Research on the influence of physical activity on students' academic achievements based on computer statistical software application

Lingshu Li¹, Junwei Lin¹
¹Department of Physical Education, Shanghai International Studies University, Shanghai, China, 200083

Corresponding author and e-mail: Lingshu Li, susanli409@163.com

Abstract. Due to the long-term concept of light sports in China, enthusiasm for physical activity is often misunderstood by parents as not expressing love. However, it has been proved that moderate to intense physical activity has a positive impact on academic performance. It is harmful to the health of young students to focus only on academic performance and ignore physical activity. In previous studies, there are long-term problems, such as insufficient experimental methods, lack of depth in content, focusing on pure physiological and psychological research, and lack of in-depth research on the relationship between sports activities and academic achievements. Therefore, this study will explore the relationship between physical activity and academic achievement, in order to change the public's original prejudice against physical activity and highlight the importance of physical activity; According to different gender and age characteristics, this paper explores that students' favorite sports have different effects on academic performance, and points out that there are intermediate variables between physical activity and academic achievement, such as aerobic endurance, stress, selective attention, sustained attention, attention shift, self-regulation ability. Physical activity can effectively promote the improvement of these variables, thus affecting academic performance, highlighting the equal status of sports disciplines and other disciplines.

1. Introduction

Recently, the physical and psychological health of students from China or other countries has been declining [1-2], and the obesity rate has been soaring [3], which arouse the concern of all sectors of society. In China, due to the concept that learning is more important than sports in China, being keen on sports activities is often misunderstood by parents that they do not love learning, but it turns out that moderate physical activity has a positive influence on the improvement of academic achievement [4]. However, despite the concern, students in China have to spend more time in schoolwork rather than physical activity, art or extracurricular activities, because of parents’ idea of "Don't let the children lose at the starting line". With this idea which makes students give up their spare time in physical activities, they have a sedentary lifestyle to study, deteriorate their health subsequently, and, finally, their academic achievement declines.

The early research found that physical activities had positive effect on academic achievement [5]. Despite the easy linear relation, some mediated variables, such as physical index or psychological factors, have been introduced into this relationship to some extent [6-7]. However, there is lack of...
systematic experimental study which combines both of the cognitive and physical factors. The study is based on the time and characteristics of junior high school students participating in the period from moderate to vigorous intensity physical activity (MVPA), body oxygen tolerance, stress, self-regulation ability, and various attention distribution among different genders and semester. The physical effects of physical activity on the academic performance of students in different grades in China and their effects under various mediator variables, further verifying the role of physical activity in promoting academic achievement and highlighting the equal status of physical education and other disciplines.

2. Research objects and research methods

2.1. Research objects
In this study, a total of 216 students from the 7th and 8th grades were selected in China, including 122 boys and 94 girls.

2.2. Research methods

2.2.1. Literature method and questionnaire survey. This research focuses on the physical activity and academic performance of the students, obtains published papers and hundreds of master's degree thesis, and borrows dozens of related academic monographs. The Chinese and English literatures are collated and read, and the relationship between physical activity and students' academic achievements is summarized.

And in this study, the self-regulation scale and the perceived stress amount were distributed to the students, and the self-regulation ability and pressure of the students in each school segment were measured to verify the relationship between each factor and the student's academic achievement.

2.2.2. Experimental research method and mathematical statistics. Conducted an experimental study on students of the Chinese Experimental School (Grade 7-8), and measure the participation of students' moderate to vigorous intensity physical activity in each semester from Monday to Sunday (Wgt3X-BT measured), aerobic endurance (measured by PACER), then test students on their own self-regulation ability (measured by self-regulation scale), stress (measured by Perceived Stress Scale), various types of attention distribution (measured by Stroop Test and Trailing Making Test), and academic achievement (measured by New York Test and Computer Science Test).

The data obtained in the study were processed and analyzed by large statistical software spss24.0 and amos22.0.

![Figure 1. The brief research route of the study.](image-url)
3.1. Human exercise energy monitoring instrument (Actigraph Wgt3X-BT)
This study used the human motion energy monitoring instrument (Actigraph Wgt3X-BT) (Figure 2)[8], which can monitor the time distribution of physical activity. Students were required to wear the experimental instrument for 7 days of physical activity testing, and each student veared 8 hours or more per day (8:00-18:00). In the end, students will get an average time of having moderate to vigorous intensity physical activity from Monday to Sunday.

3.2. The Progressive aerobic cardiovascular endurance run (PACER)
This study used progressive aerobic cardiovascular endurance running (PACER) to test the aerobic endurance of students in each semester [9]. The test method was a multi-stage shuttle run created by Leger and Lambert in 1982 with the goal of requiring participation. The person keeps running at a certain speed for as long as possible. Students run back and forth across a 20-meter space at a pace that gets faster each times. A point is gotten for a 20-meter distance finished.

3.3. Self-regulation questionnaire (SRQ-A)
The Academic Self-Regulation Questionnaire (SRQ-A), designed by Ryan and Connell in 1989[10]. The questionnaire is designed to test students' self-regulation ability and involves the reasons for students to do homework. It is suitable for primary and secondary school students. The questionnaire includes 4 dimensions, which are External Regulation, Introjected Regulation, Identified Regulation and Engine (Intrinsic Motivation). In order to obtain the Relative Autonomy Index (RAI), this study evaluated the total scale and used the following formula to combine the subscale scores: 2 × internal engine + identity regulation - injective regulation - 2 × external regulation. In order to assess the overall self-regulation ability of students in this study, the second method was used for calculation.

3.4. Perceived stress scale (PSS)
Sheldon Cohen et al The Perceived Stress Scale (PSS) is used [11]. This scale is the most widely used psychological instrument for measuring the perception of stress. It measures the degree to which situations in one’s life are appraised as stressful, and this scale also includes some direct questions about current levels of experienced stress. The test of reliability and validity shows that the alpha coefficient of the scale is 0.797, so it has better reliability and the discrimination between the entries is higher. Therefore, the scale can be used scientifically to measure the stress level of students of all ages.

3.5. The Stroop color and word test (SCWT)
The Stroop color test is a neuropsychological test that measures selective attention and inhibition control and is widely used experimentally and clinically (Figure 3) [12]. Card A is a color name printed in black ink. Card B is organized similarly to card A, which is composed of red, blue, green, brown, black, yellow, orange, and pink squares. Card C is also organized similarly to card A, representing the interference card. The stimulus is the name of the color, printed with the same color of ink, but the ink color and Color names cannot be the same. For card A, the participant needs to read the word as quickly as possible. For card B, the participant needs to read the color of the color block. For card C, the participant needs to say the color of the printed text instead of reading the text. Scoring Criteria: First, the time to complete each card task is recorded until all errors are corrected in time, and
then by subtracting the average time required to complete the first two subtasks by the time required to complete the third subtask, the average color word interference score can be calculated. \( \text{interference score} = \text{Stroop III} - \left( \frac{\text{Stroop I} + \text{Stroop II}}{2} \right) \). The lower the interference score is, the better the level of selective attention will be, and vice versa. Due to the low error rate of the results obtained in this study, these data were not analyzed (all parts of the Strup color test are in this way).

3.6. Trailing making test (TMT)

The connection test was developed by Parington in 1938 to assess persistent attention and to assess the attention shift[13]. The first part is called Part A (TMTA), requiring the participants to connect 25 randomly arranged number circles on A4 paper in ascending order; the second part is called Part B (TMTB) (Figure 4), requiring connect 12 letters and 13 numbers in alphabetical and ascending order (25 letters and numbers in total). The scores of the test were the time to complete the two tasks separately. If there is an error, the inspector will correct it without stopping the timer until the test is completed. So far, the less time is spent, the better is the level of transfer of sustained attention and attention shift, and vice versa.

4. Research results

4.1. Descriptive statistical analysis of physical activity and academic performance of all students

The moderate to vigorous intensity physical activity (MVPA) was 28.8 minutes; the self-regulation score was -11.88; the average stress score was 15.32; the aerobic endurance run (PACER) was 53.2. The average score of the Stroop Test (Stroop Total) is 122 seconds and that of Trailing Making Test (Trail Total) is 39.8. The Math Grade average grade is 14 and is graded from 1 to 18. Computer Science Grade has an average score of 13, which is also graded from 1 to 18. The average score of the Score Total is 27, which is graded from 2 to 36. It is the sum of Math grade and Computer Science (CS) grade (Table 1).

| Physical Activity and Academic Performance of Students (n=216). |
|---------------------------------------------------------------|
| Minimum value | maximum | Mean  | Standard deviation |
|----------------|----------|-------|-------------------|
| MVPA           | 1.00     | 67.80 | 28.8250           | 20.48901 |
| Self-regulation| -22.00   | -2.00 | -11.8750          | 4.54212  |
4.2. Correlation analysis between the moderate intensity physical activity time and mathematics grade scores of all students

According to the experimental design, this study takes students' moderate intensity physical activity time as the independent variable, takes self-regulation ability, stress level, aerobic endurance running, Stroop Test, Trailing Making Test as mediator variables, and the measured mathematics grade results (in terms of Variable) are used to get a bootstrap test. The results of the analysis showed that, firstly, in the regression coefficient of the independent variable MVPA for each intermediate variable (Table 2), the regression coefficients of MVPA for stress, aerobic endurance, Stroop test and Trailing Making Test were statistically significant. Secondly, in the regression coefficients of the independent variable MVPA and the mediator variable to the mathematical level of the dependent variable (Table 3), the regression coefficients of MVPA and pressure are statistically significant. Finally, the regression analysis of the mathematical level of the dependent variable (Table 4) is performed by the independent variable MVPA to calculate the total effect of the independent variable on the dependent variable. The results show that the regression equation of the MVPA to the mathematical level is significant, and the total effect is 0.1001.

| Table 2. Regression Coefficient Table of Students' MVPA for Each Mediator Variable. |
|---|---|---|---|---|
| Mediator variable | coefficient | Standard error | t | LLCI | ULCI |
| Self-Regulation | .0041 | .0152 | .2689 | -0.0258 | 0.0339 |
| Stress | .0776 | .0108 | 7.2004** | .0564 | .0989 |
| PACER | .8570 | .0629 | 13.6177** | .7330 | .9811 |
| Stroop Total | -2.0690 | .1349 | -15.3333** | -2.3349 | -1.8030 |
| Trail Total | -2.2476 | .0200 | -12.3657** | -2.871 | -2.081 |

*p<0.05, **p<0.01

| Table 3. Regression Analysis of Students' MVPA and Intermediary Variables on the Mathematical Rank of the Dependent Variables. |
|---|---|---|---|---|
| variable | coeff | se | t | LLCI | ULCI |
| MVPA | .0410 | .0123 | 3.3345** | .0168 | .0653 |
| Self-regulation | .0045 | .0313 | .1425 | -0.0572 | 0.0662 |
| Stress | .2942 | .0439 | 6.7004** | .2076 | .3807 |
| PACER | .0063 | .0078 | .8152 | -0.0090 | 0.0216 |
| Stroop Total | -0.0099 | .0236 | -1.7219 | -0.0171 | 0.0027 |
| Trail Total | -.0414 | .0237 | -1.7484 | -0.0882 | 0.0053 |

*p<0.05, **p<0.01

| Table 4. Regression Analysis of Students' MVPA Maths Grades of Dependent Variables. |
|---|---|---|---|---|---|
| R | R-sq | MSE | F | df1 | df2 |
| .6625 | .4390 | 5.4027 | 167.4312** | 1.0000 | 214.0000 |

*p<0.05, **p<0.01
Therefore, through the bootstrap test, MVPA has both significant direct impacts and indirect impacts on the level of mathematics (Table 4-5), where the stress level has a partial mediating effect in both, and the remaining mediators do not statistically find the existence of mediating effects. The total effect, direct effect and indirect effect of the independent variable MVPA on the mathematics grade level of the dependent variable are 0.1001, 0.0410, and 0.0591, respectively. The above results show that the Chinese students' moderate exercise intensity time and stress level have a positive influence on the mathematics level, and the influence of the moderate intensity physical activity time on the mathematics level is partly caused by the mediating effect of the stress level, and the medium exercise Strength time has a positive impact on aerobic endurance and attention.

**Table 5.** Analysis of the total, direct and indirect effects of students' MVPA on the mathematics scores of dependent variables.

| Effect | Effect se | t | LLCI | ULCI |
|--------|-----------|---|------|------|
| .1001  | .0077     | 12.9395** | .0849 | .1154 |
| .0410  | .0123     | 3.3345**  | .0168 | .0653 |

**Total effect of X on Y**

| TOTAL | .0591 | .0153 | .0310 | .0911 |
|-------|-------|-------|-------|-------|
| Self-regulation | .0000  | .0004  | -.0009 | .0011 |
| stress | .0228  | .0052  | .0139 | .0341 |
| pacer  | .0054  | .0050  | -.0042 | .0154 |
| Stroop Total | .0205 | .0120 | -.0017 | .0451 |
| trail  | .0103  | .0061  | -.0005 | .0240 |

*p<0.05, **p<0.01

4.3. *Correlation analysis between student' MVPA time and CS grades*

The results of the analysis showed that in the regression analysis of students' MVPA and mediator variables on the computer science grades of the dependent variables (Table 6), only the pressure had a significant effect on the dependent variable computer science grades. Regression analysis of the computer science grades of the dependent variables by MVPA (Table 7) was used to calculate the total effect of the independent variables on the dependent variables (the regression coefficient of MVPA on computer science grades). The results show that the regression equation of MVPA is not significant to computer science grade. Therefore, bootstrap test results show that Chinese students' time of medium exercise intensity has no direct influence on computer science grades, and each mediator variable does not have a mediating effect on moderate intensity physical activity time.

**Table 6.** Regression Analysis of Students' MVPA and Intermediary Variables on CS Grades of Dependent Variables.

| coeff | se  | t     | LLCI | ULCI |
|-------|-----|-------|------|------|
| MVPA  | -.0270 | .0142  | -1.9031 | -.0549 | .0010 |
| Self-regulation | .0084 | .0360  | .2331 | -.0626 | .0794 |
| Stress | .4328  | .0505  | 8.5666** | .3332 | .5324 |
| PACER  | -.0150  | .0089  | -1.6829 | -.0326 | .0026 |
| Stroop Total | -.0063 | .0042  | -1.5106 | -.0146 | .0019 |
| Trail Total | .0325 | .0273  | 1.1923 | -.0213 | .0863 |

**Table 7.** Regression analysis of students' MVPA on CS grades of dependent variables.

| R | R-sq | MSE | F | df1 | df2 |
|---|------|-----|---|-----|-----|
| .0086 | .0001 | 7.5017 | .0159 | 1.0000 | 214.0000 |

*p<0.05, **p<0.01
4.4. Analysis of the correlation between the MVPA time and total scores of all students

The results of the analysis showed that the regression coefficients of stress and selective attention were statistically significant in the regression coefficients of Chinese students' MVPA and mediator variables for the total score of the dependent variables (Table 8). Regression analysis of the total scores of the dependent variables by the independent variable MVPA (Table 9) was used to calculate the total effect of the independent variables on the dependent variables (the regression coefficient of MVPA to the total score). The results showed that the regression equation of MVPA for the total score was significant. The effect is 0.0990.

Table 8. Regression analysis of students' MVPA and mediator variables on total scores of dependent variables.

|                | coeff | se   | t     | LLCI  | ULCI  |
|----------------|-------|------|-------|-------|-------|
| MVPA           | .0141 | .0147| .9589 | -.0149| .0430 |
| Self-regulation| .0129 | .0374| .3442 | -.0608| .0865 |
| Stress         | .7270 | .0524| 13.8746**| .6237| .8303 |
| PACER          | -.0087| .0093| -.9396| -.0270| .0096 |
| Stroop Total   | -.0163| .0044| -3.7372**| -.0248| -.0077|
| Trail Total    | -.0089| .0283| -3.153| -.0647| .0468 |

*p<0.05, **p<0.01

Table 9. Regression analysis of students' MVPA on total scores of dependent variables.

| Model Summary |
|---------------|
| R            | .5050 |
| R-sq         | .2551 |
| MSE          | 12.0639 |
| F            | 73.2715** |
| df1          | 1.0000 |
| df2          | 214.0000 |

*p<0.05, **p<0.01

Through the bootstrap test, the direct and indirect effects of Chinese students' MVPA on total scores are significant (Table 10), in which stress level and stoop total have partial mediating effects between them, and the other mediator variables do not statistically find mediating effects. The total effect, direct effect and indirect effect of the independent variable MVPA on the total level of the dependent variable are respectively 0.0990, 0.0141, and 0.0849. The above results indicate that moderate exercise intensity time, stress level, and selective attention level have positive effects on total scores, and the influence of Chinese students' moderate exercise intensity time on their total scores is partly caused by the mediating effect of stress level and selective attention.

Table 10. Total effect, direct effect and indirect effect of Chinese students' MVPA on total scores of dependent variables.

| Total effect of X on Y                  | se   | t     | LLCI  | ULCI  |
|----------------------------------------|------|-------|-------|-------|
| EFFECT                                 |       |       |       |       |
| .0990                                  | .0116| 8.5599**| .0762| .1218 |
| Direct effect of X on Y                | se   | t     | LLCI  | ULCI  |
| EFFECT                                 | .0147| .9589| -.0149| .0430 |
| Indirect effect(s) of X on Y           | Effect| BootSE| BootLLCI| BootULCI|
| TOTAL                                  | .0849| .0227| .0430| .1315 |
| Self-regulation                        | .0001| .0006| -.0013| .0012 |
| Stress                                 | .0564| .0099| .0378| .0775 |
| PACER                                  | -.0075| .0074| -.0224| .0070 |
| Stroop Total                           | .0337| .0141| .0070| .0623 |
| Trail Total                            | .0022| .0087| -.0137| .0211 |

*p<0.05, **p<0.01
5. Conclusions
The average daily time of medium intensity exercise of Chinese students is close to half an hour. The average grade of mathematics is 14 and the average grade of computer science is 13. The full scores of both subjects are 18. The total score is 27, with a maximum of 36, which is 75 points in the percentage system. Meanwhile, the longer the Chinese students have medium intensity exercise everyday, the better the mathematics scores and total scores are. The results shows that the medium exercise intensity of Chinese students has successfully affected the mathematics scores and total scores, and the stress level and selective attention play an intermediary role. Physical activity improves selective attention, which improves students' math scores and total scores, but the pressure is getting greater. Also, the physical activity of Chinese students has a positive impact on aerobic endurance and attention.

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