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Does single-sex schooling improve students' physical fitness?: Evidence from a natural experiment in South Korea

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ABSTRACT

Leveraging a randomized natural experiment, this study examines the impact of attending single-sex middle schools on students' physical fitness, measured through standardized nationwide physical tests. In South Korea, middle school students are assigned by lottery to either single-sex or coeducational schools within their designated school zones, providing an ideal setting to evaluate the effects of single-sex schooling. Using school-level data covering all middle schools, the study finds that boys attending single-sex schools achieve significantly higher pass rates on standardized physical fitness tests, suggesting improved physical fitness compared to their peers in coeducational schools. However, no similar improvement is observed for girls attending single-sex schools. These findings suggest that single-sex schooling has differential effects by gender, highlighting the need to further research to understand the mechanisms underlying these varied outcomes.

1. Introduction

Implementing effective educational strategies within school settings has long been a priority for educators and policymakers, given the broad and enduring impacts on students' cognitive skills, (Crowe et al., 2013; Falch and Sandgren Massih, 2011), social development (Phillips et al., 1987), and long-term benefits such as higher educational attainment, labor productivity, and future earnings (Schoellman, 2012; Hanushek and Kimko, 2000; Chetty et al., 2014; Card and Krueger, 1992; Dearden et al., 2002; Altonji and Dunn, 1996).

Previous studies on single-sex schooling have predominantly focused on academic outcomes, showing mixed results (Booth and Yamamura, 2018; Harker, 2000; Mael et al., 2005; Sullivan et al., 2010; Lee et al., 2014; Doris et al., 2013). Recent work highlights asymmetric labor market impacts, benefiting males but disadvantaging females (Lee and Nakazawa, 2022). Beyond academics, some studies have explored the effects of single-sex schooling on non-academic outcomes such as occupational choice, fertility, marriage, extracurricular participation, and gender identity formation (Baron-Cohen, 2005; Cardona and Kaufmann, 2017; Hahn and Wang, 2019; Wong et al., 2018). On health, Kim & Kim (2022) documented positive mental health effects for girls in single-sex middle schools, while S.-K. Kim & Kim (2024) reported lower risks of underweight, unhealthy weight loss behaviors, and increased weight among these students (Choi et al., 2015).

Despite extensive literature, the impact of single-sex schooling on physical fitness remains under-explored. Physical fitness, a strong marker of health (Ortega et al., 2008), is closely linked to cognitive function, academic performance (Santana et al., 2017; Bass et al., 2013; Van Dusen et al., 2011; Haverkamp et al., 2021), and mental health and well-being (Cadenas-Sanchez et al., 2021; Åvitsland et al., 2020). To address this gap, our study investigates the impact of single-sex schooling on physical fitness, measured by national physical test, providing a comprehensive view of the effects of single-sex education on students' overall development. Our paper also contributes to the growing body of literature on the impact of peer gender composition in male-dominated educational fields.

2. Schooling system in South Korea

The compulsory education period in South Korea is nine years, including six years of elementary school and three years of middle school. After completing elementary school, all students move on to middle school, where school assignments depend on school districts in which they live.

Before the 1974 equalization policy, middle schools admitted students based on entrance exam scores, which exacerbated educational disparities. To address this, the policy divided areas into equalized and non-equalized areas. Equalized areas, primarily urban regions with high

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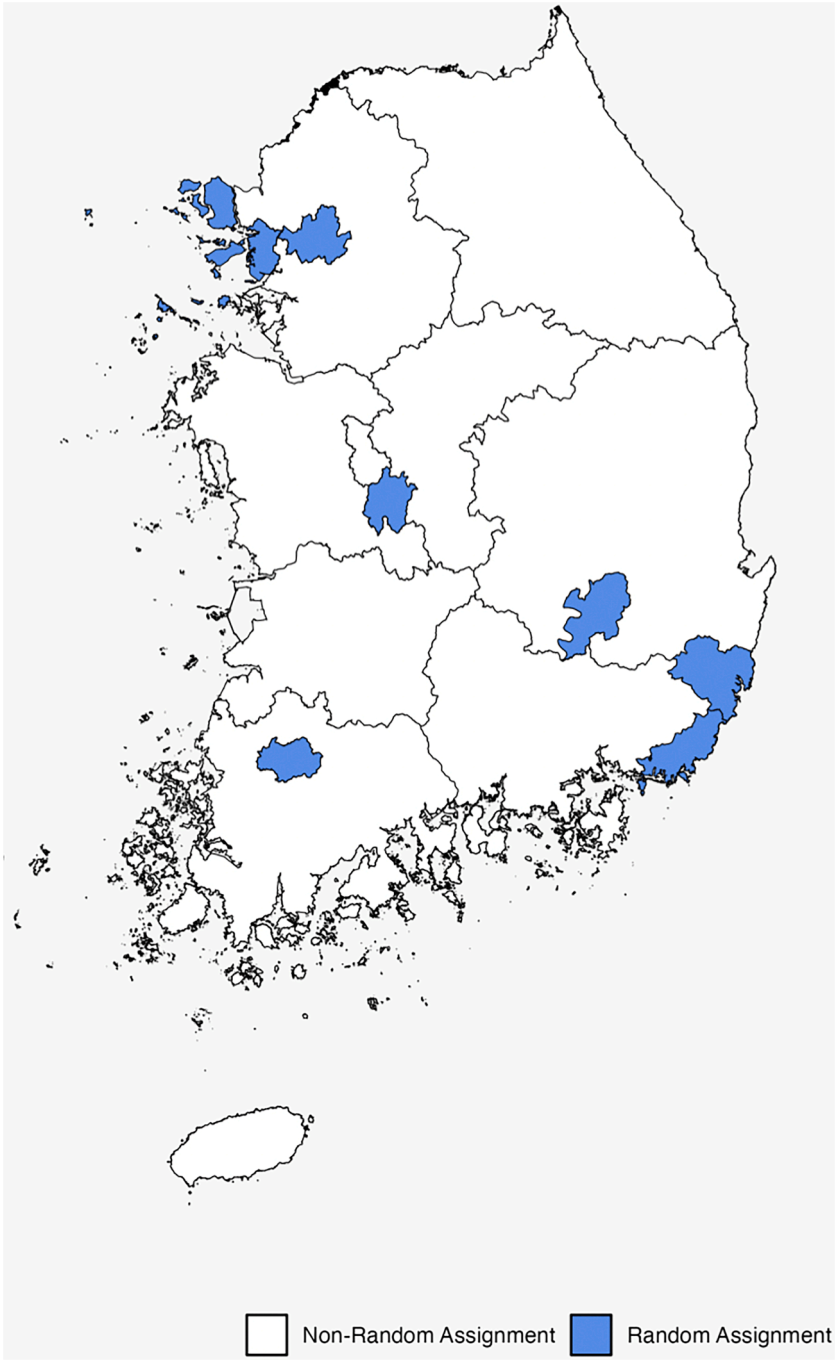

Fig. 1. Random school assignment regions in South Korea
Note: This figure displays the provinces in South Korea categorized by their middle school assignment systems: random and non-random. The six metropolitan areas—Seoul, Busan, Incheon, Daegu, Gwangju, and Ulsan—employ random assignment for middle schools and are colored in blue, while regions with non-random assignment are colored in white.

population density, replaced entrance exams with a randomized lottery system for school assignments, regardless of whether schools are private, public, single-sex, or coeducational (Lee and Nakazawa, 2022; Park et al., 2013). In contrast, non-equalized areas, typically less densely populated rural regions, allow school assignments to consider student preferences. Fig. 1 illustrates the geographical distribution of equalized and non-equalized areas. This study focuses exclusively on school zones located in equalized areas, where middle school assignments are randomized.

Another distinctive feature of the Korean system is that private schools operate similarly to public schools. Unlike in many other countries, private schools in Korea charge the same tuition, adhere to the standardized national curriculum, and admit students through a lottery system as mentioned above.

3. Data

3.1. The Korea physical activity promotion system (PAPS)

The PAPS (Physical Activity Promotion System) is a nationwide standardized physical examination initiated in 2009 for students in grades 5 through 12. Participation is compulsory for all students, and the

results are evaluated and reported by physical education instructors at each educational institution using uniform national criteria. The examination assesses five key components: cardiorespiratory endurance, flexibility, muscular endurance, speed, and body mass index (BMI). Students are ranked based on their cumulative score in these areas, with the ranking system as follows: 1st (100–80), 2nd (80–60), 3rd (60–40), 4th (40–20), and 5th rank (20–0). Students scoring below 40 are considered to have failed and must enroll in additional physical education classes. Although student-level results are not publicly available, school-level average data is accessible through the Ministry of Education's website (www.schoolinfo.go.kr) and is used for analysis. This dataset includes results from all schools in South Korea and provides detailed information on the individual tests that form PAPS. Additionally, the dataset is collected by grade and gender, enabling gender-specific analysis.

The PAPS dataset offers several strengths: (1) includes all schools (2) allows nationwide comparisons using standardized criteria (3) relies on objective measurement. The study uses data from 2016 to 2019, starting in 2016 due to data availability. To avoid potential influences from the COVID-19 pandemic, data from 2020 onwards is excluded. The analysis focuses on students in grades 7 through 9, as the test criteria for elementary schools differ from those for middle schools, and there are no single-sex schools at the elementary level. For the analysis, we only used schools located in equalized areas, where school assignments are random. This includes 1061 middle schools after excluding 14 special-purpose schools that recruit students on a nationwide level. Among these schools, 156 are male-only schools, 138 are female-only schools, and 767 are co-educational schools.

3.2. The Korea school district data

School districts are geographic areas defined by administrative boundaries, encompassing neighborhoods within cities. Each district contains a network of middle schools, where students residing in each district are randomly assigned to middle schools within that district.

As previously noted, the PAPS dataset does not include information on the school districts to which each school belongs. To address this limitation, we use data from www.schoolzone.emac.kr, providing detailed information on middle school district assignments. By matching the names and addresses of the schools in the PAPS dataset with those from the provided source, we assign each school to its respective district.

4. Empirical strategy

Self-selection bias is a key challenge in estimating the effect of single-sex schooling. To address this, we leverage the unique nature of the Korean education system, where school assignments are random within school zones in equalized areas. Following Lee and Nakazawa (2022), we restrict our analysis to these districts and apply the school district fixed effects model. This approach ensures that comparisons are made among students within the same districts, where random assignment by lottery allows us to identify the effect of single-sex schooling.

One potential concern is the possibility of students relocating to different school districts. However, data from the Korean Government Organization for Statistics indicate that the migration rate for individuals under the age of 20 was only 0.3 % between 2016 and 2019, suggesting that relocation for educational purposes is highly unlikely. Consistent with our approach, Lee and Nakazawa (2022) also did not consider relocation to be a significant factor.

Another consideration is the potential non-random assignment of teachers across single-sex and coeducational schools. While our data does not include teacher information, teacher assignments between public middle schools in South Korea are random and follow a rotation system, where teachers are periodically reassigned to ensure fairness. To validate this assumption, we use data from the Gyeonggi Education Panel Study, which surveyed schools in Gyeonggi Province, Korea's largest province. Table 1 presents a balance table of teacher characteristics across single-sex and coeducational schools, showing no significant differences.

Table 1
Balance table – teacher characteristics.

	Mean (Treatment / Same-Sex School)	Mean (Control / Co-Edu School)	Difference (Treatment -Control)
Age (20 s)	0.08	0.07	0.01
	{0.27}	{0.26}	(0.02)
Age (30s)	0.34	0.39	−0.05
	{0.47}	{0.49}	(0.03)
Age (40 s +)	0.58	0.54	0.04
	{0.49}	{0.5}	(0.04)
Professional Efficacy	−0.06	0.01	−0.07
	{2.11}	{2.13}	(0.15)
Enthusiasm for Job	0.03	−0.01	0.04
	{1.55}	{1.53}	(0.11)
Job Satisfaction	−0.07	0.01	−0.08
	{2.05}	{1.99}	(0.14)
Students' Understanding (50 % +)	0.77	0.77	−0.00
	{0.42}	{0.42}	(0.03)
Students' Understanding (70 % +)	0.3	0.27	0.03
	{0.46}	{0.45}	(0.03)
Observations	233	1309	1542

Note: This table presents the balance of teacher characteristics between the control group (co-education schools) and the treated group (same-sex schools) using data from the Gyeonggi Education Panel Study (GEPS). Columns one and two display the mean values of teacher characteristics for the control and treatment groups, while the third column presents difference estimates, with significance levels determined by *t*-tests. Standard deviations are denoted within brackets, and standard errors are enclosed within parentheses. Significance levels are indicated as follows: * $p < .10$, ** $p < .05$, *** $p < 0.01$.

Table 2
BMI and physical test pass rate result.

	BMI	Physical test pass rate (%)
Male school dummy coefficient (A1)	0.26***	1.15**
	(0.05)	(0.53)
Female school dummy coefficient (B1)	0.20***	0.25
	(0.05)	(0.41)
Male students mean in 6th grade (A2)	20.69	93.22
Female students mean in 6th grade (B2)	19.55	95.34
% change in male (100 × A1 / A2)	1.26 %	1.23 %
% change in female (100 × B1 / B2)	1.02 %	0.26 %
Number of School District	170	170
Number of observations	21,394	21,447

Note: This table illustrates the regression model results and standard errors are presented within parentheses. Standard errors are clustered at the school district level, and the student number for each gender is used as a weight in the estimation. Significance * 0.10; ** 0.05; *** 0.01.

To identify the effects of single sex school on physical fitness, we estimate the following equation in a pooled boy-and-girls' schools with school district fixed effects.

$$Y_{idgst} = \alpha + \beta_1 \text{Male School}_i + \beta_2 \text{Female School}_i + X'_{idgt}\gamma + \delta_d + \mu_g + \theta_s + \tau_t + \varepsilon_{idgst}$$

Y_{idgst} represents the outcome variables, which include BMI, PAPS pass rate, and individual test results consisting of the PAPS, for school i in school district d, with grade g, gender s, and year t. Male School$_i$ and Female School$_i$ are binary variables equal to 1 for male and female-only schools, respectively, and 0 otherwise. X'_{idgt} is a vector of school characteristics including variables such as private school status and student size. The model also includes school district fixed effects δ_d, grade fixed

Table 3
Individual physical fitness test results.

	Shuttle runs (number)	Partial Sit-up (number)	Flexibility (cm)	Grasping power (kg)	50-meter run (s)	Standing long jump (cm)
Male school dummy coefficient (A1)	0.73	4.41*	0.33**	0.10	−0.04	3.27**
	(0.77)	(2.79)	(0.15)	(0.33)	(0.04)	(1.64)
Female school dummy coefficient (B1)	0.04	−1.00	0.23*	0.09	−0.02	1.46
	(1.00)	(1.71)	(0.14)	(0.38)	(0.04)	(1.77)
Male students mean in 6th grade (A2)	86.22	73.60	7.92	23.09	9.30	165.70
Female students mean in 6th grade (B2)	74.14	56.71	14.19	21.30	9.85	146.69
% change in male (100 × A1 / A2)	0.85 %	5.99 %	4.17 %	0.43 %	−0.43 %	1.97 %
% change in female (100 × B1 / B2)	0.05 %	−1.76 %	1.62 %	0.42 %	−0.20 %	1.00 %
% of missing values compared to PAPS pass rate observation	17.90 %	68.04 %	0.42 %	31.69 %	19.23 %	60.37 %
Number of School District	163	152	170	167	168	159
Number of observations	17,609	6854	21,357	14,650	17,322	8499

Note: This table illustrates the regression model results and standard errors are presented within parentheses. Standard errors are clustered at the school district level, and the student number for each gender is used as a weight in the estimation. The partial sit-up requires the rolling up the body up to half of the usual sit-up. Significance * 0.10; ** 0.05; *** 0.01.

effect μ_g, gender fixed effect θ_s, and survey year fixed effect τ_t. ε_{idgst} is the error term. Standard errors are clustered at the school district level, and cohort sizes within each school by gender are used as weights in the estimation. β_1 and β_2 are the parameter of interest, capturing the effects of single-sex schools compared to co-educational schools.

5. Results

5.1. Body max index (BMI)

Column (1) of Table 2 presents the effects of single-sex schooling on BMI. The coefficient for the male school variable indicates that boys in male-only schools have a BMI that is 0.26 points higher than their peers in coeducational schools, representing a 1.26 % increase relative to the average BMI of 6th-grade male students. Similarly, the coefficient for the female school variable shows that girls in female-only schools have a 0.20 higher BMI, equivalent to a 1.02 % increase.

While a higher BMI does not necessarily indicate increased obesity, prior research on Korea (Choi et al., 2015) suggests that single-sex schooling is associated with higher rates of overweight students. Consistent with this literature, our findings may imply that single-sex schooling contributes to higher rates of overweight students for both boys and girls.

5.2. Physical fitness test pass rate

The column (2) in Table 2 presents the effects of single-sex schooling on the physical fitness test pass rate. The coefficient for the male school variable indicates that boys in male-only schools have a pass rate that is 1.15 percentage points higher than their peers in coeducational schools, representing a 1.23 % increase relative to the average pass rate of 6th grade male students. In contrast, the coefficient for the female school variable is small (0.25) and statistically insignificant.

5.3. Physical fitness test specific results

The physical fitness test (PAPS) includes six components: shuttle runs, sit-ups, flexibility, grasping power, 50-m run, and standing long jump. The dataset also provides school-level averages for these results, but individual test scores have a greater missing value compared to the pass rate. As shown in Table 3, the percentage of missing values varies widely, from 0.42 % for flexibility to 68.04 % for sit-ups. Since we cannot verify the randomness of the missing data, analyses of most test results should be interpreted as associations rather than causal effects, with flexibility being the only exception due to its minimal missing data.

The results in Table 3 show patterns similar to those of the overall pass rate. For flexibility, male schools show improved outcomes compared to coeducational schools, while female schools present relatively smaller effects. For other tests, despite high missing rates and statistical insignificance (except for the standing long jump), male schools generally show improved outcomes, while female schools exhibit smaller or negative effects compared to students in co-educational schools.

6. Conclusion

This paper examines the effects of single-sex schooling on the student's physical fitness using standardized nationwide physical tests in South Korea. The findings indicate that the impact of single-sex education varies by gender: male students show significant improvements in physical fitness, while female students do not experience comparable benefits. Given the well-documented links between physical fitness and broader health, cognitive, and mental outcomes, our results underscore the need for further research to understand the underlying mechanisms.

One possible explanation for our results is that male-only schools may foster greater competition among boys, who generally outperform girls in physical activities, leading to greater improvements in physical fitness. Conversely, in female-only schools, competition among girls—who typically have lower physical performance than boys—may not result in the same level of improvement. A natural direction for future research would be to empirically examine the underlying factors—such as responses to competition, peer effects, and gender norms—that may drive these differential effects.

Subject classification codes

I20, I21, I28

Statements and Declarations

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Data availability

Data will be made available on request.

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