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Train to Reason: Sports and the Girls' Math-Reading Gap

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Abstract

The aim of this paper is to evaluate if involvement in sport may generate an improvement in girls' performance in math scores relative to those in reading. Using data from the Programme for International Student Assessment (PISA, 2015) on test scores of Italian high school students we implement an Instrumental Variable strategy designed to establish the causal relationship between sports and test scores. The econometric strategy relies on two features, namely, 1) the use of mother education as an instrument to predict the level of sports performed by girls and 2) the use of the ratio of math and reading scores as the main interest-dependent variable to eliminate from the residuals unobserved elements that may shape schooling ability and are likely to be correlated with the educational level of mothers. Results highlight that physical activity improves math test scores for girls. We argue that involvement in sports for girls may make up for the lack of out-of-the-home experiences that typically takes place during childhood, generating an improvement in willingness to compete as well as in the ability to perform strategic and logical reasoning under pressure, fostering math performance.

Keywords

Test Scores, Sports, Schooling Ability, PISA Data

1. Introduction

This study analyzes the role that the practice of sport has in determining the school performance of students focusing on its impact on the gender gap in math and reading scores. By using PISA (2015) data on Italian students enrolled in the 10^{th} grade, this study shows that greater involvement of girls in sports significantly improves their performance in math. This evidence supports the idea that incentives to stimulate girls' involvement in sports may have a positive effect not only in terms of health and physical well-being but may also have a role in bridging the existing gender gap in math-intensive university majors and occupations.

Recently, the economic literature has highlighted that students who obtain a university degree in scientific, technological, engineering and mathematical disciplines (henceforth referred to simply as STEM) and follow professions in closely related fields, have a significant income advantage over graduates in non-STEM disciplines. In particular, Kinsler and Pavan (2015) show that science majors lead to occupations in high-income sectors even after controlling for SAT scores, high school GPA and worker-fixed effects. Kirkeboen et al. (2016) find that choice of degree has a marked impact on earnings after accounting for self-selection. Deming and Noray (2020) show that—all other things being equal—STEM graduates have a wage advantage that remains evident for about 10 years after entering the labor market. In parallel with the link between income and university choices, the economic literature also shows that the share of women actually involved in scientific-STEM jobs is markedly lower than the share of men and also the presence of women in STEM majors is much lower compared to that of men (among others see Card & Payne, 2021). This under-representation has important consequences for the disparity in economic status between males and females. The recent analysis of Card and Payne (2021) for the U.S. and Canada, for example, suggests that the gender gap in the likelihood of graduating with a STEM-related degree explains up to a fifth of the wage gap between younger college-educated men and women in both countries.

Evaluation of why fewer females enroll in STEM majors may lead to various explanations, including the characteristics of the jobs that may be obtained with a scientific degree, gender differences in competitiveness, or the existence of stereotypes[1]. However, at the end of high-school, the share of females who are STEM-ready appears to be much lower than that of males. In particular, Card and Payne (2021) argue that in Canada most of the gender gap in STEM entry is largely attributable to the gender gap in STEM readiness, rather than to differences in program choices conditional on readiness. Put differently, those who enroll in STEM courses are those who have top math scores at high school and, in practice, the share of women who perform at the top-tail end of the math-score distribution is substantially lower than that of males[2]. In the light of that, evaluation of the reasons explaining why more boys than girls excel in math is important.

[1]Stereotypes about science, technology, engineering and mathematics (STEM) may be associated with reduced STEM engagement amongst girls and women (Cheng et al., 2017; McGuire et al., 2020; Carlana & Corno, 2021). Gender differences in competitiveness, self-confidence or interest have also been pointed out to understand why girls tend to avoid scientific fields (Kamas & Preston, 2012; Buser et al., 2014; Almas et al., 2016; Bian et al., 2017).

[2]Contini et al. (2017) have reported evidence for Italy using INVALSI dataset.

The target of this paper is then to provide evidence that a part of the math gender gap can be attributed to the fact that girls are much less involved in sports. We argue that the practice of sport may improve girls' math scores since it may enhance the process of socialization contributing to improving the ability to employ logical reasoning in competitive environments and fostering the desire to compete. In this sense, it could make up for the lack of outside-the-home social interaction that typically characterizes girls with respect to boys thereby improving their math scores[3].

The causal relation between sports and girls' math performance is identified by 1) using as variable of interest the math score relative to the reading one and 2) applying a two-stage Instrumental Variables (IV) technique where at the first stage mother education is used as an instrument to predict the level of sport practiced by daughters. In this empirical setup, since mother education may shape the unobserved "school ability" of children and since this would affect both math- and reading-ability, mother education is likely to be orthogonal to the residuals of the second-stage regression where the dependent variable is the ratio between math and reading score. Therefore, under the assumption that mother education is correlated with unobserved students' characteristics shaping *both* math and reading scores, it is possible to use mother education as an instrumental variable to predict sports activity and to evaluate how sports affect girls' math performance relative to that in reading. A discussion on the validity of the instrument, and of possible biases that may invalidate it, is presented in the section dedicated to the identification strategy. A number of robustness checks are also proposed.

Results highlight that mother education is a strong predictor of the intensity of sport practiced by girls. Furthermore, the math performance improves for those girls who are more involved in sports. Our findings predict that one more hour of sport per week generates about a 2% improvement in math for females relative to their reading performance. We provide evidence that this result is due to an increase in math scores and not to a worsening of the reading ones. The analysis is corroborated by several robustness and falsification exercises.

Our paper contributes to the existing debate on the causes of the gender gap in academic performance in several ways. Firstly, we shed more light on the nurture/nature issue. Indeed, we show that at least a part of the observed gender gap is related to different experiences and exposure to social life and, from this perspective, we confirm the results of Entwisle et al. (1994) who were among the first to highlight this issue. Secondly, our results are also consistent with the "willingness to compete" argument of Niederle and Vesterlund (2010). In this respect, our paper puts forward a different perspective arguing that the attitude toward competition might be endogenous and potentially caused by the level of

[3]The relevance of social interaction for math learning is highlighted in the literature. See among others, Entwisle et al. (1994), Apriliyanto et al. (2018), Meroni et al. (2021), and Di Tommaso et al. (2021).

sport practised by kids. If it is possible to carry over competitive attitudes—and problem-solving skills—developed through playing games into the academic fields, the lack of female participation in sports could go some way to explaining the gender differences (in favor of males) in math scores.

The paper is organized as follows. Section 2 discusses the literature on the math gender gap as well as that on sports and educational outcomes. In Section 3, we present some stylized facts while Section 4 describes the data. Methodological issues are discussed in Section 5. Results are presented in Section 6 and Section 7 concludes.

2. The Literature

2.1. The Math Gender Gap

As reported in several studies, although the educational gender gap has narrowed dramatically over the past 60 years and women perform better than men in several subjects, a huge difference still characterizes math test scores. In particular, there are differences not only in the mean and in the standard deviation of grades, which are often slightly higher for males than for females, but also in the composition of the right tail of the grade distribution by gender[4].

Why do more boys than girls perform well in math? Three possible sets of explanations have been posited. The first relates to nature: boys and girls are genetically different so that they can perform differently in math because of biological differences. Benbow and Stanley (1980) have been among the first to analyze the issue, although not explicitly supporting the biological interpretation of the detected gap, they argue that stressing the boy-girl differences in the socialization process as the causal factor for the math score gender gap was premature at that time. The second one relates to the daily experience that young boys and girls have. These aspects are related to individual-level factors such as parents' beliefs about girls and boys attitude for solving math problems or individual expectations, and also to group-level factors, i.e. school, teacher, teacher's expectations and neighborhood. From this perspective, Entwisle et al. (1994) show that boys have more outside-the-home interactions than girls, and this affects their math skills. The third aspect studied in the literature concerns the differential manner in which men and women respond to competitive test-taking environments. Niederle and Vesterlund (2010) highlight that the reported test scores do not necessarily match the gender differences in math skills. Instead, they argue that the large gender gap in mathematics performance at high percentiles may be in part explained by gender difference in the extent to which skills are reflected in competitive performance.

2.2. Sport and Educational Attainment

As regards the effect of physical activity on educational attainment, a number of

[4]See among others, Hedges and Nowell (1995), Goldin (2006), Stoet and Geary (2013), and Contini et al. (2017) show evidence for Italy.

studies have reported a positive relationship between the practice of sport and the academic performance[5]. The study of Budde et al. (2008) highlights the existence of a positive correlation between physical activity, cognitive ability and academic achievement, while Ericsson (2008) shows that the increase from twice a week to daily sport practice has a positive impact on the results obtained in mathematics, reading and writing. Some research associates athletes with better school results (Darling et al., 2005; Eccles & Barber, 1999; Eitle & Eitle, 2002; Silliker & Quirk, 1997), more ambitious aspirations (Darling et al., 2005; Marsh & Kleitman, 2002; Otto & Alwin, 1977) and greater aptitude to study (Darling et al., 2005; Eccles & Barber, 1999). Gorry (2016) confirms that sports participation is correlated with improved academic and labor market outcomes, accounting for endogenous selection into sports. Albeit many researchers find that involvement of students in sports improves their academic performance, others argue that the impact of sports participation on academic achievement is nil or even negative (Miller & Kerr, 2002; Hood et al., 1992). Insler and Karam (2019), for example, show that sport participation reduces athletes' grades. However, it must be recognized that existing research does not permit the assessment of a causal relation between sports and educational attainment since experimental or quasi-experimental evidence is almost completely missing.

Pfeifer and Cornelißen (2010) explore the issue of gender differences in the return to sport practice. They argue that benefits of sport might be larger for women than for men because sport may enhance the ability to succeed in a male-dominated society. Similarly, Rees and Sabia (2010), using panel data to keep fixed individual unobserved fixed effects, show a limited effect of sports on academic results. The main limitation of these studies is that the different level of sport at different moments of the individual's life are likely to be endogenous so that parameters detected through fixed-effects models are unlikely to be informative about the effect of sports on academic outcomes.

3. The Evolution of Math and Reading Gender Gap: Some Stylized Facts

In this section, we provide fresh evidence about the evolution of the math gender gap for boys and girls during their first 8 years of education. To this end, we use Italian data from the National Institute for the Evaluation of the Education and Training System (henceforth simply indicated as INVALSI) containing results of standardized test score in reading and mathematics administered yearly to the universe of Italian pupils in several grades. Since our goal is to investigate the

[5]Among others, see Castelli et al. (2007), Taras (2005), Trost (2007), Sibley and Etnier (2003) and Trudeau and Shephard (2010). Strong et al. (2005) present results of a systematic evaluation of the evidence dealing with the effects of regular physical activity on several health and behavioral outcomes in US school-age youth, developing a recommendation for the amount of physical activity deemed to be appropriate to yield beneficial health and behavioral outcomes. In particular, they find a positive association between physical activity and low scores on scales of anxiety. Some recent research focuses on the potential effects of physical activity on trust and trustworthiness. Di Bartolomeo and Papa (2019) find that subjects exposed to physical activity exhibit more trust and pro-social behaviors than those who are not.

evolution of the math gender gap over time, we keep fixed a cohort of pupils and we report the distribution of their scores by gender in the 2nd, 5th and 8th grade. Note that in each of these grades math and reading contents are identical for all students (no options available). We use the cohort of pupils who first enrolled in 2010/2011 so we can observe them in the 2nd grade in 2011/2012, in the 5th grade in 2014/2015 and in the 8th grade in 2017/2018.

In **Figure 1**, we report the distribution of standardized math scores in each grade by gender. These figures are obtained by using for each grade more than 400,000 students. It is worth noting various insights. Firstly, males are more present in the top part of the distribution at all grades. Differences across gender in mean and standard deviation are always statistically significant.

The distributions for males and females are also statistically always different[6]. Secondly, the histograms clearly show that differences across gender are *not* constant over time, despite the fact that the same students are considered. Indeed, over the course of time boys become substantially more present at the top tail of the score distribution.

In **Figure 2**, we report the same graphs for reading standardized test scores. Also in this case the distributions change over time and, as expected, females are always more represented in top scores. The evolution of reading scores over time shows that girls become more present on the RHS of the distribution.

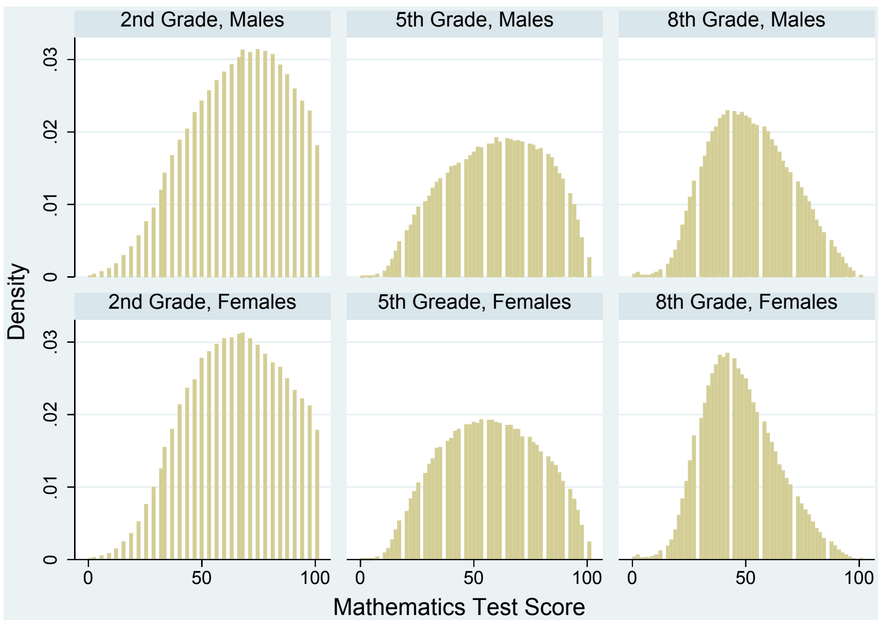

Figure 1. Distribution of standardized mathematics test score by grade and gender. Notes: INVALSI data on the cohort of students who had first enrollment in the academic year 2010-2011. Data for the 2nd, 5th and 8th grade have been collected in the academic year 2011-2012, 2014-15 and 2017-2018 respectively. The three waves involved the universe of Italian students, i.e. about 400.000 observations used in each grade.

[6]The Kolmogorov-Smirnov test always rejects equality of the distribution. Results are available from the authors.

Figure 2. Distribution of standardized reading test score by grade and gender. Notes: INVALSI data on the cohort of students who had first enrollment in the academic year 2010-2011. Data for the 2nd, 5th and 8th grade have been collected in the academic year 2011-2012, 2014-15 and 2017-2018 respectively. The three waves involved the universe of Italian students, i.e. about 400.000 observations used in each grade.

Overall, the reported evidence is important because it clearly indicates that observed gender differences in math and reading change over time. This could be caused by both biological and social factors. The target of the present study is to evaluate if a difference in involvement in sports across gender may contribute to the observed gender gap in math scores relative to those in reading. The contribution of sports to the math performance may arise through several channels, among which the role of self-confidence and competitive attitude should be stressed as well as the ability to implement strategic reasoning.

4. The Data

4.1. Data Source

The empirical analysis is based on data drawn from the Italian 2015 OECD Programme for International Student Assessment (PISA). PISA is an age-based survey, which takes place every three years, assessing competencies in Mathematics, Literacy and Science of a sample of 15-years-old students. PISA uses *Student Questionnaires* to collect information from students on various aspects of their home, family and school background, and *School Questionnaires* to collect information from schools about various aspects of organization and educational provision. In PISA (2015), 18 countries also administered a *Parent Questionnaire* to the parents of the students participating in PISA. It enquired about learning contexts, support, and resources at home as well as spending on education. The target population is defined as school students born in 1999. A minimum of 150 schools are selected in each country and, within each participating school, a predetermined number of students are randomly selected with equal probability. The target cluster size selected per school had to be of at least 20 students, in order to ensure sufficient accuracy in estimating variance components within and between schools.

In Italy, data have been collected on a sample of over 450 schools. The Italian sample was stratified by macro-geographical area and type of education (Lyceum, Technical Institutes, Vocational Institutes, Vocational Training Centres, First-level Secondary Schools). Many questionnaire items were designed to be combined in some way in order to measure latent constructs that cannot be observed directly (e.g. achievement, motivation or economic, social and cultural background). To these items, transformations or scaling procedures were applied to construct meaningful indices[7]. We, therefore, have relevant information on students' knowledge and skills (test scores) as well as their demographic, social, economic and educational background.

4.2. Descriptive Statistics

The sample consists of 11,583 students, all born in 1999 and just over half female. Given the year of birth, the target population is consequently defined as all students aged from 15 years and 3 months to 16 years and 2 months at the beginning of the assessment period. At this stage in Italy, a student must be regularly enrolled in the second year of high school (10th grade) unless he/she has been held back or red-shirted (i.e. postponed first enrollment) and therefore is in lower grades. Further, in the case of early first enrollment a student can be in the 11th grade.

Table 1 defines our variables, while **Table 2** provides some descriptive statistics. In short, most of the students are native Italian, around 16% of students attend a grade lower than 10th while approximately the 5.2% of them are in the 11th grade. About half of the students attend a Lyceum, while nearly 33% a Technical school and the remainder are in vocational schools. There is a small number of students still enrolled in lower secondary schools (0.90%), who will be excluded from our study. **Table 3** shows main statistics divided by gender. Test scores are defined as ranging from very low levels of proficiency (0) to very high levels (6). In our sample, middle levels of proficiency (from 2 to 4) are quite similar by gender, although high grades in mathematics are, as expected, more frequent for males. As indicated in **Table 2** and **Table 3**, information about sports activities is available for a subsample of 6,137 students. Physical activity is

[7]In PISA (2015), categorical items from the context questionnaires were scaled using IRT (Item Response Theory) modelling. WLEs (Weighted Likelihood Estimates) for the latent dimensions were transformed to scales with a mean of 0 and a standard deviation of 1 across OECD countries (with equally weighted countries), meaning that the average OECD student would have an index value of zero and about two-thirds of the OECD student population would be between the values of −1 and 1. It is possible to interpret these scores by comparing individual scores or group mean scores to the OECD mean. Negative values on the index for example, indicate students who responded less positively than the average student across OECD countries. Likewise, students with positive scores are those who responded more positively than the average in OECD countries.

Table 1. Variables definition.

Grade	Attended Grade	11th (early enrolees), 10th (regulars), 9th, 8th and 7th (late enrolees and students who have failed the year)
Month of birth		1st JANUARY-31st DECEMBER
Gender	Students' gender	1 if female
Failure	Grade failure	1 if student has failed the year
Nationality	Immigration status	1 if immigrant
Math	Index of performance in Mathematics	From 1—very low to 6—very high
Reading	Index of performance in Reading	From 1—very low to 6—very high
Science	Index of performance in Science	From 1—very low to 6—very high
Mother Education	Mother's education level	ISCED levels
Father Education	Father's education level	ISCED levels
Mother Occupation	Mother's occupational status	Discreate variable: 0—unemployed: 1—elementary occupations; 2—plant and machine operators; 3—clerks; 4—professionals.
Father Occupation	Father's occupational status	Discreate variable: 0—unemployed: 1—elementary occupations; 2—plant and machine operators; 3—clerks; 4—professionals.
ESCS	Index of economic, social and cultural status	Composite score built by the following indicators: parental education, highest parental occupation and home possessions.
Region	Students' school geographical localization	1—North West; 2—North East; 3—Centre; 4—South; 5—Islands.
Hours of Sport	Hours of sport performed on average during a week in the presence of a coach	Discrete variable ranging from 0 to 20.

measured in terms of extra-curricular sports in the presence of an instructor. Specifically, our variable is defined as hours of sport performed per week in the presence of a coach on top of that provided at school. Note that this specific variable measures sports performed in the presence of a professional trainer and not generic physical activity performed by students such as playing football with friends, hence it provides a measure of proper training in sports performed out of school. Henceforth, we will refer to this variable simply as hours of sport per week.

Table 4 reports information concerning family background, including parents' education and country of birth. The percentage of parents with lower secondary level of education ranges from 20% - 30%. Most of the parents are native Italian, only 10% were born abroad. About 11% of students', changed school at least once, the 20% of males and the 17% of females speak dialect at home. For each student the sample provides the index of economic, social and cultural status (henceforth, ESCS), which is a composite score built by the indicators of parental education, parental occupation and home possessions.

Table 2. Descriptive statistics—whole sample.

	Observations	%
Students	11,583	100
Gender		
Male	5791	50.00
Female	5792	50.00
Nationality		
Native	10,333	92.00
Second-Generation	373	3.32
First-Generation	526	4.68
Grade		
2nd year of lower secondary school (7th grade)	7	0.06
3rd year of lower secondary school (8th grade)	97	0.84
First year of the high school (9th grade)	1752	15.13
Second year of the high school (10th grade)	9115	78.69
Third year of the high school (11th grade)	612	5.28
Type of School		
Lyceum	5241	45.25
Technical School	3843	33.18
Vocational School	2395	20.68
Lower Secondary School	104	0.90
Grade failure		
No Failure	9713	85.73
Failure	1617	14.27
Region		
North West	2410	20.81
North East	5111	44.13
Centre	931	8.04
South	2324	20.06
South Islands	807	6.97
Hours of Sport	6137	52.98

Notes: Descriptive statistics of main variables, full dataset. PISA (2015), Italy.

Table 3. Descriptive statistics by gender.

	Male		Female	
	N.	%	N.	%
Students	5791	50.00	5792	50.00
Grade				
Second year of lower secondary school	5	0.09	2	0.03
Third year of lower secondary school	64	1.11	33	0.57
First year of the high school	1021	17.63	731	12.62
Second year of the high school	4433	76.55	4682	80.84
Third year of the high school	268	4.63	344	5.94
Type of School				
Lyceum	1991	34.38	3250	56.11
Technical School	2543	43.91	1300	22.44
Vocational School	1188	20.51	1207	20.84
Lower Secondary School	69	1.19	35	0.60
Mathematics				
0	213	3.68	313	5.40
1	696	12.02	864	14.92
2	1245	21.50	1498	25.86
3	1558	26.90	1601	27.64
4	1272	21.97	1098	18.96
5	675	11.66	365	6.30
6	132	2.28	53	0.92
Reading				
0	465	8.03	292	5.04
1	637	11.00	494	8.53
2	1526	26.35	1455	25.12
3	183	31.60	1941	33.51
4	1116	19.27	1326	22.89
5	207	3.57	270	4.66
6	10	0.17	14	0.24
Science				
0	167	2.88	218	3.76
1	799	13.80	909	15.69
2	1411	24.37	1718	29.66

Continued

3	1803	31.13	1816	31.35
4	1302	22.48	969	16.73
5	303	5.23	160	2.76
6	6	0.10	2	0.03
Hours of Sport	3072	26.52	3106	26.81

Table 4. Family background by gender.

	Males		Females	
	Freq.	**Percent**	**Freq.**	**Percent**
Mother Education				
None	26	0.46	33	0.58
ISCED 1	96	1.72	115	2.03
ISCED 2	1194	21.34	1333	23.57
ISCED 3B, C	314	5.61	373	6.60
ISCED 3A, ISCED 4	2011	35.95	2272	40.18
ISCED 5B	364	6.51	278	4.92
ISCED 5A, 6	1589	28.41	1251	22.12
Father's Education				
None	36	0.65	22	0.39
ISCED 1	134	2.41	123	2.20
ISCED 2	1385	24.95	152	27.24
ISCED 3B, C	261	4.70	297	5.32
ISCED 3A, ISCED 4	2063	37.16	2218	39.74
ISCED 5B	299	5.39	230	4.12
ISCED 5A, 6	1374	24.75	1171	20.98
School Changes				
no change	3936	81.02	4383	84.93
one change	578	11.90	563	10.91
two or more changes	344	7.08	215	4.17
Country of Birth				
Father: Italy	4969	89.35	5033	89.33
Father: Other	592	10.64	601	10.67
Mother: Italy	4885	87.34	4908	86.70
Mother: Other	708	12.66	753	13.30
Self: Italy	5238	93.09	5344	94.23
Self: Other	389	6.91	327	5.76

Continued

Language at Home				
German	221	3.92	228	4.01
Italian	3846	68.29	4087	71.83
Slovenian	30	0.53	11	0.19
Other Official Language	64	1.14	63	1.11
Dialect (ITA)	1138	20.21	1012	17.79
Other EU Language	90	1.60	59	1.04
Other Language	243	4.31	230	4.04

In **Figure 3**, we report the share of students per hours of sports performed per week, divided by gender. Almost the 30% of females do not practice any sports, while this percentage is about 23% for males. The majority of students (about 45% for males and 50% for females) practice between 1 and 5 hours per week. The rest of the sample practices at least 6 hours of sport per week including a small group who practice very intensively—20 or more hours per week—comprising 3% of the girls and 6% of the boys. The latter group is probably training to become professional athletes. This figure also shows that 52% of girls do not do any or do very little sport (1 to 2 hours per week). This percentage is, instead, 43% for boys so that a clear sport gender gap arises for Italian pupils who are aged 15.

In **Figure 4**, we plot existing correlation between hours of sports and the ESCS index. In this case our target is to assess how the family's social status affects the probability that kids are involved in sport. As expected, the figure shows a very strong and positive correlation between the two variables, implying that the higher the social status of the kids the higher their engagement in sports. It is important to note, however, that given the ESCS of the family, males appear to be much more involved in sports than females. Boys from low-ESCS families train as much as girls from high-ESCS families (around 4 hours). This may be due to the presence of gender differences in attitude to sport or to choices of parents who are less likely to involve their daughters in sports.

To further investigate this issue, in **Figure 5**, we plot the correlation between sport and mother education by gender. From this figure it appears that though mothers education is almost irrelevant in determining the level of sport activity of their sons (boys do about 4.5 hours per week irrespective of mother education), it turns out to be a crucial variable shaping the level of sport undertaken by girls. Girls whose mothers have only primary education perform about two hours of sport per week, while those whose mothers have a university degree do about four hours. This appears to be consistent with the idea that more educated mothers are more aware of the importance that physical activity may have for their daughters in terms of well-being and health.

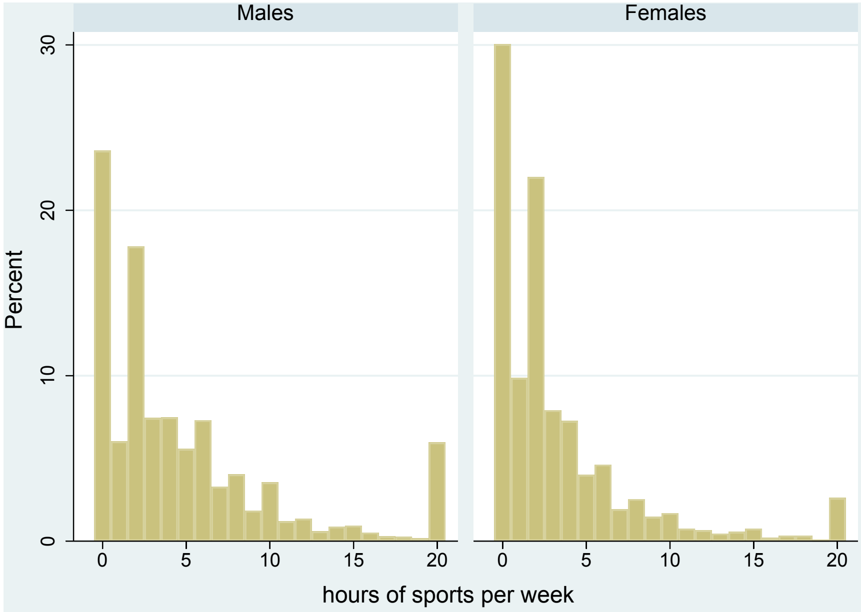

Figure 3. Percentage of students by hours of sport per week by gender. Notes: Our elaboration on PISA (2015) data.

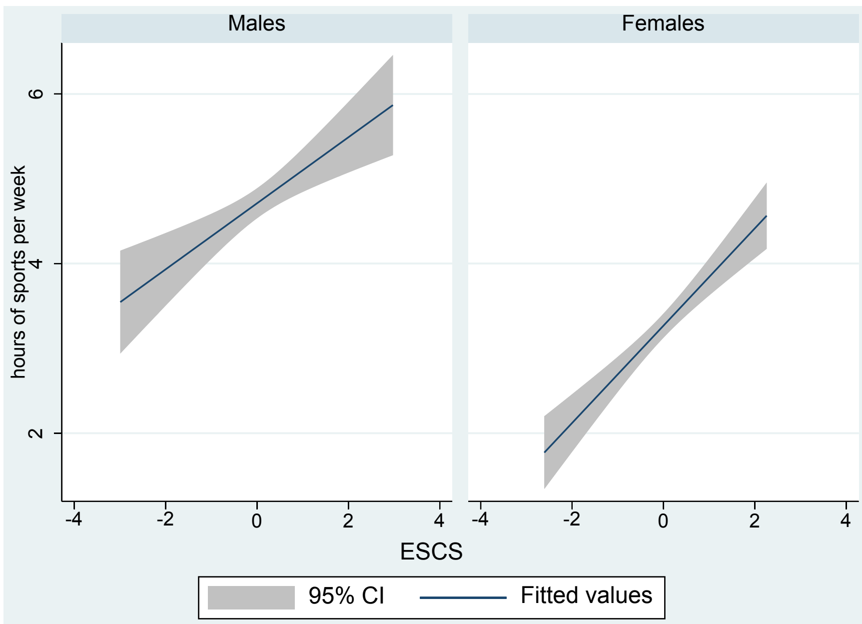

Figure 4. Hours of sport per week by family ESCS index. Notes: Our elaboration on PISA (2015) data.

Finally, in **Figures 6-8**, we focus on the correlation between test scores and sports by gender. From **Figure 6**, it appears that math scores and sports are correlated differently. While for boys their math score decreases along with the time they spend in doing sport, for girls the math performance increases along with training activity. This evidence poses a question about the fact that girls and boys are selected into sports in a very different manner. In practice, it is possible that boys heavily involved in sports are actually those with low academic ability,

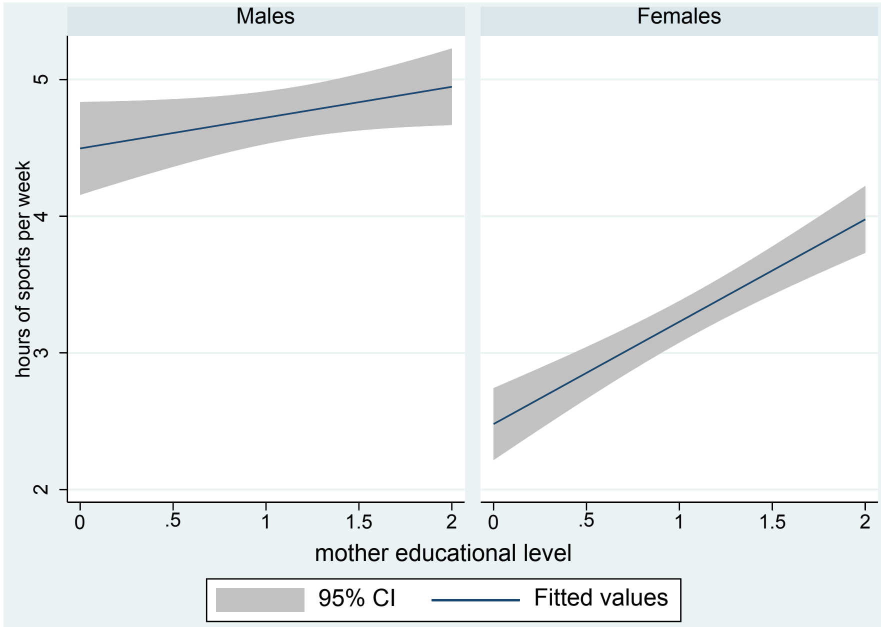

Figure 5. Hours of sport per week by mother education level. Notes: Our elaboration on PISA (2015) data.

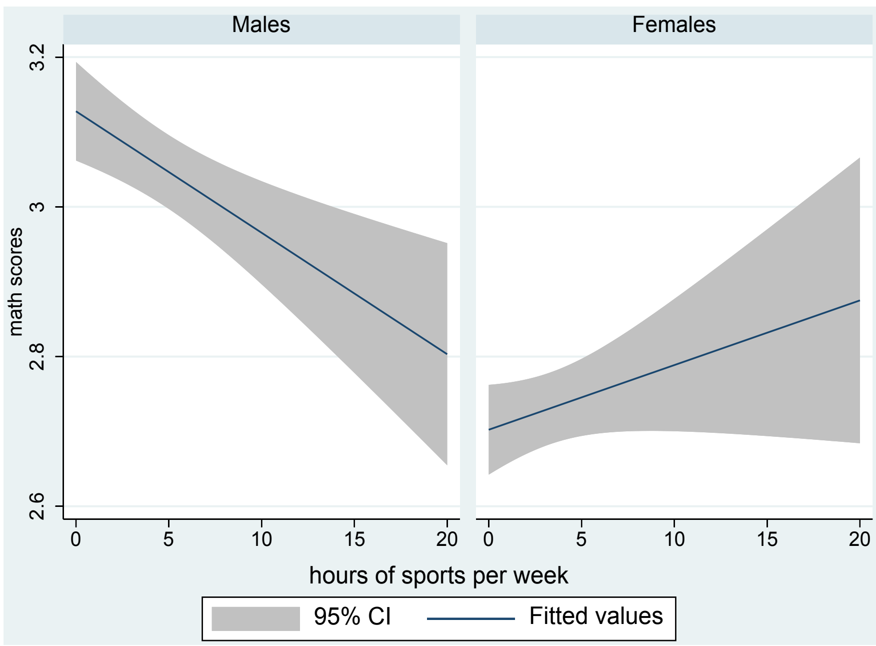

Figure 6. PISA mathematics test scores by hours of sport per week. Notes: Our elaboration on PISA (2015) data.

while girls doing intense sports may well come from privileged families so that they are also likely to be more proficient at school. However, when reading is considered (**Figure 7**), it appears that girls' scores do not improve in tandem with sport intensity while for boys the negative correlation between scores and hours of sports remains. **Figure 8** summarizes these issues by considering the math reading ratio by gender and the hours of physical activity per week. Using

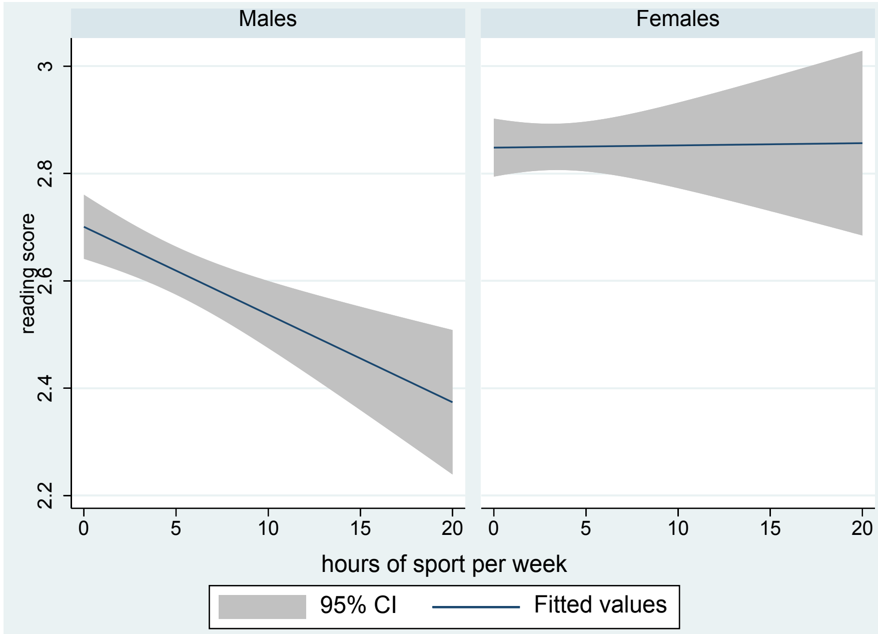

Figure 7. PISA reading test scores by hours of sport per week. Notes: Our elaboration on PISA (2015) data.

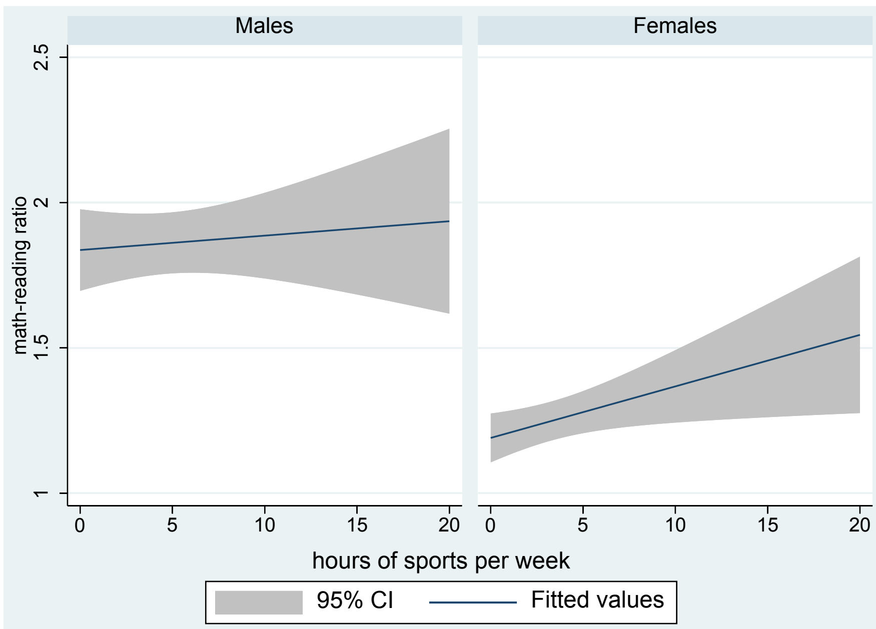

Figure 8. Math relative to reading score by hours of sport per week. Notes: Our elaboration on PISA (2015) data.

the ratio between mathematics and reading scores we keep fixed individual academic ability and look at the correlation between sport and attainment, getting rid of unobserved characteristics shaping both reading and math performance. In this case, while for boys the math-reading ratio is almost uncorrelated with the hours of sports, meaning that the time devoted to sports is negatively associated to math and reading performance alike, for girls there is an improvement in this ratio when their sport activity increases and, according to previous evidence reported in **Figure 6** and **Figure 7**, this is due to an improvement in the math score. Two mechanisms can be at the root of this. The first concerns selection. Girls selected into sport are not only those who come from privileged families but also those who perform better in mathematics than in reading. The second is the causal effect of sports which leads to an improvement in math scores for girls. The remainder of this paper sets out to untangle the latter effect.

5. Empirical Analysis

5.1. Identification Strategy: Instrumental Variables

In general, the main problem faced when evaluating the causal impact of sports on school outcomes is related to the endogenous selection into sports. In the specific case, girls with some specific unobserved characteristics may select into sports and these characteristics may also be potentially related to their school performance so that it is not possible to single out the effect of sports. In order to take into account endogeneity problems, we apply the Instrumental Variables (IV) estimation method in a setup where the main dependent variable is the math-reading ratio.

Formally, our main equation (the second-stage equation in a IV setup) is as follows:

$$MRR_i = \beta X_i + \gamma_1 Sport^{IV} + \varepsilon_i \quad (1)$$

where MRR is the math-reading ratio of girl i explained by a vector X of observed characteristics whose parameters are included in vector β. γ_1 is the parameter of main interest, i.e. the coefficient measuring the effect of sport on *MRR*. *Sport* indicates the amount of sports per week (in hours) that girl i performs in the presence of a coach, while ε_i indicates residuals. Superscript IV indicates that in Equation (1), sports is instrumented according to the following first-stage equation:

$$Sport_i = \delta X_i + \Phi_1 Mother\_Education_i + \xi_i . \quad (2)$$

In Equation (2), the amount of sport is predicted using as instrument the education level of the mother of girl i. The idea is that *ceteris paribus* the higher the educational level of the mother, the higher the probability that a girl is involved in sport. The main reason is that the higher the educational level of a mother the more informed she should be about the positive effects that sport may have in terms of health and well-being so that girls whose mothers are highly educated have more chance to be enrolled in sports. The variation of sport activities explained by mother education in Equation (2) is used to evaluate the effect of sport on the *MRR* in Equation (1). In this case, parameter γ_1 provides an unbiased estimate of the causal effect of sport on the math-reading gap conditional upon the fact that there is no correlation between the instrument *Mother_Education* and the residuals ε_i, that is:

$$corr\left(Mother\_Education, \varepsilon\right) = 0 . \quad (3)$$

This means that there must be zero correlation between the mother education and the unobserved characteristics of girl *i* that shape the dependent variable in Equation (1). With regard to this it is important to remark that—though mother education is very likely to be correlated with the unobserved' school ability' of girl *i* so that it may not represent a credible instrument in an equation whose dependent variable is test scores in either reading or mathematics, in our case the dependent variable is the *ratio* between mathematics and reading scores. In this case, even in the presence of a correlation between the educational level of the mother of girl *i* and her unobserved academic ability, under the assumption that unobserved academic ability affects both math and reading scores, in Equation (1), it cancels out so that it does not end up in residuals ε. In this case, mother education is a good instrument to predict how sports affect the math-reading ratio.

5.2. Caveats and Robustness

The identification strategy illustrated above hinges on the assumption that mother education is potentially related to the unobserved "math-ability" and "reading-ability" of their daughter in the same manner. If this is true, in Equation (1), their effect on MRR is eliminated and hence it is not included in the residuals so that they turn out to be uncorrelated with mother education.

Indeed, our instrument could not be valid if maternal education would directly influence math performance more than reading one. This may happen if more educated mothers consider the relevance of studying math for future career of their daughters or if they have stronger attitudes toward gender equality. Furthermore, they may have a growth mindset which could determine math performance. However, the issue is not clear cut. In general, world statistics do not point in this direction, since they reveal that the math-reading gender gap may be higher in wealthy families where the stereotypical idea that boys are better at math and sciences and girls are better at reading and storytelling could be more prevalent. Reardon et al. (2018), for example, show that math gaps tend to favor males more in socioeconomically advantaged U.S. school districts and this has been also reported by Rapp and Borgonovi (2019). Furthermore, Dossi et al. (2020) show that gender role norms explain the lower performance of girls in mathematics in relatively affluent white families. However, we tackle the issue and in order to show that mother education is no more relevant in determining mathematics rather than reading ability we proceed as follows.

Firstly, we replicate our IV strategy for girls by excluding from our analysis those girls whose mothers possess a STEM-related university degree and/or are involved in STEM-related professions. In this case, we end up with a sample of girls whose educated mothers have reading-related skills (law, medicine, literacy, philosophy, pedagogy and foreign languages) so that we reduce the possibility that our results depend on the fact that mother education shapes math skills more than reading.

Secondly, we make use of results in science test scores available in PISA data. We argue that if more educated mothers were to push their daughters more toward the study of STEM related subjects rather than toward the humanities, then we should detect an effect of sports also on the science-reading ratio. Conversely, no effect should arise if our assumption holds implying that more educated mothers shape the skills of their daughters equally in both domains.

Finally, we use boys to test if mother education is significantly correlated with their MRR. If our assumption is correct, we should find no correlation between mother education and the MRR of boys. On the contrary, if more educated mothers care more about mathematics than reading, then the effect on the mathematics' skills of their sons should be greater than in reading and we should detect a significant parameter linking mother education to the MRR of boys.

6. Results

6.1. A Linear Regression Model

To start our analysis, we use a sample of 1470 girls and 933 boys born in 1990 who are correctly enrolled in the 2nd year of the upper level secondary school. In this case we consider only kids enrolled at the *Lyceum* and not those enrolled at professional and technical schools in order to avoid severe selection issues as well as concerns related to the different math and reading programs covered in different schools. In practice, mother education can be related to girls' schooling choice and this may affect the math-reading ratio: girls with higher educated mothers may be those enrolled in the lyceum where math-skills are much more important than those in technical and professional schools so that our IV estimates could be upward biased by this selection mechanism. Further, we have excluded from our analysis students who had to repeat the year as well as those who started a year early since, again, we want to keep as similar as possible math and reading skills provided at school. In our robustness section, we replicate our analysis using the whole sample.

In Table 5, we begin by reporting results of a preliminary OLS regression where the impact of observables on reading and mathematics scores for boys and girls is evaluated. Standard errors are clustered at school level. Regressors include month of birth, mother and father education, father and mother occupational status, a dummy capturing immigrants of first and second generation, geographical controls and school fixed effects. The variable we are mainly interested in is the amount of sport practiced, on average, per week in the presence of a coach.

As regards the estimated parameters, our controls have the expected sign for boys and girls and for math and reading scores. In particular, students in the North of the country perform better than those located in the South and this is true for both mathematics and reading. Month of birth is not associated with different scores and this was also to be expected since the effect of age on schooling results often detected at primary school level (see Ordine et al., 2018

Table 5. OLS estimates of the impact of hours of sport per week on mathematics and reading test scores by gender.

	Column I Females Math (OLS)	Column II Females Reading (OLS)	Column III Males Math (OLS)	Column IV Males Reading (OLS)
Hours of Sport	0.007 (0.290)	−0.001 (0.926)	−0.016** (0.031)	−0.013** (0.043)
Mother Education	0.176*** (0.000)	0.127*** (0.000)	−0.071 (0.276)	−0.060 (0.244)
Father Education	−0.015 (0.795)	−0.020 (0.648)	0.116* (0.063)	0.010 (0.835)
Mother Occupation	0.075** (0.025)	0.090** (0.024)	0.040 (0.393)	0.042 (0.284)
Father Occupation	0.128*** (0.001)	0.060*** (0.003)	0.087* (0.100)	0.111** (0.012)
Month of Birth	−0.004 (0.609)	−0.001 (0.801)	−0.011 (0.368)	0.007 (0.488)
Nationality	−0.146 (0.188)	−0.015* (0.098)	−0.138 (0.171)	−0.276** (0.019)
Region	−0.306*** (0.000)	−0.203*** (0.000)	−0.294*** (0.000)	−0.234*** (0.000)
Observations	1470	1470	933	933

Notes: OLS estimates, robust *p*-value in parenthesis, standard errors clustered at school level. In Columns I and III, the dependent variable is PISA math test score, in Columns II and IV, the dependent variable is Pisa reading test score. Variables defined in Table 1. Statistical significance: *** 1% level, ** 5% level, * 10% level.

for the Italian case) fades away as children become older. Finally, first and second generation immigrants do not record lower scores than natives in mathematics, while male immigrants do worse than natives only in reading scores. Interestingly, father occupation is always positively correlated with scores in reading and in math and it is statistically significant for both genders and this is consistent with an interpretation that kids from high-income families perform better at school. Instead, father education seems to be correlated only with boys' math results of boys, while it does not shape reading scores nor those of girls in either math or reading. This evidence may be related to the fact that more educated fathers tend to have greater concern for their sons' math performance than their daughters'. Conversely, despite the fact that mothers' education and occupation affect neither the math nor the reading performance of their sons, they do shape the overall performance of their daughters, and this may be due to a sort of gender-specific-care exerted by educated parents toward their children's education. As far as sport is concerned, the school performance of females does not appear to be affected by sport, and this may stem from the fact that the majority of girls in our sample do very little sport or don't do any sport or none at all, whereas estimates for boys confirm the negative association between hours of sports and school performance.

In Table 6, we turn our attention to the score in math vis-a-vis that in reading (MRR). In this case, since the dependent variable is the ratio between the two scores, residuals in this equation should not include unobserved characteristics of individuals since both are likely to be similarly affected by unobservables. For boys, the main result is that, as expected, the explanatory variables are not

Table 6. OLS estimates of the impact of hours of sport per week on the mathematics-reading ratio (MRR) by gender.

	Column I Females MMR (OLS)	Column II Males MRR (OLS)
Hours of Sport	0.002* (0.100)	0.001 (0.981)
Mother Education	0.019* (0.075)	0.011 (0.556)
Father Education	0.002 (0.852)	0.038* (0.090)
Mother Occupation	−0.005 (0.485)	−0.007 (0.640)
Father Occupation	0.010 (0.306)	−0.020 (0.207)
Month of Birth	−0.001 (0.749)	0.001 (0.931)
Nationality	0.001 (0.955)	0.106** (0.049)
Region	−0.035*** (0.000)	−0.002 (0.852)
Observations	1470	933

Notes: OLS estimates, robust *p*-value in parenthesis, standard errors clustered at school level. In Column I and II the dependent variable is the PISA math test score relative to the reading score. Statistical significance: *** 1% level, ** 5% level, * 10% level.

significantly correlated with the MRR since their effect on the two test scores is statistically identical. The only exception is for immigrants who tend to have a lower reading score than in the math so they have a higher MRR compared to natives. For girls, once again regressors are not significantly correlated with the MRR at 5% level. Only regional controls highlight that girls from the South have lower math scores than their reading ones. In the light of the fact that this is not reported for boys, this result is of interest since it poses a question about the social factors that may be at root of the math gender gap.

Father and mother education as well as their occupational status are not differently associated with math and reading scores and this strongly supports our assumption that the family background is likely to influence kids' schooling ability in mathematics and reading fields homogeneously. Finally, sport does not seem to significantly affect the MRR for either gender. However, also in this case, the detected parameters are likely to suffer from selection-bias, that is, if students involved in sports are those with low math performance, then our estimated parameters is biased toward zero even in the presence of a positive effect of sport on the MRR.

6.2. Instrumental Variables

In Table 7, we present results from the two-stage IV procedure estimating the causal effect of sports on the math performance relative to the reading one for girls enrolled at the Lyceum. Table 7(a) in this table reports main first-stage results, i.e. the effect of the instrument (mother education) on the hours of sport, the

Table 7. IV-2SLS estimates of the impact of hours of sport per week on the mathematics-reading ratio for girls.

(a)

First-Stage Statistics **Dependent Variable:** Hours of sport		
F-statistics: 9.45	Durbin-Wu-Hausman test: 4.95 *p*-value 0.042 Null hypothesis: regressor is exogenous	
Instrument	Coefficient	*p*-value
Mother Education	0.790***	0.000

(b)

Second-Stage Estimates **Dependent Variable:** math-reading ratio		
Ind. Variables	Coeff.	*p*-value
Hours of Sport (IV)	0.028**	0.047
Father Education	0.001	0.962
Father Occupation	0.001	0.940
Mother Occupation	−0.002	0.750
Month of Birth	0.001	0.968
Nationality	0.003	0.906
Region	−0.038***	0.000
Observations	1478	

F-statistics and the Durbin-Wu-Hausman test for endogeneity are presented. In this respect, we find a positive and significant parameter showing that more educated mothers encourage their daughters to do more sport. As afore mentioned, several reasons can be at the root of this among which the fact that they are more informed about the considerable health benefits of physical activity—provided that they can also afford the expense. It is worth mentioning that the instrument is not "weak" since all the F-statistics is are very close to the rule of thumb value of 10 (Staiger & Stock, 1997). Finally, the Durbin-Wu-Hausman test suggests that there exists some endogeneity bias driven by the hours of sports variable, so it is appropriate to treat this regressor as endogenous.

Turning our attention to the second stage estimates (**Table 7(b)**), we detect a positive and statistically significant parameter (0.028 *p*-value 0.047) linking hours of sports to the math relative to the reading score. This evidence supports the view that girls may receive a substantial contribution from doing sports in terms of competitive attitude and ability to implement logical and strategic reasoning under pressure. Given that during their childhood, girls are usually much more "helicoptered" by their parents who do not let them go out of the house and play on the road with their friends, it is possible that being involved into sports makes up for the lack of this type of social interaction so that sport represents a channel through which girls actually learn to compete and develop their ability to make logical connections under pressure.

At this stage, it must be reckoned that the causal interpretation of this result crucially hinges on the assumption that mother education is uncorrelated with the residuals of the second stage regression which means that, despite the possibility of determining unobserved factors shaping both math and reading scores, it should be uncorrelated with the ratio between the two tests. In the following section, we implement a series of econometric exercises to provide evidence in support of this assumption.

6.3. Robustness

6.3.1. Excluding Girls with STEM-Mothers

We shall start our robustness analysis by presenting the results of the IV model discussed above obtained after having excluded, from the analysis, girls whose mothers have a STEM degree and/or work in math- and science-related professions. To identify these professions we use the 6-digit ISCED classification provided in the data set, so that we can identify precisely the mother's type of job and can exclude girls whose mothers are likely to encourage the study of math rather than that of reading. In this way, we are left with a sample of girls whose higher educated mothers are involved in professions related to law, the humanities, pharmacy, medicine, in order to reduce the possibility that girls more involved in sports are also those who are more oriented toward math by their mothers. This is particularly true if we consider the evidence on the inter-generational transmission of professions (among others see Aina & Nicoletti, 2018) so that by excluding girls with STEM mothers we are likely to capture girls who are more drawn to reading than to math. In **Table 8**, we report the results obtained from 1149 observations. Interestingly, mother education remains a good instrument and, most importantly, the effect of sport on the math-reading ratio is statistically significant with a point estimate of 0.023.

6.3.2. A Glance at Science Test Score

As a second exercise, we use information about girls' test score in the science domain. Basically, we replicate the IV procedure implemented above but, instead of looking at the math-reading ratio, we use, as dependent variable, the science-reading ratio. The *rationale* for this is that, since the science test in the 10^{th} grade is only based on knowledge related to natural and biological science, difficulties in the test score are not related to math skills. If more educated mothers were to push their daughters toward the STEM-preparatory disciplines (which covers both math and science), we should actually detect a significant effect of (instrumented) sports on the science-reading ratio as well. This would be caused by the correlation of the used instrument with some unobserved individual characteristics which induce a better performance in science than in reading. Conversely, if our strategy is correct we should not find any statistical effect of sports on the science-reading ratio. In Column (I) of **Table 9**, we report

Table 8. IV-2SLS estimates of the impact of hours of sport per week on the mathematics-reading ratio (MRR) for girls: only girls with no-STEM mothers.

(a)

First-Stage Statistics **Dependent Variable:** Hours of sport		
F-statistics: 8.95	Durbin-Wu-Hausman test: 4.45 *p*-value 0.048 Null hypothesis: regressor is exogenous	
Instrument	Coefficient	*p*-value
Mother Education	0.930***	0.000

(b)

Second-Stage Estimates **Dependent Variable:** math-reading ratio		
Ind. Variables	Coeff.	*p*-value
Hours of Sport (IV)	0.023**	0.031
Father Education	0.001	0.962
Father Occupation	0.001	0.940
Mother Occupation	−0.002	0.750
Month of Birth	0.001	0.968
Nationality	0.003	0.900
Region	−0.033***	0.000
Observations	1149	

Table 9. IV-2SLS estimates of the impact of hours of sport per week on science-reading and math-science ratio for girls.

	Column I	Column II
	Dep. Variable: science-reading ratio	Dep. Variable: math-science ratio
Ind. Variables	Coeff.	Coeff.
Hours of Sport (IV)	0.001 (0.739)	0.030** (0.046)
Father Education	0.001 (0.986)	0.001 (0.988)
Father Occupation	0.001 (0.776)	0.001 (0.878)
Mother Occupation	−0.002 (0.544)	−0.001 (0.229)
Month of Birth	0.001 (0.998)	0.001 (0.812)
Nationality	0.003 (0.879)	0.002 (0.656)
Region	−0.008 (0.765)	−0.028*** (0.000)
Observations	1478	1478

Notes: In Column I and Column II, second stage estimates reported. Hours of sport instrumented with Mother education as in Table 7(a). In Column (I), the dependent variable is the science-reading ratio. In Column (II), the dependent variable in the math-science ratio. Robust *p*-values in parenthesis. *, ** and *** indicates 10%, 5% and 1% statistical significance respectively.

our second-stage results. We do not detect a significant effect of sports on the science-reading gap and this supports our main identification assumption. Further, in Column (II), we report the IV results of a second-stage equation where the math-science ratio is considered. Interestingly, in this case the point estimate is statistically significant at 5% and slightly higher than that found when considering the math-reading ratio and, again, this is consistent with a positive effect of sports on math scores while it appears to be at odds with the hypothesis that more educated mothers encourage daughters to study specifically STEM-related disciplines.

6.3.3. Using Boys to Construct a Falsification Test

Our third exercise makes use of boys to construct a falsification test. The idea is that, if IV estimates presented in Table 7 are biased by the fact that more educated mothers tend to favor the study of mathematics over that of reading, we should find evidence of this effect also for boys. Hence, we re-estimate our main IV model on boys in our sample enrolled at the Lyceum using as instrument mother education to predict sport activity. The idea is that, given that during their childhood boys are much more involved in out-of-the-home activities than girls, we do not expect to find any direct impact of sports on the MRR so that, whenever we detect a statistically significant effect, this should be interpreted as a warning about our main identification assumption. We also replicate our study by using father education as an instrument. In Table 10, we report the results. Column (I) considers mother education as the instrument for sports activity while Column (II) uses father education. Interestingly, as far as the first stage is concerned, it turns out that neither mother nor father education is good instruments to predict boys' level of commitment to sport. In both cases, sports is not a relevant factor in shaping the math performance of boys relative to that in reading.

6.3.4. IV Using the Whole Sample

As a final test, we present the results of our main IV strategy implemented on the whole sample, i.e. on girls from all schools (Lyceum, Professional and Technical schools) in our data set. As already discussed, we do not consider this as a first-best strategy since some possible sample-selection issue may undermine the reliability of the results. In practice, mother education can be related to girls' schooling choice and this may affect the math-reading ratio: girls with higher educated mothers may be those enrolled in the lyceum where math-skills are much more important than in technical and professional schools so that IV estimates could be upward biased by such a mechanism. Notwithstanding this, it is useful to run the regression on top of that highlighted in Section 6.2, since we can thereby check if our main result still holds after having considerably modified the sample size.

Results are presented in Columns (I) and (II) of Table 11. Column (I) considers all girls, while Column (II) excludes girls whose mothers work in STEM professions and/or have a STEM university degree. In both cases, a regressor

Table 10. IV-2SLS estimates of the impact of hours of sport per week on the math-reading ratio for boys.

	1st Stage Results	
	Column I Instrument: Mother education	Column II Instrument: Father education
	Coeff.	Coeff.
Instrument	0.013 (0.564)	0.244 (0.110)
	2nd Stage Results	
	Dep. Variable: math-reading ratio	Dep. Variable: math-reading ratio
Ind. Variables	Coeff.	Coeff.
Hours of Sport (IV)	0.001 (0.876)	0.004 (0.132)
Mother Education		0.001 (0.988)
Father Education	0.001 (0.776)	
Father Occupation	−0.012 (0.234)	−0.041 (0.229)
Mother Occupation	0.021 (0.698)	0.011 (0.432)
Month of Birth	0.013 (0.999)	0.022 (0.444)
Nationality	0.012*** (0.010)	0.028*** (0.000)
Region	−0.022 (0.020)	−0.014 (0.020)
Observations	933	933

Notes: Only boys from Lyceum considered. In Column I, the instrument for hours of sport is mother education, in Column II, the instrument is father education. In all columns, the 2nd stage dependent variable in the math-reading ratio. Robust *p*-values in parenthesis. *, ** and *** indicates 10%, 5% and 1% statistical significance respectively.

Table 11. IV-2SLS estimates of the impact of hours of sport per week on the mathematics-reading ratio of girls: whole sample.

(a)

First-Stage Statistics. **Dependent Variable:** Hours of sport		
Column I F-statistics: 10.81 Durbin-Wu-Hausman test: 6.11 *p*-value 0.034 Null hypothesis: regressor is exogenous		Column II F-statistics: 11.45 Durbin-Wu-Hausman test: 6.95 *p*-value 0.023 Null hypothesis: regressor is exogenous
Instrument	Coefficient	Coefficient
Mother Education	0.880*** (0.000)	0.672*** (0.000)

(b)

Second-Stage Estimates. Dependent Variable: math-reading ratio		
Ind. Variables	Coeff.	Coeff.
Hours of Sport (IV)	0.031** (0.025)	0.035** (0.041)
Father Education	0.001 (0.987)	0.001 (0.966)
Father Occupation	0.001 (0.943)	0.001 (0.988)
Mother Occupation	−0.002 (0.327)	−0.011 (0.614)
Month of Birth	0.001 (0.998)	0.001 (0.999)
Nationality	0.006 (0.712)	0.001 (0.772)
Region	−0.028*** (0.000)	−0.032*** (0.000)
High School Type	−0.013** (0.032)	−0.011** (0.039)
Observations.	2834	2230

Notes: In Column (I), all girls in our sample considered, in Column (II), girls whose mothers have a STEM degree and/or are involved in STEM occupations have been excluded. In all cases, mother education is the instrument for hours of sport.

controlling for high-school type has been added to the previous specification. The results go in the expected direction, confirming that mother education is a good predictor of the level of sport performed by girls. Further, sports improve the math performance of girls relative to that in reading highlighting a positive co-efficient of 3.1% and 3.5% in Columns (I) and (II) respectively. Both coefficients are larger than that estimated in Table 7, and this is consistent with our expectation about the upward bias of the IV coefficient estimated on the whole sample.

7. Conclusion

Using PISA (2015) data on students enrolled in the 10th grade in the Italian school system, we evaluate if sports may have a role in improving the math skills of girls relative to their reading ones. Problems related to endogenous selection into sports are handled by applying an IV strategy in a setup where the main dependent variable is the math-reading ratio, and the coefficient of interest is the one associated with the variable which indicates the amount of hours of sport per week performed in the presence of a coach. A valid instrument to predict involvement in sport is found in the level of education of the mother since—all else being equal—the higher the educational level of the mother the more informed she should be about the positive effects that sports may have in terms of health and well-being. The use of the math-reading ratio in test scores as a dependent variable allows us to get rid of the effects of unobservables that may relate mothers' characteristics to the academic ability of their daughters. We find that involvement in sports improves girls' math scores relative to their reading ones. The causal interpretation of this result is supported by several robustness exercises.

Our results contribute to previous literature in several ways. Firstly, we show that at least a part of the observed gender gap in math scores may be related to differences in experience and exposure to out-of-the-home social life. Secondly, since sport by its nature generally involves more than an element of competition, our results are also consistent with the "willingness to compete" argument on the math gender gap. In general, our findings reflect the idea that—since girls are much more likely to be helicoptered by their parents and expected to lead to a more protected life centred around the home—involvement in sports may improve their ability to make logical connections under pressure as well as help channel their competitiveness, thereby increasing their STEM-readiness and of the chance of entering STEM majors and high-wage occupations where a math background is essential. In terms of policy, we conclude by drawing attention to the positive consequences that incentives to participate in sports for young girls may have not only in terms of health-related issues but also in terms of math performance and STEM readiness.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Aina, C., & Nicoletti, C. (2018). The Intergenerational Transmission of Liberal Professions. *Labour Economics, 51,* 108-120. https://doi.org/10.1016/j.labeco.2017.12.003

Almas, I., Cappelen, A. W., Salvanes, K. G., Sørensen, E. O., & Tungodden, B. (2016). Willingness to Compete: Family Matters. *Management Science, 62,* 2149-2162. https://doi.org/10.1287/mnsc.2015.2244

Apriliyanto, B., Saputro, D., & Riyadi, R. (2018). Student's Social Interaction in Mathematics Learning. *Journal of Physics: Conference Series, 983,* Article ID: 012130. https://doi.org/10.1088/1742-6596/983/1/012130

Benbow, C. P., & Stanley, J. C. (1980). Sex Differences in Mathematical Ability: Fact or Artifact? *Science, 210,* 1262-1264. https://doi.org/10.1126/science.7434028

Bian, L., Leslie, S. J., & Cimpian, A. (2017). Gender Stereotypes about Intellectual Ability Emerge Early and Influence Children's Interests. *Science, 355,* 389-391. https://doi.org/10.1126/science.aah6524

Budde, H., Voelcker-Rehage, C., Pietraßyk-Kendziorra, S., Ribeiro, P., & Tidow, G. (2008). Acute Coordinative Exercise Improves Attentional Performance in Adolescents. *Neuroscience Letters, 441,* 219-223. https://doi.org/10.1016/j.neulet.2008.06.024

Buser, T., Niederle, M., & Oosterbeek, H. (2014). Gender, Competitiveness, and Career Choices. *The Quarterly Journal of Economics, 129,* 1409-1447. https://doi.org/10.1093/qje/qju009

Card, D., & Payne, A. (2021). High School Choices and the Gender Gap in STEM. *Economic Inquiry, 59,* 9-28. https://doi.org/10.1111/ecin.12934

Carlana, M., & Corno, L. (2021). *Parents and Peers: Gender Stereotypes in the Field of Study.* CEPR Discussion Papers No. 16582.

Castelli, D. M., Hillman, C. H., Buck, S. M., & Erwin, H. E. (2007). Physical Fitness and Academic Achievement in Third- and Fifth-Grade Students. *Journal of Sport and Exercise Psychology, 29,* 239-252. https://doi.org/10.1123/jsep.29.2.239

Cheng, A., Kopotic, K., & Zamarro, G. (2017). *Can Parents' Growth Mindset and Role Modelling Address STEM Gender Gaps?* EDRE Working Paper No. 2017-07. https://doi.org/10.2139/ssrn.2920623

Contini, D., Di Tommaso, M. L., & Mendolia, S. (2017). The Gender Gap in Mathematics Achievement: Evidence from Italian Data. *Economics of Education Review, 58,* 32-42. https://doi.org/10.1016/j.econedurev.2017.03.001

Darling, N., Caldwell, L. L., & Smith, R. (2005). Participation in School-Based Extracurricular Activities and Adolescent Adjustment. *Journal of Leisure Research, 37,* 51-76. https://doi.org/10.1080/00222216.2005.11950040

Deming, D., & Noray, K. (2020). Earnings Dynamics, Changing Job Skills, and STEM Careers. *Quarterly Journal of Economics, 135,* 1965-2005. https://doi.org/10.1093/qje/qjaa021

Di Bartolomeo, G., & Papa, S. (2019). The Effects of Physical Activity on Social Interactions: The Case of Trust and Trustworthiness. *Journal of Sports Economics, 20,* 50-71. https://doi.org/10.1177/1527002517717299

Di Tommaso, M. L., Contini, D., De Rosa, D., Ferrara, F., Piazzalunga, D., & Robutti, O. (2021). *Tackling the Gender Gap in Math with Active Learning Methodologies.* IZA Discussion Paper No. 14572. https://doi.org/10.2139/ssrn.3892600

Dossi, G., Figlio, D., Giuliano, P., & Sapienza, P. (2021). Born in the Family: Preferences for Boys and the Gender Gap in Math. *Journal of Economic Behavior & Organization, 183,* 175-188. https://doi.org/10.1016/j.jebo.2020.12.012

Eccles, J. S., & Barber, B. L. (1999). Student Council, Volunteering, Basketball, or Marching Band: What Kind of Extracurricular Involvement Matters? *Journal of Adolescent Research, 14,* 10-43. https://doi.org/10.1177/0743558499141003

Eitle, T. M., & Eitle, D. J. (2002). Race, Cultural Capital, and the Educational Effects of Participation in Sports. *Sociology of Education, 75,* 123-146. https://doi.org/10.2307/3090288

Entwisle, D. R., Alexander, K. L., & Olson, L. S. (1994). The Gender Gap in Math: Its Possible Origins in Neighborhood Effects. *American Sociological Review, 59,* 822-838. https://doi.org/10.2307/2096370

Ericsson, I. (2008). Motor Skills, Attention and Academic Achievements. An Intervention Study in School Years 1-3. *British Educational Research Journal, 34,* 301-313. https://doi.org/10.1080/01411920701609299

Goldin, C. (2006). The Quiet Revolution that Transformed Women's Employment, Education, and Family. *American Economic Review, 96,* 1-21. https://doi.org/10.1257/000282806777212350

Gorry, D. (2016). Heterogenous Effects of Sports Participation on Education and Labor Market Outcomes. *Education Economics, 24,* 622-638. https://doi.org/10.1080/09645292.2016.1143452

Hedges, L. V., & Nowell, A. (1995). Sex Differences in Mental Test Scores, Variability, and Numbers of High-Scoring Individuals. *Science, 269,* 41-45. https://doi.org/10.1126/science.7604277

Hood, A. B., Craig, A. F., & Ferguson, B. W. (1992). The Impact of Athletics, Part-Time Employment, and Other Activities on Academic Achievement. *Journal of College Student Development, 33,* 447-453.

Insler, M. A., & Karam, J. (2019). Do Sports Crowd out Books? The Impact of Intercollegiate Athletic Participation on Grades. *Journal of Sports Economics, 20,* 115-153. https://doi.org/10.1177/1527002517716975

Kamas, L., & Preston, A. (2012). The Importance of Being Confident; Gender, Career Choice, and Willingness to Compete. *Journal of Economic Behavior & Organization, 83,* 82-97. https://doi.org/10.1016/j.jebo.2011.06.013

Kinsler, J., & Pavan, R. (2015). The Specificity of General Human Capital: Evidence from College Major Choice. *Journal of Labor Economics, 33,* 933-972. https://doi.org/10.1086/681206

Kirkeboen, L., Leuven, E., & Mogstad, M. (2016). Field of Study, Earnings, and Self-Selection. *The Quarterly Journal of Economics, 131,* 1057-1111. https://doi.org/10.1093/qje/qjw019

Marsh, H., & Kleitman, S. (2002). Extracurricular School Activities: The Good, the Bad, and the Nonlinear. *Harvard Educational Review, 72,* 464-515. https://doi.org/10.17763/haer.72.4.051388703v7v7736

McGuire, L., Mulvey, K. L., Goff, E., Irvin, M. J., Winterbottom, M., Fields, G. E., Harston-Rose, A., & Rutland, A. (2020). STEM Gender Stereotypes from Early Childhood through Adolescence at Informal Science Centers. *Journal of Applied Developmental Psychology, 67,* Article ID: 101109. https://doi.org/10.1016/j.appdev.2020.101109

Meroni, E. C., Piazzalunga, D., & Pronzato, C. (2021). Allocation of Time and Child Socio-Emotional Skills. *Review of Economics of the Household,* 1-38. https://doi.org/10.1007/s11150-021-09580-9

Miller, P. S., & Kerr, G. (2002). The Athletic, Academic and Social Experiences of Intercollegiate Student Athletes. *Journal of Sport Behavior, 25,* 346-367.

Niederle, M., & Vesterlund, L. (2010). Explaining the Gender Gap in Math Test Scores: The Role of Competition. *Journal of Economic Perspectives, 24,* 129-144. https://doi.org/10.1257/jep.24.2.129

Ordine, P., Rose, G., & Sposato, D. (2018). Parents Know Them Better: The Effect of Optional Early Entry on Schooling Attainment. *Economic Inquiry, 56,* 1678-1705. https://doi.org/10.1111/ecin.12568

Otto, L. B., & Alwin, D. F. (1977). Athletics, Aspirations, and Attainments. *Sociology of Education, 50,* 102-113. https://doi.org/10.2307/2112373

Pfeifer, C., & Cornelißen, T. (2010). The Impact of Participation in Sports on Educational Attainment—New Evidence from Germany. *Economics of Education Review, 29,* 94-103. https://doi.org/10.1016/j.econedurev.2009.04.002

PISA (2015). Programme for International Student Assessement. Volume I, Excellence and Equity in Education, OECD.

Rapp, J., & Borgonovi, F. (2019). Gender Gap in Mathematics and Reading: A Within-Student Perspective. *Journal of Supranational Policies of Education, No. 9,* 6-56. https://doi.org/10.15366/jospoe2019.9.001

Reardon, S. F., Fahle, E. M., Kalogrides, D., Podolsky, A., & Zarate, R. C. (2018). *Gender Achievement Gaps in U.S. School Districts.* Center for Education Policy Analysis, Stanford University.

Rees, D. I., & Sabia, J. J. (2010). Sports Participation and Academic Performance: Evidence from the National Longitudinal Study of Adolescent Health. *Economics of Education Review, 29,* 751-759. https://doi.org/10.1016/j.econedurev.2010.04.008

Sibley, B. A., & Etnier, J. L. (2003). The Relationship between Physical Activity and Cognition in Children: A Meta-Analysis. *Pediatric Exercise Science, 15,* 243-256.

https://doi.org/10.1123/pes.15.3.243

Silliker, S. A., & Quirk, J. T. (1997). The Effect of Extracurricular Activity Participation on the Academic Performance of Male and Female High School Students. *The School Counselor, 44,* 288-293.

Staiger, D., & Stock, J. H. (1997). Instrumental Variable Regression with Weak Instruments. *Econometrica, 65,* 557-586. https://doi.org/10.2307/2171753

Stoet, G., & Geary D. C. (2013). Sex Differences in Mathematics and Reading Achievement Are Inversely Related: Within- and Across-Nation Assessment of 10 Years of PISA Data. *PLOS ONE, 8,* e57988. https://doi.org/10.1371/journal.pone.0057988

Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., & Rowland, T. (2005). Evidence Based Physical Activity for School-Age Youth. *The Journal of Pediatrics, 146,* 732-737. https://doi.org/10.1016/j.jpeds.2005.01.055

Taras, H. (2005). Physical Activity and Student Performance at School. *Journal of School Health, 75,* 214-218. https://doi.org/10.1111/j.1746-1561.2005.00026.x

Trost, S. G. (2007). State of the Art Reviews: Measurement of Physical Activity in Children and Adolescents. *American Journal of Lifestyle Medicine, 1,* 299-314. https://doi.org/10.1177/1559827607301686

Trudeau, F., & Shephard, R. J. (2010). Relationships of Physical Activity to Brain Health and the Academic Performance of Schoolchildren. *American Journal of Lifestyle Medicine, 4,* 138-150. https://doi.org/10.1177/1559827609351133