

# EFFECTS OF DAILY EXERCISE TIME ON THE ACADEMIC PERFORMANCE OF STUDENTS: AN EMPIRICAL ANALYSIS BASED ON CEPS DATA

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*This paper examines the effects of daily exercise time on the academic performance of junior high school students in China, with an attempt to figure out the most appropriate daily exercise time for students from the perspective of improving students' test scores. By dividing the daily exercise time into five sections to construct a categorical variable in a linear regression model as well as using another model to draw intuitive figures, I find that spending both too little and too much time on physical activity every day would have adverse impacts on students' academic performance, with differences existing in the impacts by gender, grade, city scale, and location type of the school. The findings of this paper carry implications for research, school health and education policy and physical and general education practice. The results also provide recommendations for students, parents and teachers.*

## I. INTRODUCTION

Under the heavy academic pressure and the concern about pursuing higher education<sup>1</sup>, Chinese high school students tend to spend the majority of their time on study but merely a fraction of their time on sports. Furthermore, the promotion of China's high school administrators and teachers is mainly based on students' academic performance in examinations. Therefore, concerning that gym time may be taking away from study time, some schools cut down student's daily exercise time and some teachers occupy P.E. classes to teach other compulsory subjects such as Math, Chinese, English, etc. (Zhu M. et al., 2009; Tian H., 2019).

Is it true, as some parents and teachers previously thought that, academic performance is negatively affected by daily exercise time? Correa-Burrows et al. (2014) found that Chilean adolescents with the highest allocation of time to regular physical activity performed much better in mathematics and language than inactive students. Nevertheless, some previous studies suggested that test scores were not significantly related to physical activity levels (e.g., Coe et al., 2006). Howie E.K. and Pate R.R.'s (2012) review took a historical perspective on the science of physical activity and academic achievement prior to April 2012 (with a total of 125 studies included), which concluded that the majority of published articles had reported positive associations between physical activity and academic achievement, but the results continue to be inconsistent.

Most of the previous studies were conducted by doing a randomized-controlled trial and examining the effects of introducing more physical activity or physical activity education programs on students' academic performance. However, the effects may vary with the amount and intensity of physical activity, which therefore is likely to bring about completely opposite results in analysis. Since the insignificance and the inconsistency of the results of previous studies may come from lack of consideration of the amount and intensity of physical activity, this paper attaches much more importance to daily exercise time rather than physical activity intervention, and examines the impact of daily exercise time on the academic performance of junior high school students in China by using a nationally representative middle school student survey – China Education Panel Survey (CEPS). Specifically, to address the insignificance problem and to compare the results of different groups of students, I cut the daily

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<sup>1</sup> Compared with many western countries, where admissions to high schools or universities are based on multiple dimensions such as teacher recommendations and personal leadership potential, China's admissions are exclusively based on entrance examinations. According to the statistics released by the Ministry of Education of the People's Republic of China (MOE of China), only approximately 57% of junior secondary school graduates were admitted to regular senior secondary schools in 2021.

exercise time into several sections to construct a categorical variable in my first regression model.<sup>2</sup>

In addition, this paper attempts to figure out how long the daily exercise time should be in a gesture to reap tremendous benefit for students' academic performance. According to the *WHO 2020 guidelines on physical activity and sedentary behavior*, children and adolescents should do at least an average of 60 minutes per day of moderate to vigorous-intensity, mostly aerobic, physical activity, across the week. Besides, the *Outline of the national program for medium and long-term educational reform and development (2010-2020)* issued by The Central people's Government of the People's Republic of China requires that primary and secondary schools should ensure that students have one hour of physical activity every day. We will take the recommended "1-hour principle" into consideration and examine whether it is the most appropriate exercise time for students from the perspective of improving academic performance.

The rest of this paper is constructed as follows. Section 2 describes the data source and the data set used in the analysis. Section 3 discusses the empirical strategy. Section 4 presents the main empirical results and does robustness checks. Section 5 explore possible mechanisms. The last section offers a brief conclusion.

## II. DATA

The data comes from the baseline wave of China Educational Panel Survey (CEPS) conducted by the National Survey Research Center at Renmin University of China. The CEPS is China's first nationally representative longitudinal survey that aims to track middle school students through their educational progress and later labor market activities throughout their life cycles. The baseline survey of the CEPS adopted a stratified, multistage sampling design with probability proportional to size, randomly selecting approximately 20,000 seventh-grade and ninth-grade students from 438 classes of 112 schools in 28 counties in mainland China during the 2013-2014 academic year.

The CEPS conducted a questionnaire survey to ask students how long on average they spent on playing sports every day last weekdays and weekend, which allows me to define the key explanatory variable used in this paper. The CEPS also contains detailed information on students' academic performance - the school records on students' mid-term test scores<sup>3</sup> in the following three compulsory subjects: Math, Chinese and English, which together with the average of the scores of these three subjects form the outcome of interest in this paper. Besides, self-reported academic performance indicators at the sixth grade in the primary school are included in the data.<sup>4</sup> Except for students' characteristics, the CEPS collected their family background information, such as parents' education levels, household income levels and number of siblings, which may be important determinants of students' academic performance.

To construct the explanatory variable, I firstly define the daily exercise time as the weighted average of the exercise time on weekdays and on weekend. Then I drop those data with key variables (test scores, daily exercise time) missing (with 1411 observations deleted) and those whose daily exercise time is loner than 5 hours (with only 214 observations deleted). Finally, the sample used in the analysis includes 17,862 students, comprising of 9,475 grade 7 students and 8,387 grade 9 students.

Table 1 presents the summary statistics of main variables for students in grade 7 and grade 9 of the junior high school. As we expected, since Grade 9 students have to prepare the senior high school entrance examination, their average daily exercise time is 0.022 hours less than that of grade 7 students.

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<sup>2</sup> It is much similar to Threshold Regressive Model. But to take students' daily routine and the recommended daily exercise time (by WHO and MOE of China) into consideration, we intentionally separate the daily exercise time.

<sup>3</sup> The mid-term test scores are standardized in terms of school and grade.

<sup>4</sup> The CEPS asked students to recall the difficulty degree of learning Math, Chinese and English when they attended the sixth grade in the primary school: very difficult ('1'), difficult ('2'), somewhat difficult ('3'), and not difficult ('4').

TABLE 1—SUMMARY STATISTICS OF MAIN VARIABLES

	All students	Grade 7 students	Grade 9 students
<i>Panel A: Student Characteristics</i>			
Average score	70.23	70.26	70.19
Math score	70.23	70.25	70.20
English score	70.22	70.27	70.16
Chinese score	70.23	70.25	70.21
Daily exercise time (h)	0.834	0.844	0.822
Male (%)	51.1	52.5	49.4
Age	13.50	12.56	14.56
Minority (%)	8.25	8.02	8.51
Agricultural hukou (%)	54.6	53.7	55.7
Migrant (%)	17.6	20.3	14.6
Live on the campus (%)	32.5	31.3	33.9
Difficulty degree of learning in grade6			
Math	2.882	2.878	2.886
English	2.734	2.820	2.635
Chinese	3.160	3.110	3.216
<i>Panel B: Household Characteristics</i>			
Mother's year of education	9.593	9.731	9.437
Mother's education level (%)			
Primary school or below	24.2	22.2	26.5
Middle school	41.2	41.5	40.8
High/technical school	21.5	22.9	20.0
College or above	13.1	13.4	12.7
Father's year of education	10.35	10.45	10.23
Father's education level (%)			
Primary school or below	15.0	14.0	16.2
Middle school	44.1	43.2	45.2
High/technical school	25.3	26.8	23.5
College or above	15.6	16.0	15.1
Household income level (%)			
Low	20.9	21.4	20.4
Middle	73.1	72.6	73.6
High	5.96	5.91	6.02
Number of siblings	0.735	0.740	0.730
Observations	17,862	9,475	8,387

### III. EMPIRICAL STRATEGY

Since the effect of daily exercise time on the academic performance is unlikely to be linear, I cut the daily exercise time into five sections to construct a categorical variable as our key explanatory variable. The five sections are “0 per day”, “0 to 0.5 hours per day”, “0.5 to 1.5 hours per day”, “1.5 to 2.5 hours per day” and “more than 2.5 hours per day”. We take “0.5 to 1 hours per day” as our reference category and create four dummy variables: *Exert1*, *Exert2*, *Exert3* and *Exert4*, which represent “0 per day”, “0 to 0.5 hours per day”, “1.5 to 2.5 hours per day” and “More than 2.5 hours per day”, respectively. The reason for my construction is that the recommended daily exercise time for students is 1 hour, as shown in the introduction. In addition, the sample data shows that the mean exercise time is 0.834 hours, relatively close to 1 (see Table 1).

I run the following regression across subjects using the OLS method:

$$Score_{icgs} = \beta_0 + \beta_1 Exert1_{icgs} + \beta_2 Exert2_{icgs} + \beta_3 Exert3_{icgs} + \beta_4 Exert4_{icgs} + \beta_5 X_{icgs} + e_{icgs} \#(1)$$

Where  $Score_{icgs}$  denotes the mid-term test scores in the three subjects (Math, Chinese and English) and the average of those three for student  $i$  in class  $c$  of grade  $g$  of school  $s$ .  $Exert1_{icgs}$ ,  $Exert2_{icgs}$ ,  $Exert3_{icgs}$  and  $Exert4_{icgs}$  are dummies standing for “0 per day”, “0 to 0.5 hours per day”, “1.5 to 2.5 hours per day” and “More than 2.5 hours per day”, respectively. The covariate vector  $X_{icgs}$  represents the characteristics that are important determinants of student’s academic performance, including student’s gender, age, ethnic minority status, agricultural hukou status, whether living on campus, whether being a migrant student and difficulty degree of learning in grade 6<sup>5</sup> as well as parents’ education levels, number of siblings and household income level. Throughout the analysis, I cluster the standard errors at the school level to allow for heteroskedasticity and arbitrary serial correlation across students within each school.

To overcome the possible effects of class level characteristics on students’ test scores<sup>6</sup>, class fixed effects ( $\mu_{cgs}$ ) is used. That is:

$$e_{icgs} = \mu_{cgs} + \varepsilon_{icgs} \#$$

Where  $\varepsilon_{icgs}$  denotes the new error term. Conditioning on the class fixed effects, the key explanatory variables should be orthogonal to the error term ( $\varepsilon_{icgs}$ ) and the estimation precision has increased.

#### IV. MAIN RESULTS

In this section I firstly examine the causal effect of the daily exercise time on students’ standardized mid-term test scores in the three compulsory subjects (Math, Chinese and English) and the average test scores of those three subjects. Then I do robustness checks by using various samples. Finally, I use another model to figure out the most appropriate daily exercise time for students from the perspective of improving academic performance.

##### A. Effects on Students’ Academic Performance

As shown in Table 2, exercising “0 per day”, “1.5 to 2.5 hours per day” and “More than 2.5 hours per day” all have negative and statistically significant effects on the test scores respectively, comparing to exercising “0.5 to 1.5 hours per day”. While exercising “0 to 0.5 hours per day” have positive but relatively small and sometimes even insignificant effects on the test scores.

To be more specific, Panel A of Table 2 shows that comparing to exercising “0.5 to 1.5 hours per day”, exercising “0 per day” would reduce students’ average test scores by 1.512 points. Furthermore, when comparing the results in Panel B, Panel C and Panel D, I find that Chinese score is the most sensitive – there is a 2.137-point decrease if students seldom engage in physical activity.

Exercising “1.5 to 2.5 hours per day” have similar effects on all three subjects – students are likely to perform much worse in mid-term exams (approximately 1 point less) when they exercise “1.5 to 2.5 hours per day” than “0.5 to 1.5 hours per day”. If students spend much more time on sports, their test scores are much lower – 2.756 points less when they exercise “more than 2.5 hours per day” than exercise “0.5 to 1.5 hours per day”.

It is surprising that exercising “0 to 0.5 hours per day” have positive but relatively small and sometimes even insignificant effects on the test scores (comparing to exercising “0.5 to 1.5 hours per day”). The possible

<sup>5</sup> The regression of the average test score controls for difficulty degree of learning all three subjects (Math, Chinese and English) in grade 6. The regression of the Math (Chinese, English) score controls for difficulty degree of learning Math (Chinese, English) in grade 6.

<sup>6</sup> Krueger (1999) found that class size has significant effect on students’ performance on standardized tests. Hu (2018) found that migrant peers have large and negative effects on the academic performance of local students in China. Thus I take the class fixed effect into consideration.

explanation may be related to the argument that spending some time on sports may reduce the time spending on study and hence

TABLE 2—EFFECTS OF DAILY EXERCISE TIME ON STUDENTS' MID-TERM TEST SCORES: MODEL 1

	All students	Grade 7 students	Grade 9 students
<i>Panel A: Average score</i>			
0 per day	-1.512*** (0.154)	-1.644*** (0.201)	-1.343*** (0.273)
0 to 0.5 hours per day	0.420** (0.177)	0.241 (0.234)	0.598** (0.277)
1.5 to 2.5 hours per day	-0.986*** (0.220)	-0.737*** (0.260)	-1.316*** (0.383)
More than 2.5 hours per day	-2.072*** (0.262)	-1.548*** (0.325)	-2.756*** (0.456)
Observations	16664	8886	7778
R <sup>2</sup>	0.259	0.278	0.243
<i>Panel B: Math score</i>			
0 per day	-1.399*** (0.173)	-1.439*** (0.244)	-1.347*** (0.278)
0 to 0.5 hours per day	0.736*** (0.223)	0.554* (0.306)	0.913*** (0.301)
1.5 to 2.5 hours per day	-1.092*** (0.249)	-0.944*** (0.313)	-1.302*** (0.387)
More than 2.5 hours per day	-2.239*** (0.358)	-1.453*** (0.427)	-3.293*** (0.567)
Observations	17098	9042	8056
R <sup>2</sup>	0.203	0.221	0.187
<i>Panel C: Chinese score</i>			
0 per day	-2.137*** (0.187)	-2.285*** (0.240)	-1.910*** (0.323)
0 to 0.5 hours per day	0.102 (0.177)	0.131 (0.242)	0.072 (0.281)
1.5 to 2.5 hours per day	-1.030*** (0.286)	-0.386 (0.317)	-1.747*** (0.484)
More than 2.5 hours per day	-2.353*** (0.300)	-1.708*** (0.417)	-3.154*** (0.525)
Observations	17066	9026	8040
R <sup>2</sup>	0.189	0.194	0.186
<i>Panel D: English score</i>			
0 per day	-1.419*** (0.173)	-1.659*** (0.240)	-1.125*** (0.290)
0 to 0.5 hours per day	0.476** (0.207)	0.142 (0.263)	0.824** (0.327)
1.5 to 2.5 hours per day	-0.973*** (0.222)	-0.745** (0.286)	-1.266*** (0.389)
More than 2.5 hours per day	-2.136*** (0.316)	-2.056*** (0.400)	-2.248*** (0.481)
Observations	16719	8920	7799
R <sup>2</sup>	0.272	0.292	0.252

Notes: All regressions control for student characteristics including student's gender, age, ethnic minority status, agricultural hukou status, whether living on campus, whether being a migrant student and difficulty degree of learning in grade 6, household characteristics including parents' education levels, number of siblings and household income level. Robust standard errors clustered at the school level are in parentheses.

\*\*\* significant at 1 percent level, \*\* significant at 5 percent level, \* significant at 10 percent level.

have negative effects on students' academic performance, which I will explore in the next section.

When I examine the effects of the daily exercise time on students' mid-term test scores in terms of grade, the results in Table 2 show that the adverse impact of not playing sports on Grade 9 students' academic performance is smaller than that of Grade 7 students. On the contrary, the adverse impact of doing exercise longer than 1.5 hours per day on Grade 9 students' academic performance is larger than that of Grade 7 students.

When taking gender into consideration, the results in Panel A of Table 3 show that negative effects of exercising "0 per day" and "more than 2.5 hours per day" are concentrated among male students. Moreover, it is interesting that exercising "0 to 0.5 hours per day" have very small and insignificant positive effects on the test scores of male students, but have relatively large and significant effects on the test scores of female students. The reason may be that the best daily exercise time for female students is shorter than that for male students, which I will explain in detail later.

In terms of city scale, the results in Panel B of Table 3 show that students in the large cities are more likely to be influenced by the daily exercise time when they exercise "1.5 to 2.5 hours per day" or "more than 2.5 hours per day". That is, students' test scores are dropping much more when they do exercises for too long every day. Surprisingly, in the subsample of Large cities, exercising "0 to 0.5 hours per day" have negative effects on the test scores and the negative effects are mainly concentrated among Grade 7 students, which are completely contrary to the results in the whole sample and other subsamples.

TABLE 3—HETEROGENEITY BY GENDER, CITY SCALE AND LOCATION TYPE

	All students	Grade 7 students	Grade 9 students
<i>Panel A: Gender</i>			
(a) Male			
0 per day	-1.939*** (0.257)	-2.206*** (0.332)	-1.586*** (0.433)
0 to 0.5 hours per day	0.066 (0.274)	0.021 (0.367)	0.094 (0.431)
1.5 to 2.5 hours per day	-1.007*** (0.297)	-0.825** (0.339)	-1.324** (0.515)
More than 2.5 hours per day	-2.594*** (0.380)	-2.187*** (0.457)	-3.172*** (0.649)
Observations	8465	4624	3841
R <sup>2</sup>	0.214	0.227	0.199
(b) Female			
0 per day	-1.151*** (0.192)	-0.985*** (0.274)	-1.303*** (0.314)
0 to 0.5 hours per day	0.789*** (0.206)	0.625** (0.284)	0.972*** (0.311)
1.5 to 2.5 hours per day	-1.156*** (0.270)	-0.705* (0.382)	-1.729*** (0.480)
More than 2.5 hours per day	-1.214*** (0.441)	-0.525 (0.541)	-2.111*** (0.750)
Observations	8199	4262	3937
R <sup>2</sup>	0.226	0.246	0.215
<i>Panel B: City scale</i>			
(a) Large cities			
0 per day	-1.626*** (0.300)	-2.072*** (0.362)	-1.154** (0.535)

0 to 0.5 hours per day	-0.230 (0.252)	-0.663* (0.390)	0.271 (0.431)
1.5 to 2.5 hours per day	-1.800*** (0.423)	-1.635*** (0.593)	-2.380*** (0.756)
More than 2.5 hours per day	-2.912*** (0.567)	-2.622*** (0.644)	-3.915*** (1.023)
Observations	3853	2205	1648
R <sup>2</sup>	0.262	0.227	0.248
(b) Others			
0 per day	-1.482*** (0.180)	-1.527*** (0.231)	-1.409*** (0.324)
0 to 0.5 hours per day	0.622*** (0.209)	0.522* (0.275)	0.706** (0.335)
1.5 to 2.5 hours per day	-0.763*** (0.252)	-0.469* (0.267)	-1.089** (0.436)
More than 2.5 hours per day	-1.856*** (0.295)	-1.227*** (0.386)	-2.547*** (0.501)
Observations	12811	6681	6130
R <sup>2</sup>	0.261	0.281	0.242
<i>Panel C: Location type</i>			
(a) The central area of the city			
0 per day	-1.431*** (0.233)	-1.872*** (0.273)	-0.888* (0.449)
0 to 0.5 hours per day	0.313 (0.280)	0.084 (0.363)	0.615 (0.399)
1.5 to 2.5 hours per day	-1.741*** (0.355)	-1.071** (0.461)	-2.639*** (0.599)
More than 2.5 hours per day	-2.341*** (0.399)	-1.869*** (0.553)	-3.010*** (0.790)
Observations	6610	3521	3089
R <sup>2</sup>	0.267	0.303	0.238
(b) Urban fringe and rural-urban fringe zone			
0 per day	-1.608*** (0.337)	-1.687*** (0.461)	-1.514** (0.639)
0 to 0.5 hours per day	0.796** (0.311)	0.447 (0.398)	1.193** (0.472)
1.5 to 2.5 hours per day	-0.652 (0.450)	-0.341 (0.496)	-1.080 (0.838)
More than 2.5 hours per day	-2.184*** (0.469)	-1.574** (0.604)	-3.041*** (0.931)
Observations	4085	2258	1827
R <sup>2</sup>	0.276	0.304	0.248
(c) Towns and rural areas			
0 per day	-1.482*** (0.250)	-1.363*** (0.332)	-1.703*** (0.361)
0 to 0.5 hours per day	0.262 (0.313)	0.131 (0.440)	0.383 (0.504)
1.5 to 2.5 hours per day	-0.360 (0.288)	-0.473 (0.373)	-0.248 (0.455)
More than 2.5 hours per day	-1.676*** (0.490)	-1.062* (0.535)	-2.448*** (0.721)
Observations	5969	3107	2862
R <sup>2</sup>	0.253	0.243	0.265

Notes: All regressions control for the same characteristics as in Table 2. Robust standard errors clustered at the

school level are in parentheses. \*\*\* significant at 1 percent level, \*\* significant at 5 percent level, \* significant at 10 percent level.

When I divide the analysis sample into students in “the central area of the city”, “the urban fringe and rural-urban fringe zone” and “towns and rural areas”, the results in Panel C of Table 3 show that for students who do exercises more than 1.5 hours per day, the academic performance of those from the central area of the city is more likely to be influenced by the daily exercise time than those from the rural-urban fringe zone, which is then also more likely to be influenced than those students from towns and rural areas. It is worth mentioning that exercising “1.5 to 2.5 hours per day” have even insignificant effects on the test scores of students from the rural-urban fringe zone and rural areas.

## B. Robustness Checks

In view of the fact that the data in this study consists of three parts: the national core sample, the Shanghai sample and the national supplementary sample, among which the Shanghai sample accounts for 8.1% of the total sample, I do the regression after deleting the data from Shanghai to test the robustness of the results. As shown in Panel A of Table 4, the results remain robust to excluding schools in Shanghai. Similarly, as shown in Panel B of Table 4, the estimation results remain almost unchanged when I include only public schools in the sample.<sup>7</sup>

Overall, the robustness check results in Table 4 and the heterogeneity results in Table 3 show that the main results remain robust to various samples.

TABLE 4—ROBUSTNESS CHECKS

	All students	Grade 7 students	Grade 9 students
<i>Panel A: Excluding Shanghai</i>			
0 per day	-1.503*** (0.160)	-1.637*** (0.208)	-1.343*** (0.287)
0 to 0.5 hours per day	0.483** (0.186)	0.338 (0.248)	0.623** (0.292)
1.5 to 2.5 hours per day	-0.900*** (0.225)	-0.683** (0.271)	-1.162*** (0.388)
More than 2.5 hours per day	-2.050*** (0.276)	-1.426*** (0.342)	-2.841*** (0.470)
Observations	15445	8178	7267
R2	0.261	0.278	0.245
<i>Panel B: Including only public schools</i>			
0 per day	-1.592*** (0.158)	-1.708*** (0.202)	-1.439*** (0.282)
0 to 0.5 hours per day	0.346* (0.182)	0.168 (0.244)	0.528* (0.288)
1.5 to 2.5 hours per day	-1.106*** (0.224)	-0.775*** (0.265)	-1.548*** (0.386)
More than 2.5 hours per day	-2.144*** (0.265)	-1.650*** (0.342)	-2.800*** (0.453)
Observations	15485	8272	7213
R2	0.265	0.281	0.251

Notes: All regressions control for the same characteristics as in Table 2. Robust standard errors clustered at the school level are in parentheses. \*\*\* significant at 1 percent level, \*\* significant at 5 percent level, \* significant at 10 percent level.

<sup>7</sup> The 112 schools in the CEPS are classified into two large categories: public schools (112 in total) and private schools (8 in total).



### C. Another Model

In view of the above analysis, which concludes that spending both too little and too much time on physical activity every day would have adverse impacts on students' academic performance, I infer that the test score-daily exercise time curve may show an inverted U shape. To figure out the most appropriate daily exercise time for students from the perspective of improving academic performance (I call it “the best daily exercise time” below), we require a continuous function to present the intuitive correlation between average test score and daily exercise time. After trying multiple regression models and comparing the fit of the regression results of these models to the results of the previous linear one, I ultimately identify the following model:

$$Score_{icgs} = \beta_0 + \beta_1 Exertime^1_{icgs} + \beta_2 Exertime^2_{icgs} + \beta_3 Exertime^3_{icgs} + \beta_4 \sqrt{Exertime}_{icgs} + \beta_5 X_{icgs} + \mu_{cgs} + \varepsilon_{icgs} \#(2)$$

where  $Score_{icgs}$  denotes the average of student  $i$ 's Math, Chinese and English mid-term scores,  $Exertime_{icgs}$  denotes the daily exercise time for student  $i$  in class  $c$  of grade  $g$  of school  $s$ , and other variables are defined the same as above. I cluster the standard errors at the school level and use the class fixed effects in this model as well.

The regression results are shown in Table 5. Since the results in Table 3 and Table 4 suggest large differences in the effects by gender, grade, city scale, and location type of the school, I do regression in various subsamples in a gesture to test the reliability of the results as well as to gain an authentic and intuitive glimpse into the correlation between daily exercise time and students' academic performance.

TABLE 5—EFFECTS OF DAILY EXERCISE TIME ON STUDENTS' AVERAGE MID-TERM TEST SCORES: MODEL 2

	All	Grade		Gender		City scale		Location type		
	students	7th	9th	Male	Female	Large	Other	City center	Urban fringe	Rural area
$Exertime^1$	-6.624*** (1.118)	-6.116*** (1.539)	-7.246*** (1.923)	-4.748*** (1.551)	-8.378*** (1.613)	-2.963 (2.127)	-7.678*** (1.272)	-6.389*** (1.853)	-7.868*** (2.130)	-5.456*** (1.915)
$Exertime^2$	1.194*** (0.405)	1.167** (0.581)	1.258* (0.680)	0.459 (0.535)	1.662*** (0.625)	-0.168 (0.784)	1.585*** (0.461)	0.948 (0.678)	1.449** (0.706)	1.127 (0.733)
$Exertime^3$	-0.119** (0.057)	-0.123 (0.081)	-0.121 (0.095)	-0.033 (0.071)	-0.138 (0.093)	0.055 (0.115)	-0.169** (0.065)	-0.074 (0.095)	-0.140 (0.102)	-0.133 (0.103)
$\sqrt{Exertime}$	7.012*** (0.794)	6.703*** (1.045)	7.344*** (1.394)	6.225*** (1.120)	7.928*** (1.117)	4.538*** (1.497)	7.729*** (0.908)	6.784*** (1.295)	8.227*** (1.719)	5.955*** (1.248)
Observations	16664	8886	7778	8465	8199	3853	12811	6610	4085	5969
R2	0.260	0.279	0.243	0.214	0.227	0.262	0.261	0.267	0.276	0.253

Notes: All regressions control for the same characteristics as in Table 2. Robust standard errors clustered at the school level are in parentheses. \*\*\* significant at 1 percent level, \*\* significant at 5 percent level, \* significant at 10 percent level.

According to the results in the first column of Table 5, I draw Figure 1, where  $\Delta Score = Score_t - Score_0$  denotes the difference between the average test score of students when daily exercise time is  $t$  and when daily exercise time is 0, ceteris paribus. As shown in Figure 1,  $\Delta Score$  rises as the daily exercise time increases from 0, and then a peak of 1.971 points occurs when the daily exercise time is 0.366 hours, which followed by a downward trend with exercise time continuing to increase. We conclude that the best daily exercise time is 0.366 hours, which perfectly meshes the results in Table 3: Exercising “0 to 0.5 hours per day” have positive but relatively small effects (0.450 points) on the test scores comparing to exercising “0.5 to 1.5 hours per day”.

Figure 2.1 is drawn on the basis of the second and the third columns of Table 5, which take grade difference into consideration. The increasing parts of the two curves in Figure 2.1 almost coincide with each other, with only a slight distinction in the best daily exercise time—the best daily exercise time for grade 9 students is around 5.46

minutes shorter than that for grade 7 students. Nevertheless, great distinctions take place in the downward part of the two curves, which suggests that grade 9 students are much more influenced by the continuous increase in daily exercise time—the same conclusions that we drew in the prior subsection.

FIGURE 1—EFFECTS OF DAILY EXERCISE TIME ON  $\Delta$ SCORE

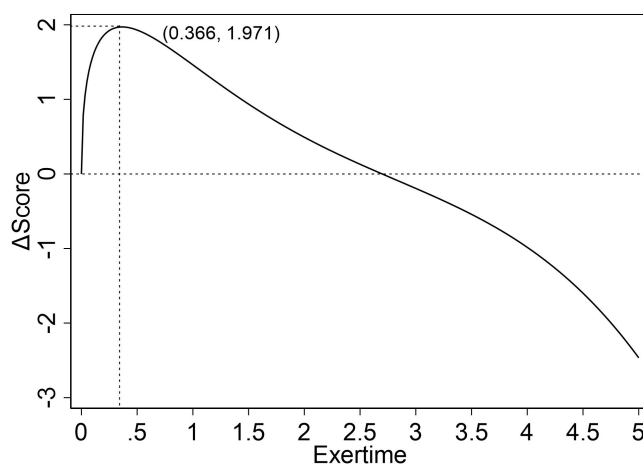


FIGURE 2.1—EFFECTS BY GRADE

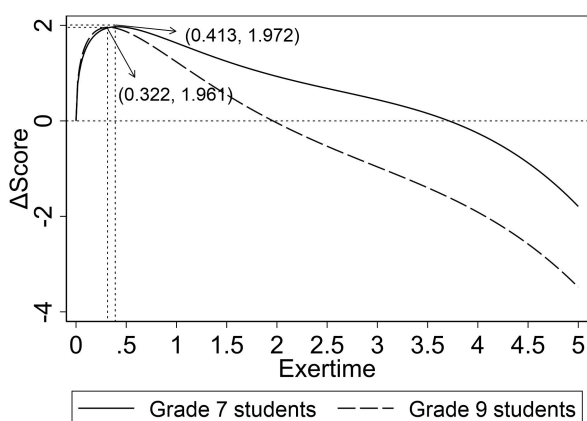


FIGURE 2.2—EFFECTS BY GENDER

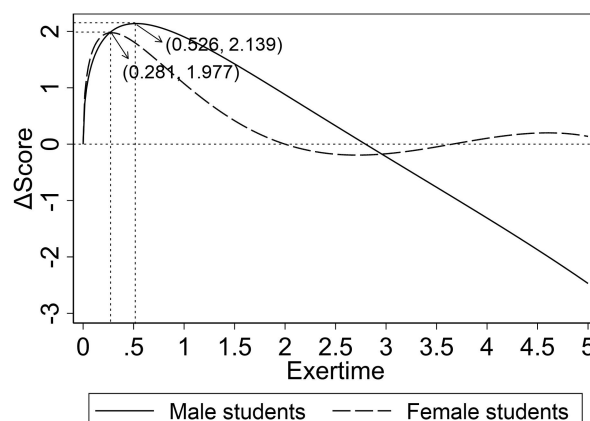


FIGURE 2.3—EFFECTS BY CTY SCALE

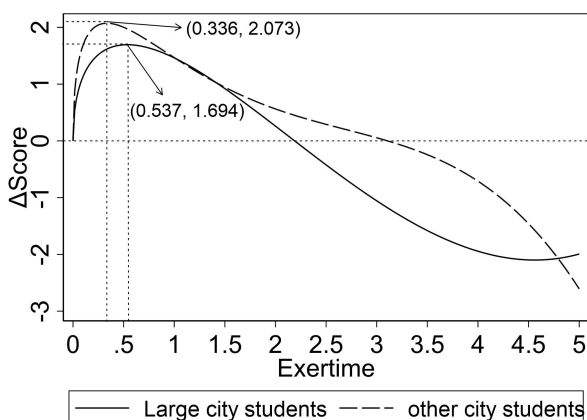
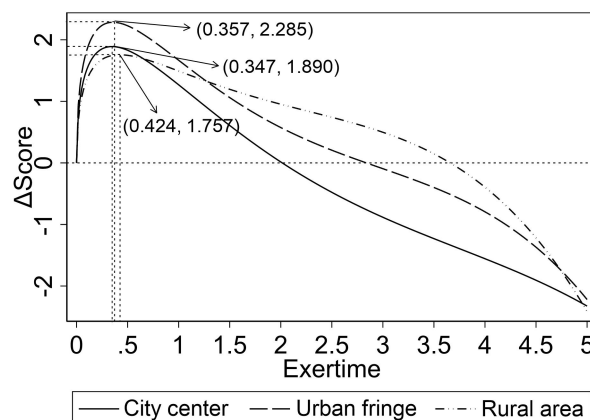


FIGURE 2.4—EFFECTS BY LOCATION TYPE



In subsection IV. A, we concluded that the negative effects of exercising “0 per day” and “more than 2.5 hours per day” are concentrated among male students. It is easy to draw similar conclusions from Figure 2.2, since the

curve representing male students is higher than the one representing female when the daily exercise time is in the interval (0.5, 1.5), and the male curve drops much quicker than the female one when the exercise time is longer than 2.5 hours. Besides, Figure 2.2' shows that the best daily exercise time for female students (0.281 points) is shorter than that for male students (0.526 points), which accounts for the results in Panel A of Table 4: The positive effects of exercising "0 to 0.5 hours per day" on the test scores of female students are (0.723 points) larger than that of male students. However, it is odd that the female curve shows a slightly upward trend when the exercise time is longer than 2.5 hours. The possible explanation may be the limitation of the regression function we used.

As shown in Figure 2.3, the best daily exercise time of large city students is 0.537 hours, which is 0.201 hours (around 12 minutes) longer than that of other city students. This partially explained why exercising "0 to 0.5 hours per day" have negative effects on the test scores of large city students, which is contrary to the results in other samples, as we stated in subsection IV. A. However, the curve representing large city students falls more rapidly than the other one when daily exercise time is longer than 1.5 hours. Similar properties appear in Figure 2.4. The curve standing for students from the central area of the city drops the most sharply after reaching the best daily exercise time, while the one representing rural students show relatively flatter trend than the other two.

## V. MECHANISMS

As indicated by the above analysis, physical activity has positive effects on students' academic performance when the daily exercise time is in an appropriate interval (around (0, 2)). There have been lots of studies suggesting the mechanisms through which physical activity operate. Firstly, physical activity is generally promoted for its beneficial effects on children's physical health and mental health (Penedo, et al., 2005), which are positively correlated to students' academic performance. For example, Dusen et al. (2011) found that five fitness variables (which measure aerobic capacity, abdominal strength and endurance, trunk extensor strength and flexibility, upper body strength and endurance, and flexibility respectively) showed significant and positive associations with academic performance. In addition, there is a strong belief that regular participation in physical activity is linked to enhancement of brain function and cognition, thereby positively influencing academic performance (Chaddock-Heyman et al., 2014; Hillman et al., 2008). Besides, regular participation in physical activity may improve students' behavior in the classroom, increasing the odds of better concentration on the academic content of their lessons (Caterino et al., 1999). Therefore, moderate physical activity can improve students' physical fitness and mental health, stimulate the development of the brain and promote students' concentration, which then have beneficial effects on students' academic performance.

However, spending too much time (more than 2.5 hours, for example, according to Figure 1) on physical activity will have adverse impacts on students' academic performance. The most trivial explanation is related to the argument that hours "wasted" on physical activity would have negative effects on students' academic performance (Hansen, 1990; Hanson et al., 1989). The less trivial one is the harm of excessive exercise to physical and mental health (e.g. Paluska et al, 2000)<sup>8</sup>

To better explain the possible mechanisms underlying the differences in the effects by gender, grade, city scale, and location type of the school, I collect some descriptive statistics of these specific samples and form Table 6. The CEPS also asked students to recall their time on average last week spent on homework assigned by school and by their parents or cram school, as well as the time on average last week spent on taking cram school courses (related to schoolwork). I construct another variable called "daily study time" in Table 6, defined as the sum of students' self-reported average time spent on homework assigned by school and by their parents or cram school, and the time

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<sup>8</sup> Paluska et al. (2000) found that excessive physical activity may lead to overtraining and generate psychological symptoms that mimic depression.

spent on taking cram school courses.

Comparing to Grade 7 students, Grade 9 students are confronted with the pressure of senior high school entrance

TABLE 6—DESCRIPTIVE STATISTICS OF SPECIFIC SAMPLES

	Means and (standard deviations)									
	All	Grade		Gender		City scale		Location type		
	students	7th	9th	Male	Female	Large	Other	City center	Urban fringe	Rural area
Average test scores	70.338 (8.498)	70.379 (8.370)	70.292 (8.641)	68.295 (8.895)	72.491 (7.477)	70.468 (8.226)	70.308 (8.560)	70.281 (8.538)	70.295 (8.488)	70.429 (8.462)
Daily exercise time	0.832 (0.886)	0.842 (0.920)	0.820 (0.846)	0.944 (0.968)	0.714 (0.773)	0.807 (0.882)	0.838 (0.887)	0.814 (0.877)	0.876 (0.885)	0.821 (0.896)
Daily study time	3.759 (2.498)	3.417 (2.288)	4.149 (2.664)	3.545 (2.469)	3.986 (2.509)	3.898 (2.279)	3.727 (2.545)	4.347 (2.428)	3.528 (2.438)	3.287 (2.486)
Observations	16639	8856	7783	8536	8103	3156	13483	6477	4109	6053

Notes: I drop those data with variables (average test scores, daily exercise time and daily study time) missing and those whose daily exercise time is longer than 5 hours or whose daily study time is longer than 12 hours. Standard errors are reported in parentheses.

examination and greater learning intensity, thus they need to spend much more time on study rather than on physical activity. It is verified by the statistics in Table 6, which shows that Grade 9 students spend approximately 44 minutes more on study than Grade 7 students do. Therefore, if grade 9 students sacrifice their study time to physical activity, their test scores would drop quicker than that of Grade 7 students, which accounts for the smaller best daily exercise time and the steeper trend of the curve of Grade 9 students as shown in Figure 2.1.

Similar argument can be applied to interpreting the differences in effects by city scale and location type. With high-quality educational resources and excellent students concentrated (Yu et al., 2016; Wu et al., 2012), students from large cities or from the central area of the city face much more fierce competition and invest more time on study, which is also verified by the statistics in Table 6<sup>9</sup>. Hence hours “wasted” on physical activity would have larger negative effects on the academic performance of those students from large cities or the city center, partially accounting for the different trends of the curves in Figure 2.3 and Figure 2.4 respectively.

Nevertheless, the mechanisms underlying the gender difference are comparatively complicated and hard to interpret. To figure out the possible explanations, physiological distinctions between male and female students may be considered, which waits for further research.

## VI. CONCLUSIONS

This paper examines the impact of daily exercise time on the academic performance of junior high school students in China using the baseline wave of China Education Panel Survey (CEPS), a nationally representative survey administered to middle school students in China. To the best of my knowledge, this study is unique in at least 3 ways: first, daily exercise time is used as a measure of the amount of physical activity and several tricks are used to better examine the effects of daily exercise time on the academic performance. Second, I examined the best daily exercise time for students from the perspective of improving students’ academic performance. Finally, I examined the differences in effects by gender, grade, city scale, and location type of the school.

By dividing the daily exercise time into five sections to construct a categorical variable to analyze the effects of

<sup>9</sup> Teng et al. (2021) found that the conditions of shortage of teachers, the level of school governance and the quality of teachers’ professional learning activities in urban areas were significantly better than those in rural areas, which results in the remarkable rural-urban disparities in students’ academic achievement.

each section respectively, as well as using another model to draw intuitive graphs, I find that spending both too little and too much time on physical activity every day would have adverse impact on students' academic performance, with differences exist in the impact by gender, grade, city scale, and location type of the school.

While the recommended daily exercise time by WHO and MOE of China is 1 hour, this paper suggested that the best daily exercise time for students from the perspective of improving academic performance is around 22 minutes. However, exercising 1 hour per day would lead to only approximately 0.5 points lower than exercising 22 minutes per day, and still have positive effects (around 1.5 points) on students' academic performance comparing to not exercising. Hence, the "1-hour principle" is still recommended if the goal of the education of middle school is not merely to pursue high scores but to achieve comprehensive physical and mental development.

The findings of this paper carry implications for research, school health and education policy and physical and general education practice. The results also provide recommendations for students, parents and teachers.

For research, next steps should include investigations of the mixed effects of exercise time, exercise frequency and exercise intensity on student's academic performance. Biological research should also be pursued to elucidate potential physiological mechanisms mediating the differences of effects on academic performance between male and female students.

As *The Sports Law of the People's Republic of China* (2017) stipulated, "Students shall be guaranteed the time they spend on physical activity every day in school." The school administrators should strive to meet the national health objective of daily physical education and offer students a balanced academic program that includes opportunities for physical activity

Lastly, parents should encourage students to strike a proper balance between study and sports, and teachers are supposed to avoid the appearance of some misbehavior which has seriously interfered the going on of physical education. After all, fear of negatively affecting academic performance doesn't seem to be a legitimate reason for reducing students' exercise time or eliminating physical education programs.

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