 0.268* | 0.236* | 0.244* | 0.028* | 0.062* | 0.060* | 0.056* | 1 | | | | | | | | |
| var9 | 0.053* | 0.065* | 0.061* | 0.028* | 0.023* | 0.030* | 0.001 | 0.055* | 1 | | | | | | | |
| var10 | 0.201* | 0.139* | 0.195* | 0.010* | 0.090* | 0.086* | 0.048* | 0.242* | 0.114* | 1 | | | | | | |
| var11 | 0.121* | 0.154* | 0.122* | 0.023* | 0.099* | 0.076* | 0.009* | 0.134* | 0.029* | 0.167* | 1 | | | | | |
| var12 | 0.010* | 0.099* | 0.023* | -0.05* | -0.077* | -0.027 | 0.000* | 0.035* | -0.08* | 0.041* | -0.039* | 1 | | | | |
| var13 | -0.039* | -0.065* | 0.071* | 0.033* | -0.015* | -0.003 | 0.358* | 0.073* | 0.028* | 0.028* | 0.006* | -0.010* | 1 | | | |
| var14 | 0.144* | -0.114* | 0.148* | 0.061* | 0.002 | -0.069* | 0.043* | -0.077* | 0.017* | 0.089* | 0.078* | -0.001* | 0.033* | 1 | | |
| var15 | 0.051* | 0.084* | 0.067* | 0.006* | 0.010* | 0.090* | 0.089* | 0.030* | 0.031* | 0.049* | 0.034* | -0.012* | 0.028* | 0.141* | 1 | |
| var16 | -0.099* | -0.132* | 0.114* | 0.056* | 0.020* | 0.025* | 0.035* | 0.000 | 0.026* | 0.034* | 0.064* | 0.066* | 0.059* | 0.017* | 0.0054* | 1 |

Note: Var 1: Math scores. Var 2: Reading scores. Var 3: Science scores. Var 4: Practice sports. Var 5: Days exercised 60 min per day. Var 6: Age of child. Var 7: Immigrant status. Var 8: Owns internet. Var 9: Family income. Var 10: Mother's education. Var 11: Owns books. Var 12: Friends easily. Var 13: International language at home. Var 14: Additional minutes of study. Var 15: Index of attitudes and preferences. Var 16: Teacher bullying. Asterisks mean: *p < 0.05.

Next, we performed a formal test to rule out the presence of multicollinearity among our independent variables. In **Table 3** we present a multicollinearity analysis. We use the Variance Inflator Factor (VIF) to perform this test. Previous literature indicates that a VIF greater than 5 can demonstrate that multicollinearity exists in our data. As we can see, no variable has a VIF greater than 5, therefore we rule out multicollinearity problems in our independent variables. This analysis is important since multicollinearity problems cause instability of the parameters of a regression, incorrect signs and higher standard errors, which translates into statistical insignificance of the parameters.

**Table N° 3:** Multicollinearity test of the variables

| Variable | VIF | SQRT-VIF | Tolerance | R-Squared |
|---|---|---|---|---|
| Practice sports | 1.07 | 1.03 | 0.9348 | 0.0652 |
| Days exercising 60 min per day | 1.07 | 1.03 | 0.9384 | 0.0616 |
| Child's age | 1.01 | 1.00 | 0.9932 | 0.0068 |
| Immigrant status | 1.12 | 1.06 | 0.8897 | 0.1103 |
| Has internet | 1.09 | 1.04 | 0.9212 | 0.0788 |
| Family income | 1.03 | 1.01 | 0.9739 | 0.0261 |
| Mother's education | 1.10 | 1.05 | 0.9122 | 0.0878 |
| It has books | 1.05 | 1.02 | 0.9553 | 0.0447 |
| Friends easily | 1.01 | 1.01 | 0.9858 | 0.0142 |
| International language | 1.12 | 1.06 | 0.8937 | 0.1063 |
| Additional study minutes | 1.02 | 1.01 | 0.9797 | 0.0203 |
| Attitudes and preferences index | 1.03 | 1.01 | 0.9709 | 0.0291 |
| Teacher bullying | 1.01 | 1.01 | 0.9879 | 0.0121 |
| *Mean VIF* | *1.15* | | | |

**Figure 1** shows correlation graphs to illustrate the dispersion between the standard deviation and the mean of the three academic achievement variables to be analyzed, which are: mathematics, reading and science. In this figure we can see that there are countries where the standard deviation is higher, i.e., students obtain grades with wider differences. Specifically, we observe that the highest dispersion with respect to the mean is reflected in the reading scores. This information shows that reading averages are more dispersed across

countries in this student test. On the other hand, a lower dispersion is observed in the science category scores. Thus, it can be inferred that knowledge in this test category is more homogeneous among countries. A similar pattern is observed in the mathematics scores, where less dispersion is observed with respect to the mean between countries.
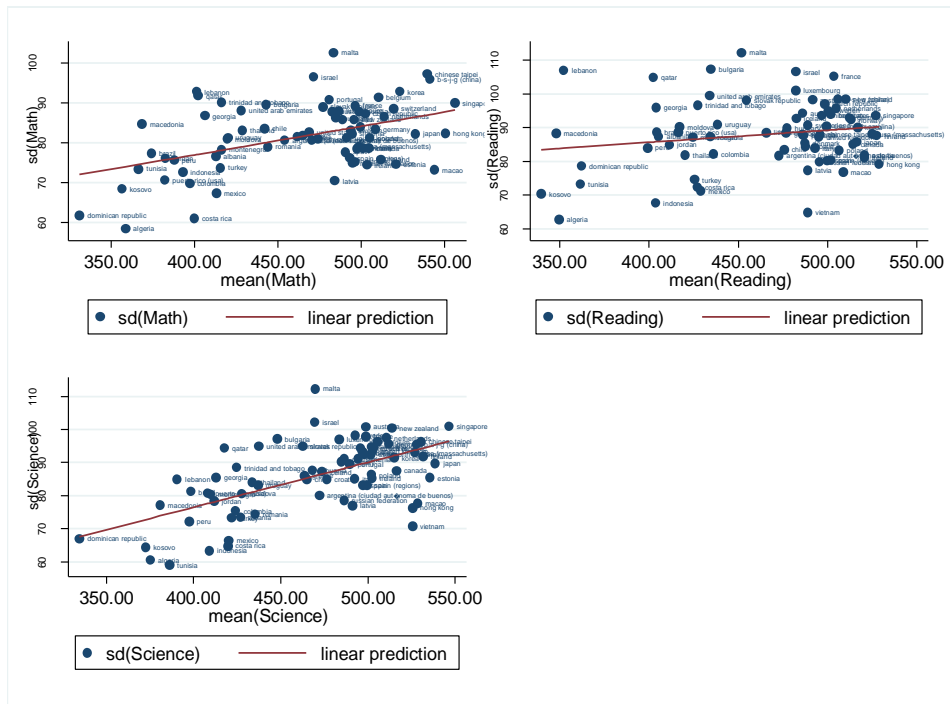


**Figure 1.** Correlation (Dispersion) between standard deviation and domain mean in reading, science and mathematics.

Next, we analyze the distributions of our academic achievement variables in math, reading and science. **Figure 2** shows that the scores of the three tests behave as a normal distribution, while in the variable of number of days a student exercises 60 minutes we observe that the data are concentrated in the 8-day category. In general, this figure indicates that the school performance data are efficient and follow a normal distribution.
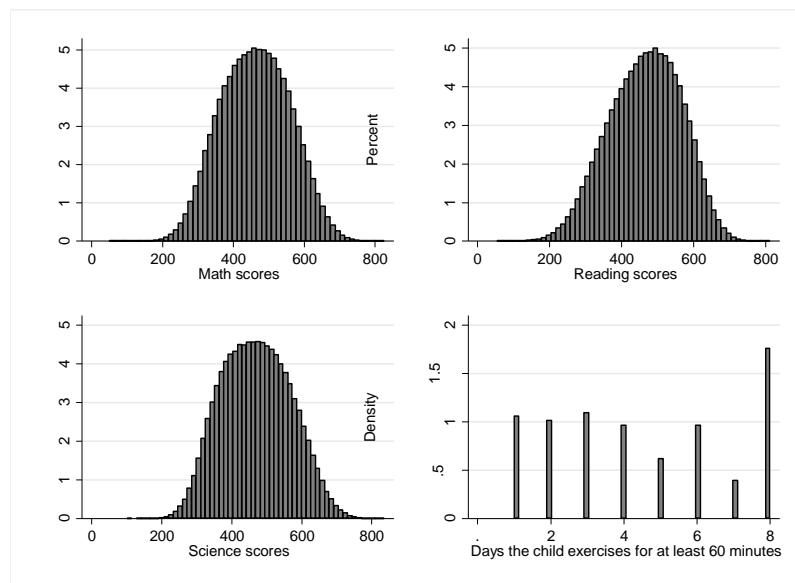


**Figure 2.** Distribution of academic performance and physical health variables.

Subsequently, we performed a linear regression analysis to estimate the correlation between physical activity (physical health) and school performance. In **Table 4** we observe that there is a positive correlation

between physical activity and math, reading and science scores. Specifically, we observed that students who played sports scored 11. 18 (CI=10.502,11.861), 20.39 (CI=19.726,21.051) and 16.24 (CI=15.549,16.938) points higher in math, reading and science respectively, compared to those students who do not play sports. In addition, we observed that there is a positive and significant correlation between age and academic performance in all three tests. Another interesting result is the fact that there is a positive correlation between owning the Internet and academic performance. We observed a positive correlation also in the variables of a higher level of family income, a higher educational level of the mother, owning books, making friends more easily and a higher index of attitudes and preferences. On the other hand, we observed a negative correlation in the variables of speaking international language at home (probably reflecting the fact of being an immigrant), a greater number of additional minutes to study outside school, and a higher frequency of bullying by the teacher.

**Table N° 4:** Linear regression analysis between physical health and academic performance with a dichotomous variable

| | M1 | M2 | M3 |
|---|---|---|---|
| | **Math** | **Reading** | **Science** |
| *Practice sports* | | | |
| No | Ref. | | |
| Yes | 11.181*** | 20.389*** | 16.243*** |
| | [10.502,11.861] | [19.726,21.051] | [15.549,16.938] |
| *Child's age* | | | |
| Age | 8.285*** | 13.077*** | 10.715*** |
| | [7.196,9.374] | [12.014,14.139] | [9.602,11.828] |
| *Immigrant status* | | | |
| Native | Ref. | | |
| Second generation | 1.469* | 3.146*** | -0.992 |
| | [0.078,2.861] | [1.789,4.503] | [-2.414,0.430] |
| First generation | -4.026*** | -0.741 | -0.311 |
| | [-5.410,-2.641] | [-2.091,0.610] | [-1.726,1.104] |
| *Do you have internet?* | | | |
| No | Ref. | | |
| Yes | 67.093*** | 65.950*** | 63.518*** |
| | [65.839,68.347] | [64.727,67.173] | [62.237,64.800] |
| *Family income* | | | |
| Low income | Ref. | | |
| Average income | 30.648*** | 27.891*** | 30.536*** |
| | [28.591,32.705] | [25.885,29.897] | [28.434,32.638] |
| High income | 27.577*** | 20.108*** | 29.012*** |
| | [25.871,29.282] | [18.445,21.771] | [27.270,30.755] |
| *Mother's education* | | | |
| Low education | Ref. | | |
| Secondary education | 22.573*** | 22.442*** | 22.018*** |
| | [21.354,23.792] | [21.253,23.631] | [20.772,23.264] |
| High education | 46.741*** | 47.417*** | 47.736*** |
| | [45.498,47.983] | [46.205,48.629] | [46.466,49.006] |
| *Do you own books on science, art and music?* | | | |
| No | Ref. | | |
| Yes | 14.442*** | 18.904*** | 16.476*** |
| | [13.787,15.097] | [18.265,19.542] | [15.807,17.145] |
| *Make friends easily?* | | | |
| Strongly agree | Ref. | | |
| Agree | 12.390*** | 11.634*** | 13.025*** |
| | [11.595,13.184] | [10.860,12.409] | [12.213,13.836] |
| Disagree | 14.581*** | 16.269*** | 19.235*** |
| | [13.536,15.626] | [15.250,17.289] | [18.167,20.303] |
| Strongly disagree | -17.107*** | -14.929*** | -11.872*** |
| | [-18.615,-15.599] | [-16.400,-13.459] | [-13.413,-10.330] |
| *International language at home?* | | | |
| language of test | Ref. | | |
| International language | -8.172*** | -17.897*** | -16.319*** |

|  | [-9.293,-7.051] | [-18.990,-16.804] | [-17.465,-15.174] |
|---|---|---|---|
| ***Additional study minutes per week*** |  |  |  |
| Minutes studied outside of school | -0.716*** | -0.811*** | -0.765*** |
|  | [-0.738,-0.693] | [-0.833,-0.788] | [-0.788,-0.742] |
| ***Attitudes, preferences*** |  |  |  |
| Attitudes and preferences index | 6.906*** | 9.195*** | 8.599*** |
|  | [6.570,7.242] | [8.867,9.522] | [8.255,8.942] |
| ***Does your teacher ridicule you?*** |  |  |  |
| Never | Ref. |  |  |
| Almost never | -0.770 | -5.092*** | -2.660*** |
|  | [-1.640,0.099] | [-5.940,-4.244] | [-3.548,-1.772] |
| Sometimes | -21.244*** | -30.444*** | -25.332*** |
|  | [-22.615,-19.874] | [-31.781,-29.108] | [-26.733,-23.932] |
| Always | -35.075*** | -46.112*** | -38.878*** |
|  | [-36.817,-33.333] | [-47.811,-44.413] | [-40.658,-37.098] |
| Constant | 233.745*** | 168.487*** | 200.579*** |
|  | [216.352,251.138] | [151.525,185.450] | [182.804,218.354] |
| Observations | 270354 | 270354 | 270354 |
| Adjusted $R^2$ | 0.141 | 0.171 | 0.147 |
| *AIC* | 3164221.10 | 3150662.13 | 3175962.74 |
| *BIC* | 3164431.25 | 3150872.27 | 3176172.89 |
| r2 | 0.141 | 0.171 | 0.147 |
| F | 2339.465 | 2941.867 | 2451.157 |
| ll | -1582090.550 | -1575311.063 | -1587961.372 |

95% confidence intervals in brackets $^*p < 0.05,$ $^{**}p < 0.01,$ $^{***}p < 0.001$

Next, we performed the same linear regression analysis, but changed our independent variable of interest and obtained a continuous variable. **Table 5** demonstrates that a greater number of days a student exercises at least 60 minutes per day is positively correlated with school performance. Specifically, an additional 60-minute exercise day increases by 4.47 (CI= 4.351,4.602), 3.65 (CI= 3.528,3.775) and 4.03 (CI= 3.911,4.167) the math, reading and science averages respectively. These data confirm the findings found in the previous table, that greater physical activity or greater physical health is positively correlated with higher school performance. On the other hand, the control variables used in this model have the same signs and significance as in the previous table.

**Table N° 5:** Linear regression analysis between physical health and academic performance with a continuous variable

|  | M1 | M2 | M3 |
|---|---|---|---|
|  | Math | Reading | Science |
| ***Physical health*** |  |  |  |
| Days exercising 60 min per day | 4.477*** | 3.652*** | 4.039*** |
|  | [4.351,4.602] | [3.528,3.775] | [3.911,4.167] |
| ***Child's age*** |  |  |  |
| Age | 8.106*** | 12.773*** | 10.516*** |
|  | [7.053,9.159] | [11.738,13.809] | [9.438,11.593] |
| ***Immigrant status*** |  |  |  |
| Native | Ref. |  |  |
| Second generation | 3.214*** | 4.599*** | 0.540 |
|  | [1.869,4.559] | [3.276,5.921] | [-0.837,1.916] |
| First generation | -1.921** | 0.605 | 1.282 |
|  | [-3.264,-0.579] | [-0.715,1.925] | [-0.092,2.656] |
| ***Do you have internet?*** |  |  |  |
| No | Ref. |  |  |
| Yes | 67.662*** | 66.652*** | 63.974*** |
|  | [66.482,68.841] | [65.492,67.812] | [62.766,65.181] |
| ***Family income*** |  |  |  |
| Low income | Ref. |  |  |
| Average income | 30.659*** | 28.402*** | 31.166*** |
|  | [28.680,32.638] | [26.456,30.349] | [29.140,33.192] |
| High income | 26.146*** | 18.752*** | 28.181*** |
|  | [24.514,27.779] | [17.146,20.357] | [26.510,29.852] |
| ***Mother's education*** |  |  |  |
| Low education | Ref. |  |  |
| Secondary education | 22.252*** | 21.488*** | 21.369*** |

| | | | |
|---|---|---|---|
| | [21.089,23.414] | [20.344,22.631] | [20.179,22.559] |
| High education | 45.760*** | 45.426*** | 46.101*** |
| | [44.571,46.948] | [44.257,46.594] | [44.885,47.317] |
| *Do you own books on science, art and music?* | | | |
| No | Ref. | | |
| Yes | 12.890*** | 17.223*** | 14.730*** |
| | [12.256,13.523] | [16.600,17.846] | [14.082,15.379] |
| *Make friends easily?* | | | |
| Strongly agree | Ref. | | |
| Agree | 14.340*** | 14.145*** | 15.337*** |
| | [13.571,15.108] | [13.389,14.900] | [14.550,16.123] |
| Disagree | 18.615*** | 21.453*** | 23.924*** |
| | [17.610,19.620] | [20.465,22.441] | [22.895,24.952] |
| Strongly disagree | -14.926*** | -12.343*** | -9.629*** |
| | [-16.377,-13.474] | [-13.771,-10.916] | [-11.115,-8.143] |
| *International language at home?* | | | |
| language of test | Ref. | | |
| International language | -7.506*** | -17.933*** | -16.028*** |
| | [-8.590,-6.422] | [-18.998,-16.867] | [-17.138,-14.919] |
| *Additional study minutes per week* | | | |
| Minutes studied outside of school | -0.765*** | -0.866*** | -0.822*** |
| | [-0.787,-0.743] | [-0.887,-0.844] | [-0.844,-0.799] |
| *Attitudes, preferences* | | | |
| Attitudes and preferences index | 6.348*** | 8.604*** | 8.007*** |
| | [6.022,6.673] | [8.284,8.924] | [7.674,8.340] |
| *Does your teacher ridicule you?* | | | |
| Never | Ref. | | |
| Almost never | -1.245** | -6.165*** | -3.447*** |
| | [-2.087,-0.404] | [-6.993,-5.338] | [-4.309,-2.586] |
| Sometimes | -22.403*** | -32.298*** | -26.791*** |
| | [-23.729,-21.077] | [-33.602,-30.994] | [-28.149,-25.434] |
| Always | -35.959*** | -47.788*** | -40.265*** |
| | [-37.639,-34.278] | [-49.441,-46.135] | [-41.986,-38.545] |
| Constant | 218.645*** | 162.883*** | 189.849*** |
| | [201.832,235.459] | [146.350,179.417] | [172.638,207.059] |
| Observations | 288552 | 288552 | 288552 |
| Adjusted $R^2$ | 0.161 | 0.177 | 0.159 |
| AIC | 3376427.35 | 3366750.09 | 3389894.07 |
| BIC | 3376638.80 | 3366961.55 | 3390105.53 |
| r2 | 0.162 | 0.177 | 0.160 |
| F | 2925.504 | 3276.591 | 2882.768 |
| ll | -1688193.674 | -1683355.047 | -1694927.037 |

95% confidence intervals in brackets * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Finally, by having a continuous independent variable to measure activity (physical health) we calculate the marginal impacts (MI) of the independent variable on higher academic performances in the three tests. **Figure 3** shows that as the number of days a student exercises at least 60 minutes per day increases, so do math, reading and science test scores (academic performance). Specifically, we observe higher MI in math scores, i.e., physical fitness marginally increases plus math scores. This given that we observe that 6 days of 60 minutes of physical activity increases by an additional 31 points in math, 25.5 in reading and 28 points in science.
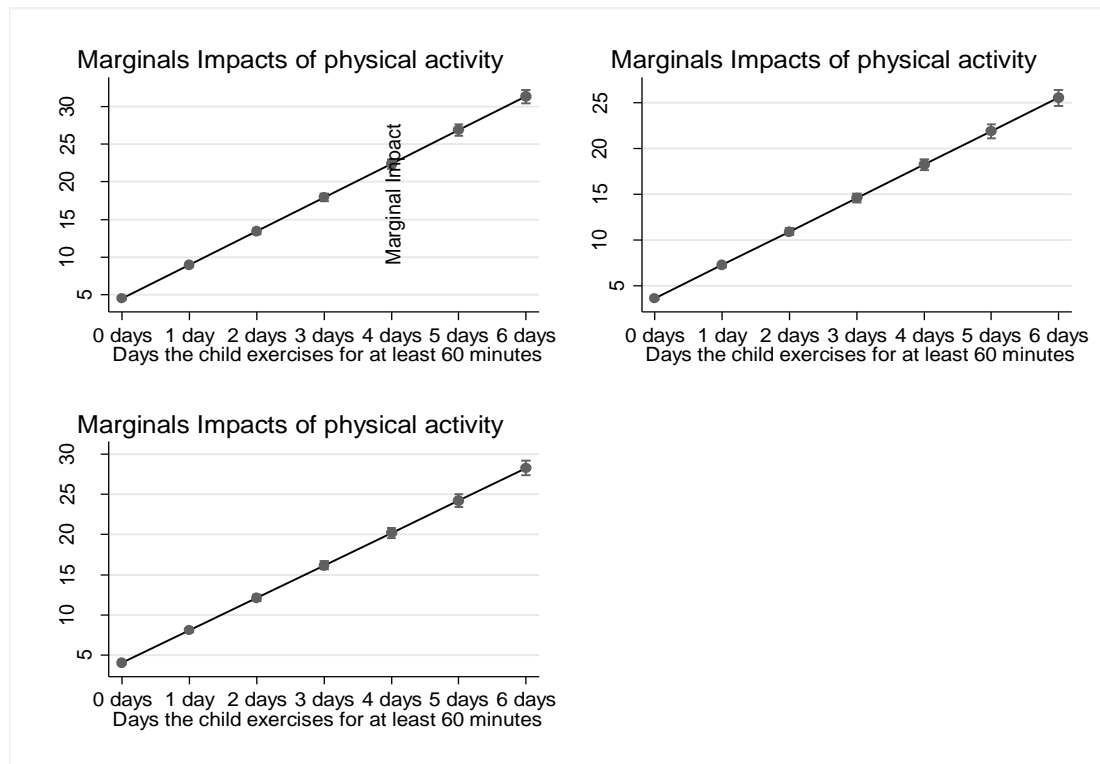
**Figure 3.** Marginal impacts of physical health and their respective 95% confidence intervals

### IV.    Discussion

In the present study we found a significant correlation between physical activity and academic performance. Currently, the World Health Organization recommends that an average of at least 60 minutes a day should be dedicated to moderate to intense physical activities, mainly aerobic, throughout the week. In our results we were able to determine that 33.22% of our sample reported not practicing sports, while 66.78% reported that they did practice sports. Likewise, the average number of days that a student exercised 60 minutes a day was 4.57 days. Therefore, the recommended physical activity in the majority of our study population is adequate.

There are multiple studies that show that physical activity in general has a positive effect on learning multiple school tasks, thus, physical exercise takes a prominent place as a factor likely to modify brain function and structure, providing clear benefits in cognitive performance and psychological well-being. Taking into account the objectives of the present research, when analyzing academic performance together with the practice of physical activity according to the duration of the same, we were able to observe that 88.07% of the students reported that they are native speakers, 89.51% reported having internet at home, 91.13% of students reported having a high family income. Likewise, 45.82% of the students reported that the mother has a high education and 55.98% of students evidenced that they have science, arts and music books at home.

The students in our sample also reported that they study an additional 18.95 minutes on average away from home. On the other hand, the attitude and preference index on average was 0.09 and the percentage of students who reported never being bullied by the teacher was 73.30%, while the percentage of students who reported always being bullied by the teacher was 4.12%. In addition, it was found that there is a positive correlation between physical activity and mathematics, reading and science scores.

Specifically, we observed that students who practiced sports obtained 11.18 (CI=10.502,11.861), 20.39 (CI=19.726,21.051) and 16.24 (CI=15.549,16.938) more points in mathematics, reading and science respectively, compared to those students who did not practice sports. These results coincide with the study conducted in Mexico in which it was found that by applying a physical activity program for new months, the percentage of students with deficient condition in the areas of mathematics, science and language decreased by 32.56%.[13]. Another study conducted in Santiago de Chile established that there is a direct correlation between physical activity and the grades obtained in mathematics and in the average grades obtained in the four subjects studied.[14]. It has been shown that improved academic performance may be related to increased blood flow to various areas of the brain that may be involved in the cognitive processes necessary for learning.

The results obtained are in line with other studies that have analyzed the effects of physical activity on cognitive variables in children and adolescents, and in particular those that have studied specific aspects of

executive functions.[15]. Another interesting result is the fact that there is a positive correlation between owning the Internet and academic performance. We also observed a positive correlation in the variables of a higher level of family income, a higher level of education of the mother, owning books, making friends more easily and a higher index of attitudes and preferences.[9]data that coincide with our results.

On the other hand, an association was identified between school performance and the time dedicated to physical activity or sports, with whom the student lives, parents' level of studies, time dedicated to watching television and time dedicated to video games. Having knowledge of these associated factors, the importance of physical activity is emphasized, at least four days a week with 30 minutes per day, with a balanced diet and good hydration practice, having support from family members or guardians to strengthen the desire to continue doing physical activity and consolidate values and habits, maintain conversations with parents or guardians, as well as with classmates, about their physical activity to maintain or improve self-confidence, autonomy, decision making and attention-concentration, attitudes that will be beneficial to continue improving school performance and reduce television and video game time.[4].

In addition, other studies suggest that physical activity developed in the sports context may have a greater impact on brain functioning, given the great cognitive involvement that these situations have, derived from the high intensity of the game, and even because of the socioemotional implications they entail.[16]. These results provide new data on this phenomenon and suggest that we should continue to study in depth those aspects of physical activity that may have an impact on the cognitive development of children and adolescents. Thus, it is necessary to emphasize the need to assess the role of the subject of Physical Education at school, and the time devoted to this subject in schools should be increased. In fact, the findings in the area of cognitive development indicate the need for Physical Education to be an important part of the students' curriculum.[14]. Moreover, this need becomes more evident when the results of surveys on frequent physical practice in children and adolescents indicate high levels of sedentary lifestyles, also affecting other aspects that can influence the cognitive performance of adolescents such as obesity.[17].

## V. Conclusion

Based on the results obtained, it is accepted that the motor and cognitive development of children and adolescents improves with the regular practice of physical activity. Physical exercise has a strong influence on factors that had not been previously considered such as emotional states like anxiety and depression, stress reduction, improvements in motor and cognitive development, supported by functional changes from the practice of physical activity and sport. This would imply that sport activity could be considered as a central and fundamental element in health promotion programs, both for child and youth populations without pathologies as well as for those with specific pathologies. However, more research is needed to relate physical activity with academic performance and to determine more precisely in which areas the practice of physical activity has more influence and the effect over time (months and years) of physical practice on academic performance in primary and secondary education.

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