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Retraction

Retracted: Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope

(2) Discrepancies in the description of the research reported

(3) Discrepancies between the availability of data and the research described

(4) Inappropriate citations

(5) Incoherent, meaningless and/or irrelevant content included in the article

(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] X. Xiang and Q. Wang, "Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence," *Mobile Information Systems*, vol. 2022, Article ID 1106573, 10 pages, 2022.

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Research Article

Physical Exercise Improves Academic Performance: Based on CNKI Meta-Analysis Evidence

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Background. It has long been a major source of debate in academic circles whether physical activity has a positive or negative effect on academic performance. Although this subject has been covered in several studies at various levels, only a small number of researchers have examined and supported the data found in the literature. *Methods*. A meta-analysis is used to thoroughly examine the literature on physical exercise and academic performance included in the China National Knowledge Infrastructure (CNKI) database. After three rounds of searching, screening, and according to the criteria of literature inclusion, 13 valid documents are obtained for analysis with 90 final indicators. *Results*. (1) Physical exercise has a significant effect on academic performance; (2) physical exercise has a significant effect on single-subject performance, and there are no group differences in academic performance between different subjects; and (3) different exercise intensities have a significant effect on academic performance and significant differences in academic performance. *Conclusions*. (1) Physical exercise can improve academic performance and should increase students' physical education participation; (2) physical exercise in different disciplines should hold physical education as equal to other cultural subjects; and (3) sports exercise with different sports intensities has different benefits for academic performance, and sports should be scientifically designed to achieve the maximum effect on academic performance.

1. Introduction

School physical education plays an important role in students' physical and mental health and learning and growth and has become a key factor affecting the future development of young people. It has been a concern of the Chinese national government and of ordinary people in the new era. On September 10, 2018, President Xi Jinping provided important instruction at the National Education Conference to give play to students to "enjoy fun, enhance their physical fitness, improve their personality, and temper their will," summarizing the value and role of sports and pointing out the development direction for an in-depth reform of school sports work in the new era. In the new era, all levels of society, especially sports workers, need to correctly interpret the connotations and practice paths of school sports and other problems. In 2020, the general office of the CPC Central Committee and the State Council issued policies for comprehensively strengthening and improving the new era of school physical education work by deepening the reform of the overall new era education evaluation plan, such as through policy, strengthening school physical education, training, and improved physical education to enhance youth physical health. The policy focuses on strengthening sports evaluation and thoroughly discussing national education. The numerous policy enactments illustrate that the national government and school education and sports departments work in different ways to clearly guide teenagers to participate in sports and exercise in ways conducive to their healthy growth. The earlier issued Opinions on Strengthening Youth Sports and Enhancing Youth Physical Fitness document points out that "the decline in students' physical health is mainly due to the influence of the one-sided pursuit of enrollment rates and the tendencies of intellectual education and physical education in social and school life" [1]. Under the influence of exam-oriented academic pressure, more students in the education system, dedicate more time and energy to their academic performance and sacrifice their

physical exercise, which is due to the influence of traditional education and teaching ideas [2]. At the same time, to improve students' cultural performance, schools often replace physical exercise and education [3]. In response, the General Office of the State Council issued Opinions on Strengthening School Sports and Promoting the All-round Development of Students' Physical and Mental Health to encourage young people to develop good habits of actively participating in physical exercise. However, the country strongly advocates for the current gap between students' active participation in physical exercise and the current social environmental support of students, and the time and intensity students dedicate to participating in physical exercise do not meet the requirements, which not only affects students' physical and mental health but also their academic performance [4].

Can physical exercise improve academic performance, and how do the two affect each other? Academic circles have long paid attention to the associations between physical exercise and adolescent cognitive processing ability and academic performance [5]. Specifically, physical exercise can maintain and improve cognitive ability by enhancing synaptic function, gene expression, and blood oxygen function in cognitive processing-related brain regions [6]. Scholars, using different forms of theoretical speculative elaboration, questionnaires, and empirical classes, have learned about physical exercise and academic performance since the middle of the last century and have combined social science methods in the new era; as a result, academic achievements have improved [7]. Most scholars in this area believe that appropriate physical exercise can positively affect academic performance but that under China's current education system, parents and some school administrators prioritize academic performance and pursue investment in cultural learning such that students do not have enough time for physical exercise. It is urgently necessary to recognize the importance of students' physical exercise at different levels, change the misconception that "physical exercise negatively affects academic performance," and carry out systematic and rigorous verification of long-term, relevant academic research results. As an in-depth empirical means of analyzing existing documents, meta-analysis has been recognized at home and abroad in recent years and has been applied increasingly widely in different fields. From medicine to pedagogy to psychology, the use of this approach in different disciplines is increasing [8]. Thus, we conduct a systematic literature review of early academic research and then code and screen the literature according to scientific standards. We in turn analyze and discuss the logical relationship between physical exercise and academic performance to strengthen scientific and evidence-based research support for students to actively participate in physical exercise.

2. Literature Review

With the continuous development of the sports discipline, many scholars have developed different conceptual definitions and divisions of "physical exercise" for different stages. For example, Caspersen et al. [9] define physical exercise as regular physical exercise; the China Sports Dictionary [10] defines it as a physical activity process that improves physical health and quality through participation in various sports; and Luyuan [11] believe that physical activity can enrich spiritual and cultural activities and promote physical health and development. In sports including ball sports such as basketball and football and long jump and other track and field sports, aerobic and anaerobic activity and low-, medium-, and high-intensity activities are combined in a single sport [12]. Upon searching the literature related to "physical exercise" and "academic performance," it was found that the corresponding literature focuses on the concepts enumerated above. Therefore, the present research is conducted at a macro level. "Physical exercise" includes physical education teaching, after-school physical activities, and extracurricular sports training conducted in school physical education. "Academic performance" mainly covers overall performance, average scores in different disciplines, and results for a single subject.

Foreign researchers believe that 2 hours of physical exercise per week is not enough to have a positive impact on students [13]. Che [14] analyzed the influencing factors of physical exercise time in the realms of school and family and found that an increase in time spent engaged in physical exercise for middle school students helps improve performance; studies show that medium-intensity physical exercise has a positive impact on academic performance over 10 weeks when done 3 times a week, increasing physical education time by approximately 60% [15]. In addition, students with excellent grades engage in a significantly longer period of physical exercise than students with average grades, and short duration, moderate intensity exercise may affect cognition. Crush [16] compared the effects of five different motor skill use durations on cognition and found that significantly increased cognitive function began after 30 and 45 min of exercise without significant alterations. Motor characteristics, including intensity and duration, may play a role in regulating the effects of exercise on motor learning. Although there is some evidence for high-intensity and relatively long-duration exercise, Ana et al. [17] evaluated the effects of long and short-intensity physical activity on memory and found that both long and short-duration exercise favors memory retention and improvement in a time-limited environment. Of course, studies have also found that single sessions of moderate to vigorous exercise have a positive impact on cognitive outcomes in children and adolescents. However, the dose-response effect of exercise duration is largely unknown. Individuals not only do not improve their cognitive performance after physical exercise activity lasting 10, 20, or 30 min, but adolescents also show no significant decrease in cognitive performance than under sedentary conditions [18]. Lingshu and Liu [19] found that the longer primary and secondary school students participate in physical activity, the more they participate in physical activity every week, and the better their academic performance becomes. Because of the positive effect of exercise on the human body and spirit and other aspects, physical exercise enhances the flexibility of the central nervous system, improves the balance of interactions between excitement

and inhibition processes, improves individual response abilities, and then improves learning efficiency. In addition, physical exercise also stabilizes students' emotions and improves their ability to withstand academic pressure.

In conclusion, intervention effects of different exercise intensities on academic performance vary. High-intensity physical activity can cause burnout, resulting in a negative effect on learning motivation and learning states. Moderate-intensity exercise enhances and maintains physical oxygen levels, blood circulation, and learning interest, while low-intensity exercise has the least significant effect on learning. However, domestic and foreign research is still insufficient, and the changing and causal relationships between different exercise intensities and academic performance still need to be more thoroughly and comprehensively researched.

A large number of studies have found that different sports programs have different effects on academic performance. Zhang et al. [20] replaced the traditional physical education teaching mode with instruction in professional sports such as football and aerobics and found that traditional physical education courses have a complex impact on students' academic performance. After short-term physical intervention, students' English and Chinese scores increased, but girls' scores in math decreased; after long-term physical intervention, students' Chinese scores improved, while their English and math scores decreased. Phinikaridou et al. [21] found through a 14-week track and field training program that the music and various language scores of the experimental group were significantly higher than those of the control group; in addition, the self-esteem of the experimental group significantly improved after training. Chinese researchers, through a physical intervention study of high school students, found that engagement in cheerleading gymnastics is significantly related to academic performance among high school students. Cheerleading gymnastics has also significantly improved students' Chinese, math, and foreign language performance [22]. Different ball sports also have different effects on academic performance.

The above research shows that different physical exercise programs have different effects on academic performance, although most studies have found that after an intervention, the change in academic performance does not achieve statistical significance. Studies have shown that physical activity does indeed change structural function, gene expression, hormones, and neurotransmitter function in the brain. However, we found no evidence of a causal relationship between these physiological changes and academic performance [6, 23]. In addition, different physical exercise programs have different requirements for individuals' skills. For example, basketball, football, volleyball, and other team sports require a high degree of cooperation between individuals, and table tennis requires considerable skill. Therefore, why different sports lead to inconsistent research results needs to be explored in more comprehensive studies.

From the above summary of relevant studies conducted at home and abroad, there has been much research on the relationship between physical exercise and students' academic performance, and it has had a positive effect on encouraging teenagers to actively participate in physical exercise. However, in China's social environment, in studies on physical exercise and students' academic performance, relevant issues should be addressed through national policies. Further, future work must explore the logical relationship between physical exercise and students' academic performance. Studies rarely use a meta-analysis of research methods to measure the relationship between physical exercise and students' academic performance. The failure to reveal the intrinsic connections between these variables based on scientific studies makes it impossible to provide theoretical support for parents seeking to actively encourage their children to engage in physical exercise. Finally, regarding study subjects, studies lack a focus on the effects of physical exercise on adolescents and especially the impacts of different sports programs on students' academic performance. Such work can help school departments actively promote physical exercise in youth courses, constituting an important area for further research.

3. Materials and Methods

3.1. Hypothesis. Does exercise have an impact on academic performance? (RQ1)

Can physical activity have an impact on performance in a single subject? (RQ2)

What impact do various exercise intensities have on academic performance? (RQ3)

3.2. Research Type and Data Analysis. Quasi-experimental research documents related to physical exercise and academic performance were searched and screened using the CNKI journal and master's doctoral literature database, data were compiled in strict accordance with the meta-method procedure, and the effect of physical exercise on academic performance was analyzed to further clarify the relationship between the two. In meta-analyses, the standard mean deviation (SMD) and weighted mean deviation (WMD) are usually used. When research methods or interventions are inconsistent, the SMD should be selected as the effect scale index of a meta-analysis. Therefore, the SMD is used as the effective value after combining different documents.

The included literature was used for data analysis using RevMan5.3 software. After obtaining the literature, the data were first tested for heterogeneity; if $P > 0.1$ and $I^2 < 50\%$, a fixed-effects model was used; if $P < 0.1$ and $I^2 > 50\%$, a random-effects model was used. The effect values include the SMD and 95% confidence interval. Forest maps (forest plots) are a common expression form used to directly describe the results of a meta-analysis. A forest map is an intuitive graph based on statistical indicators and drawn from the results of statistical indicators and numerical methods. It judges the relationships between studies by describing the effect sizes and confidence intervals used in studies, and a 95% confidence interval that does not include 0 is statistically significant. A funnel diagram (funnel plot) is used to measure publication bias in the literature, the biased distribution and the graphic asymmetry of the employed design; if at the top

of the funnel there is no publication bias, this denotes a high level of research accuracy [24, 25].

When an original study specifies the mean, standard deviation, and sample size of the experimental group and controls and applies the same operation for the outcome variables (ESIM), the standard mean deviation of the calculation formula, SMD, is as follows:

$$\text{SMD} = \frac{M_1 - M_2}{S_P}, \qquad SP = \sqrt{\frac{(n1-1)s12 + (n2-1)s22}{(n1-1)+(n2-1)}}. \tag{1}$$

M_1 and M_2 are the mean values of the experimental and control groups, S_P denotes the combined standard deviation of the two data groups, n_1 and n_2 denote the sample sizes of the experimental and control groups, respectively, and s_1^2 and s_2^2 are the standard deviations of the two groups, respectively. When the sample size was less than 20, a corrected effect size formula was applied to reduce the study bias:

$$\text{SMD}' = \left[1 - \frac{3}{4N-9}\right]\text{SMD}. \tag{2}$$

3.3. Data Sources. To screen for compliant and exhaustive subject-related literature data wherever possible, we applied a three-phase screening process. The first round was conducted through the CNKI China Knowledge Series knowledge database using search terms "physical exercise," "sports," "physical activity," "sports," "physical sports," "sports project," "academic performance," "cultural performance," and "learning performance" for 1949–2020 and for core journals (CSSCI, CSCD, and Peking University Core) and doctoral programs. The second round of study on primary articles eliminated experimental work not involving academic performance test data and other documents, leaving 8 journal papers and 14 master's and doctoral papers. The data extraction table produced in the third round was used for index data extraction, from which incomplete indicators and missing data were removed. A total of 13 documents conforming to the meta-analysis requirements were finally included, and a total of 90 entries were collated.

3.4. Data Exclusion Criteria. The included studies have the following features.

(1) The studies conduct quasi-experimental research that explores the relationship between physical exercise and academic performance; independent variables for physical exercise, physical sports, physical activity, physical activities, and sports; and dependent variables for academic performance, learning performance, and other themes.

(2) The studies' quasi-experimental designs include experimental and control groups.

(3) These studies show no significant differences between the pretest results of the experimental and control groups.

(4) The sample sizes of the experimental and control groups are clear with no obvious differences between the two.

(5) Mean, standard deviation, *t* value, *p*-value, and other statistical indicators used are complete.

We exclude the following work:

(1) nonexperimental documents, such as reviews, meeting minutes, and reports;

(2) studies with unclear academic performance indicators (e.g., fair, good, and excellent performance measures used to describe academic performance);

(3) nonexperimental studies set, such as studies with a single experimental group.

(4) studies with missing research data indicators, such as the mean and standard deviation of the pretest data.

3.5. Data Extraction and Encoding. We used Excel 2010 to encode features of each selected study, including the author(s), year of publication, sampling method, sample size, sample grade, duration of physical exercise intervention, physical exercise form, and specific physical items, as detailed in Table 1. Features of the included literature show that the effects of physical exercise on academic performance began to increase after 2015; convenience sampling methods were used to collect study samples; most experimental and control study samples included approximately 30 people; most experimental subjects came from primary and secondary schools; most physical exercise interventions were studied in 8–12-week interval; physical exercise mainly involved classroom exercise; only two studies considered extracurricular training; and studies have explored a variety of sports and physical education classes of varying intensity. The projects included in the literature are relatively comprehensive, but there are still insufficient. Research on primary and secondary schools, vocational colleges, and junior colleges is still limited, and there have been few studies on the impacts of specific sports projects on academic performance.

4. Results

4.1. Publication Bias Test. Since literature with significant results is more susceptible to editing for publication, search terms, search tools, and limitations of the search process, relevant literature on physical exercise and academic performance could not be fully retrieved and included in this meta-analysis. This may lead to an exaggerated association between physical exercise and academic performance. Therefore, literature inclusion bias is considered through publication bias tests. There are multiple ways to assess publication bias, including funnel diagrams and Egger's test. The funnel plot method was used to assess publication bias, and the results are shown in Figure 1. According to the

Table 1: Meta-analysis data collation.

Author	Year	Sampling method	Sample size	Grade	Physical exercise intervention duration	Exercise form	Specific physical exercise items
Ni Qi	2018	Convenience sampling	CG:39IG (1):41IG (2):36	Grade five	IG (1): 3 times/week for 6 weeks; IG (2): 3 times/week for 12 weeks	Classroom exercise	Medium-intensity basketball and synchronized rope skipping combination
Zhou Banglun	2017	Convenience sampling	CG:48IG (1):50IG (2):51IG (3):51	Grade three	12 weeks	Classroom exercise	Physical education class of varying intensity
Sang Hongkun	2017	Convenience sampling	CG:40IG (1):43IG (2):43	Grade one	Three times/week for 10 weeks	Classroom exercise	Physical education class of varying intensity
Yan Yun	2019	Convenience sampling	CG:39IG (1):40IG (2):43	Grade one	12 weeks	Classroom exercise	Physical education class of varying intensity
Zhu Lin	2020	Convenience sampling	CG:31IG(1): 31IG(2):31	Grade five	12 weeks	Classroom exercise	Physical education class of varying intensity
Fan Yarong	2016	Convenience sampling	CG:49IG (1):50IG (2):51IG (3):50IG (4):50	Grade two	3 times/week for 8 weeks	Classroom exercise	Athletics, basketball, and table tennis
Huang Lingling	2016	Convenience sampling	CG:37IG (1):33IG (2):39IG (3):34	Grade one	2 times/week for 8 weeks	Classroom exercise	Basketball project
Yang Dan	2017	Convenience sampling	CG:30IG (1):30	Grades one and two	Ten weeks	Extracurricular training	Cheerleading
Yu Tingting	2016	Convenience sampling	CG:22IG (1):18IG (2):29	Grade six	Ten weeks	Classroom exercise	Basketball
Zhao Yufeng	2016	Convenience sampling	CG (1):12IG (1): 12; CG (1):7IG (1):7; CG (1):6IG (1):6; CG (1):7IG (1):7	Grades one, four, five, and six	Six times/week and 15 weeks/semester for 270 weeks	Classroom exercise and extracurricular training	Volleyball
Zhang Peipei	2016	Convenience sampling	CG:40IG (1):37	Grade five	2 times/week for 8 weeks	Classroom exercise	Soft bar softball
Liu Si-Liang	2017	Convenience sampling	CG:41IG (1):44IG (2):44	Grade one	Three times/week for 10 weeks	Classroom exercise	Physical education class of varying intensity
CAI Yaohui	2020	Convenience sampling	CG:24IG (1):12IG (2):12	Senior class	Nine weeks	Classroom exercise	Table tennis

Note: CG: control group (control group); IG: intervention group (intervention group).

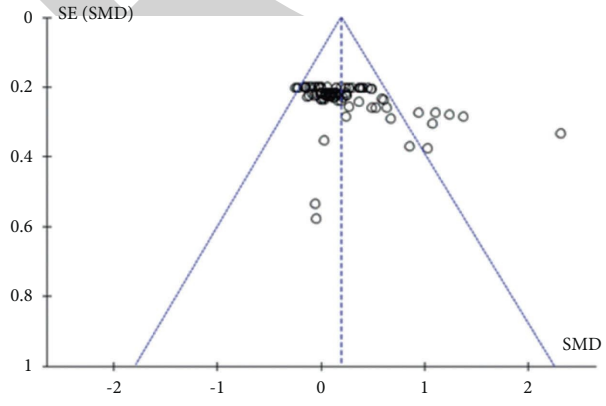

Figure 1: Publication bias funnel plot test.

results given in Figure 1, the data of the included samples are evenly distributed around effect value ES = 0.20, and the data are concentrated in the middle and upper parts of the funnel map with fewer studies outside of the funnel, indicating no obvious publication bias and the high accuracy of this study.

4.2. Effect of Physical Exercise on Academic Performance. To determine the overall effect of physical exercise on academic performance, 13 studies meeting the criteria and a 90 effect size were analyzed. The heterogeneity test results show that $I^2 = 53\%$ ($50\% < I^2 < 75\%$). The samples of the 13 independent studies included reach significance levels according to the heterogeneity test criteria. From the random effect model, combined effect size ES = 0.20, 95% CI = [0.13,0.26], and confidence interval excluding 0, $Z = 5.58$, $P < 0.001$, the results are shown in Figure 2. The analysis

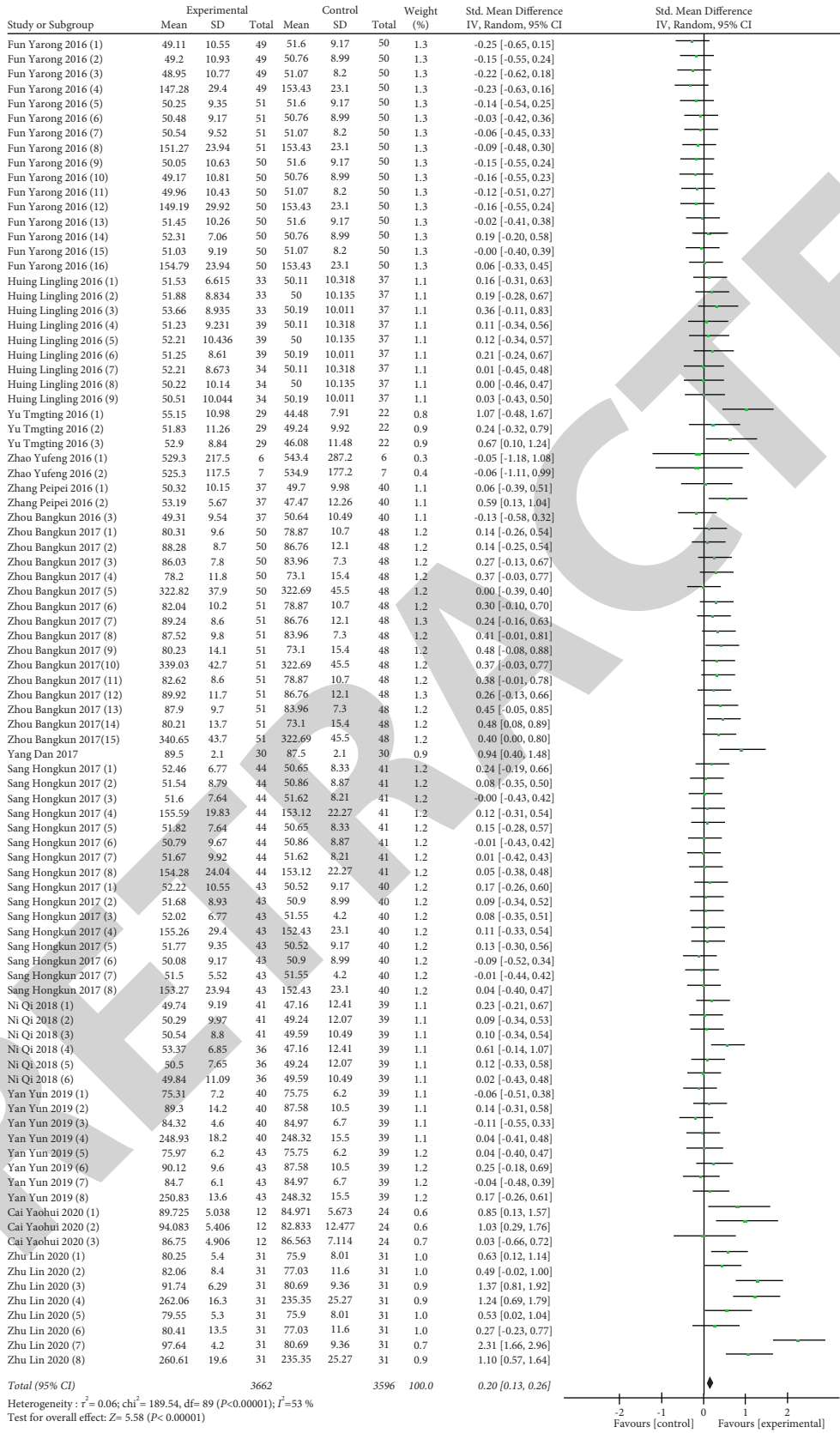

Figure 2: Effect of physical exercise on academic performance.

shows that the overall effect value of the random effect model is greater than 0 and reaches an extremely significant level, indicating that physical exercise significantly improves academic performance.

4.3. Impact of Physical Exercise on Academic Performance in Different Subjects. From the overall analysis, physical exercise has a positive effect in promoting academic performance. To analyze its specific effects, we further analyzed the effect of physical exercise on performance in different disciplines. Analysis data based on the details of the included literature are summarized in Table 2. The results show that a combined effect size of SMD = 0.22, $Z = 2.23$, and $P < 0.01$, and the studies reach significance at the 0.01 level, indicating a positive effect of physical exercise on performance in different disciplines. As shown by the specific effect sizes of different subjects, students showed significant positive improvements in Chinese (SMD = 0.18, $P < 0.01$), math (SMD = 0.26, $P = 0.01$), English (S MD = 0.19, $P < 0.001$), and physical performance (SMD = 0.44, $P < 0.01$). The effect P value between groups is 0.29 ($P > 0.05$), indicating no difference in effects of physical exercise across different disciplines and showing a relatively stable effect. Moreover, most of the effect sizes are small between 0.14 and 0.45, indicating that physical exercise has a small to moderate effect in improving learners' performance in different subjects.

4.4. Regulatory Effects of Different Exercise Intensities on Academic Performance. To further explore the effect of physical exercise on academic performance, the included literature was analyzed by induction. It was found that different exercise intensities have different effects on academic performance. Therefore, to further clarify the variability in the influence of different exercise intensities on academic performance, the literature included in the study was classified by study exercise intensity, a total of 72 effect sizes were included, and the specific data are shown in Table 3 for analysis. The data show a P-group effect P value of different exercise intensities on academic performance of $P < 0.001$, reaching a statistically significant level, indicating that the effects of different physical exercises on students' academic performance vary. The data show that exercise intensity levels of approximately 60% to 80% are more significant than other exercise intensities in improving academic performance.

5. Discussion

According to the above research results, physical exercise has a positive effect on promoting students' academic performance. This finding is consistent with the results of Yannis et al. [5], Xu [23], Getu [26], and Colak et al. [27]. This may be because physical exercise can improve the synthesis of certain neurotransmitters (such as dopamine and acetylcholine), improve nerve conduction speed, and thus improve cognitive processing speed and cognitive performance [6, 23], which has a positive effect on students' academic performance. In addition, physical exercise can effectively relieve students' learning anxiety, change students' emotional states, improve students' learning efficiency and learning effects, and promote the improvement of students' academic performance [28].

However, the above results are inconsistent with the work of Daley and Ryan [29], who argue that it is not that physical exercise that helps students improve their academic performance but rather that better academic performance encourages students to participate in more physical exercise. This finding may be related to the research approach the authors use, which does not involve an experimentally controlled intervention. In addition, Ahamed et al. [30] found a negative correlation between physical exercise and academic performance, but the correlation was very weak and not significant, potentially because the time of exercise and exercise intensity setting are not reasonably related. Deng et al. [31] found that physical exercise performed beyond a certain time and intensity has a negative impact on students' academic performance. However, this article, through a comprehensive combination of literature and meta-analysis, found that physical exercise and academic performance are significantly improved. The influencing mechanism may be such that physical exercise makes abstract learning content visualization, visualization, and knowledge increasingly situational. Students independently explore in a naturally interactive way, which deepens students' understanding of knowledge. Qualitative change influence occurs imperceptibly during the process of prolonged quantitative accumulation [32].

The effects of physical exercise on academic performance in different subjects show that physical exercise has a certain effect on various disciplines, while the differences between different disciplines do not reach a statistically significant level, indicating that the impact of physical exercise on academic performance in different disciplines does not significantly differ. This result is not consistent with the results of Zhang [33] but is consistent with the results of Qi [34], Tingting [35], and Dan [22]. This may be due to the need for physical exercise programs to have a stable and consistent focus on team competitive sports. These sports improve the quality of individual attention [34], increase attention and learning efficiency, and finally, promote academic performance [36]. However, there are no significant differences in the effects of physical exercise on different disciplines, which shows that physical exercise will not significantly improve performance in a certain discipline, and the impact on academic performance is comprehensive.

There are differences in the beneficial effects of different exercise intensities on academic performance, and approximately 60%~80% exercise intensity has an obvious effect on academic performance. This shows that different exercise intensities have different effects on the improvement in academic performance, and moderate-to high-intensity exercise has the most significant effect in improving academic performance. This is consistent with the results of Elizabeth et al. [16], Banglun [37], and Aiguo et al. [38] and partly consistent with the results of Xinnan [39] but not consistent with the results of Jian and Shiliang [15]. This may

Table 2: Differences in effects of physical exercise on academic performance in different disciplines.

Subject	Number of effects	Effect level (SMD)	95% confidence interval		Z	Effect conspicuousness	Differences between groups
			Superior limit	Lower limit			
Chinese	23	0.18	0.07	0.30	3.09	$P < 0.01$	$P = 0.29$
Mathematics	23	0.16	0.07	0.26	3.40	$P < 0.001$	
English	23	0.19	0.01	0.36	2.10	$P < 0.01$	
Physics	3	0.44	0.21	0.68	3.78	$P < 0.001$	
Amount	18	0.22	0.03	0.41	2.23	$P < 0.01$	

Table 3: Differences in the effects of different exercise intensities on student academic performance.

Exercise intensity level (%)	Number of effects	Effect level (SMD)	95% confidence interval		Z	Effect size significance	Differences between groups
			Superior limit	Lower limit			
30	4	−0.21	−0.41	−0.02	2.12	$P = 0.030$	$P < 0.001$
40	7	0.03	−0.13	0.19	0.33	$P = 0.740$	
50	23	0.16	0.02	0.30	2.29	$P = 0.020$	
60	28	0.21	0.08	0.33	3.15	$P = 0.002$	
70	5	0.36	0.18	0.54	3.94	$P < 0.001$	
80	5	0.40	0.22	0.57	4.37	$P < 0.001$	

be because Jian and Shiliang [15] only considered the role of moderate-to high-intensity exercise on learning with no systematic longitudinal comparison of multiple motor strengths, while Elizabeth et al. [16] and Ali et al. [40–42] compared multiple levels of intensity. This result may also be related to the different arousal effects of different sports on learning motivation, with low intensity and low arousal levels having little effect on students' learning enthusiasm. For example, Xinnan [39] found that high exercise intensity had a negative effect on students, moderate exercise intensity was accompanied by positive emotions, and the relation between low exercise intensity and emotional arousal was weak. Considering the above results, different exercise intensities have a positive effect on promoting academic performance. In addition, there are also significant differences between the effects of exercise intensities, with approximately 60%~80% exercise intensity having the best effect on promoting learning.

6. Conclusion and Suggestions

6.1. Conclusions. First, physical exercise can improve academic performance. Through the present in-depth analysis of publication bias, effect size, significance, and other indicators by meta-analysis, we not only confirm that physical exercise proposed in the previous research literature improves learning but also further show that the effect of physical exercise in promoting academic performance is significant and empirical. This strongly refutes the false perception that physical exercise will delay academic performance and provides a better theoretical basis for the dialectical relationship between physical exercise and curriculum learning.

Second, physical exercise improves performance in different subjects. Upon confirming that physical exercise improves overall academic performance, we further analyzed how physical exercise improves performance in different subjects, such as Chinese, mathematics, English, and physics, and no group differences were found between these subjects. Those with a focus on education, including schools, parents, and social training institutions, must stop ignoring the importance of physical education and other subjects and view them as of equal "status," and physical exercise should be prioritized to improve school performance and allow the associated benefits to complement each other.

Third, certain levels of physical exercise intensity are more effective in improving academic performance. The present analysis shows the influence of different sports intensities on academic performance and demonstrates that 60%~80% exercise intensity has the best effect on academic performance. Thus, professionals such as physical education teachers and coaches can refer to this sports theory to enable the maximum effect on academic performance.

6.2. Research Recommendations. First, teachers' application of physical activity technology should be improved. Givent the positive impact of physical activity on overall academic performance, we call to accelerate the application of teaching models for physical activity, incorporate a targeted teaching design, and make full use of the technical characteristics of physical activity to improve students' academic performance. In addition, teachers can introduce physical activity technology into low-level courses to enable teaching content to have targeted and visual effects, stimulate students' learning interest and attitudes, and thus enhance students' subjective initiative. Finally, in view of the unsatisfactory effect of physical activity among middle school students, we recommend increasing the application of and research on physical activity in junior high schools and further exploring the internal logical relationship between physical activity and students' academic performance.

Second, sports subjects should be given the same status as other cultural subjects. As different sports programs have good applications in most disciplines, they have good discipline applicability. This study demonstrates that importance should be attached to deep integration between different movements and disciplines. In addition, teachers should combine discipline characteristics and make full use of the technical advantages of various physical exercises to carry out teaching innovation. For the main subjects of Chinese, mathematics, and English, teachers should make full use of different sports skills, build a rich teaching environment, apply role playing, and build students' personal knowledge. For science courses such as physics, teachers should make full use of different sports techniques to present formula theorems and structures through 3D models and animations to embody and visualize abstract knowledge, reducing students' cognitive burden, and enhancing their information processing, restructuring, and reconstruction capabilities.

Finally, scientifically based physical exercise programs must be developed. Physical sports have an obvious role in promoting students' performance. Thus, schools must constantly develop and apply diversified sports programs and physical exercise activities and enhance students' knowledge of physical exercise programs to encourage students to actively participate in physical exercise and then relieve their negative psychological states and emotions. Such an approach can change students' physiological states, improve their focus, and continue to improve their academic performance.

6.3. Research Limitations. Due to limitations on time and objective factors, we call for a further extension of this study. First, we evaluated the impact of physical exercise on academic performance overall without considering specific processes of learning. Second, we only systematically reviewed the relevant domestic literature and did not examine foreign literature, and we thus conducted no systematic evaluation of the influence of cultural differences. Therefore, future research should refine the impacts of physical exercise on memory, cognition, thinking and other aspects. In addition, domestic and foreign literature should use other methods to further discuss the relationship between physical exercise and academic performance.

Data Availability

The datasets used during the current study are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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