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Article

The effects of table tennis on the eyesight of primary and middle school students: A meta-analysis

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Abstract: Objective: To systematically evaluate the influence of table tennis on the eyesight of primary and secondary school students. Methods: Literature research was conducted by computerized search of CNKI, Wanfang, and VIP databases, Web of Science, Embase, PubMed, and The Cochrane Library databases for randomized controlled trials on table tennis exercise on students' visual health. Traditional Meta-analysis, subgroup analysis and sensitivity analysis were performed sequentially using Stata 17.0 and Review Manager 5.4 (RevMan5.4 for short). Results: A total of 11 papers with 670 study participants were included for analysis. The effect of table tennis exercise on students' visual acuity improvement was statistically significant in the experimental group compared to the control group, whose total effect of the literature showed that the left eye [SMD = 1.41, 95% CI (0.95, 1.87), Z = 6.02, P < 0.001] and the right eye [SMD = 1.59, 95% CI (1.08, 2.11), Z = 6.07, P < 0.001] ; subgroup analysis also showed that table tennis sport intervened on left eye vision [SMD = 1.51, 95% CI (0.89, 2.13), P < 0.001] and right eye vision [SMD = 1.72, 95% CI (1.01, 2.42), P < 0.001] in primary school students versus table tennis sport in secondary school students' left eye vision [SMD = 1.23, 95% CI (0.68, 1.78), P < 0.001], and right eye visual acuity [SMD =1.33, 95% CI (0.99, 1.67), P < 0.001] were statistically significant for prevention and protection of vision. Conclusion: Table tennis exercise interventions have been shown to have a positive effect on preventing and protecting the visual health of primary and secondary school students, and different table tennis exercise cycles, exercise duration, and frequency of exercise and other sports also have a significant effect on preventing and protecting the visual health of primary and secondary school students.

Keywords: table tennis; middle school students; primary school students; visual acuity; meta-analysis

1. Introduction

The prevalence of myopia is showing a significant upward trend globally, increasingly becoming a serious public health issue for the coming decades. According to statistics from the World Health Organization's "World Report on Vision," published in October 2019, it is estimated that the number of myopic individuals worldwide will reach 2.62 billion by 2020 and further increase to 3.36 billion by 2030 [1]. The number of individuals with high myopia is also expected to rise dramatically from 399 million in 2020 to 516 million by 2030. By 2050, it is projected that the prevalence of myopia will affect 65% of the Asian population, 56% of the Western European population, 54% of the Central European population, and 50% of the Eastern European population [2]. In the past decade (2005–2015), the prevalence of myopia among East Asians has increased by 23% [3].

Research indicates that the prevalence of myopia varies across different countries and regions, but the rates among adolescents continue to rise. Fan et al. reported that the prevalence of myopia among preschool children in Hong Kong (average age 4.66 years; range 3–6 years) significantly increased from 2.3% to 6.3% over a decade [4]. The incidence of myopia in high-risk groups begins to rise sharply around the age of 6. In Australia, a cross-sectional study of 12-year-old children reported an increase in prevalence from 11.5% in 2006 to 18.9% in 2011. In Northern Ireland, the prevalence among 12-year-olds rose from 17.7% in 2007 to 22.8% in 2017. Similarly, between 2001 and 2014, the prevalence among children aged 5 to 15 in New Delhi increased from 7.4% to 13.1%, reaching 21.1% four years later [5]. In East Asia, where the prevalence is already high, the rate among urban children aged 14 to 16 increased steadily from approximately 56.0% in 2006 to 65.5% in 2015 [6].

Meanwhile, the continuous development of electronic products brings convenience to children and adolescents in terms of learning, but it also poses significant safety risks to their physical and mental health, as well as their visual development. Children, adolescents, and students, who are in a sensitive period of visual development, have weak cognitive and self-control abilities when it comes to electronic products and eye health. Excessive use of various electronic devices can lead to visual fatigue, impaired vision, and an increased risk of myopia [7]. Moreover, the academic burden and learning intensity for primary and secondary school students are gradually increasing, resulting in more close eye work such as reading, studying, and writing. This can lead to excessive tension in the inner and outer eye muscles, causing increased visual fatigue and decreased ciliary muscle regulation ability. Without a change in this situation, the degree of myopia is likely to become more severe [8].

Medical and Epidemiological studies have shown that physical exercise has a protective effect on the visual acuity of children and adolescents [9–11]. Some studies have found that outdoor activities have a significant impact on eye regulation. The functional activity of eye-regulating muscles is strengthened, and exposure to outdoor light can stimulate the release of retinal dopamine, which helps prevent eye elongation and plays a significant role in reducing and controlling the incidence rate of myopia [12]. It was found that children who participated in table tennis activities had the lowest myopia rate compared to other sports. Ball sports, including table tennis, have a positive impact on visual problems in children and adolescents, and their myopia rate is lower compared to other sports [13]. The main purpose of using meta-analysis in this study is to further explore the therapeutic effect of table tennis as a treatment for visual problems in primary and secondary school students. It aims to investigate the role of table tennis exercises in improving visual function and lay the foundation for understanding the intervention effect of table tennis exercises on vision.

2. Sources and methods of literature data

2.1. Literature retrieval strategy

The literature search used Boolean calculation for subject term and free term

retrieval. The searched databases included CNKI, Wanfang, VIP, PubMed, Embase, Crochare Library, and Web of Science. The search was conducted from the establishment of each database until 23 April 2024. The Chinese search strategy comprised the terms ("sport" OR "table tennis") AND ("student" OR "pupil" OR "elementary school students" OR "middle school student") AND ("vision" OR "myopia") AND ("Randomized" OR "Randomized controlled trial"). The English search strategy included the terms (Vision Disorders OR Macropsias OR Visual Impairment OR Micropsia) AND (primary OR secondary school students) AND (table tennis ball OR Sports) AND (randomized controlled trial OR randomized OR placebo).

2.2. Inclusion and exclusion criteria for literature data

The literature screening criteria adopted the PICOS strategy, which is widely used in evidence-based medicine and practice. Inclusion criteria were as follows: the study population consisted of primary and secondary school students aged 6–18 years; the intervention involved table tennis exercise; the control group received regular physical education classes, did not engage in table tennis exercise, or received no intervention; outcome measures referred to visual acuity assessment; the study design was a randomized controlled trial. The literature assessment was conducted independently by two authors. In case of disagreement between the two authors, a third author would assess the study. Exclusion criteria included studies that did not meet the requirements for meta-analysis, review articles, and studies with incomplete data.

2.3. Risk assessment of bias included in the study

The bias assessment and forest plot were conducted using RevMan 5.4 and Stata 17.0. Subgroup analysis was performed on the data. The data in this study mainly consisted of continuous variables. When $I^2 > 40\%$, heterogeneity can be ignored, and the fixed-effect model (FEM) was selected for meta-analysis. When $40\% < I^2 < 70\%$, there is high heterogeneity, and when $70\% < I^2 < 100\%$, it indicates very high heterogeneity. In both of these cases, the random-effects model (REM) should be used for data analysis.

3. Results

3.1. Literature screening process and results

A total of 132 articles on the topic of table tennis intervention for visual acuity were identified through searches in multiple databases (as shown in **Figure 1**). After removing duplicate articles using Endnote, 96 articles remained. Subsequently, a preliminary screening was conducted based on the titles and abstracts, followed by a thorough examination of the full texts for further screening. Finally, 11 articles met the criteria for inclusion.

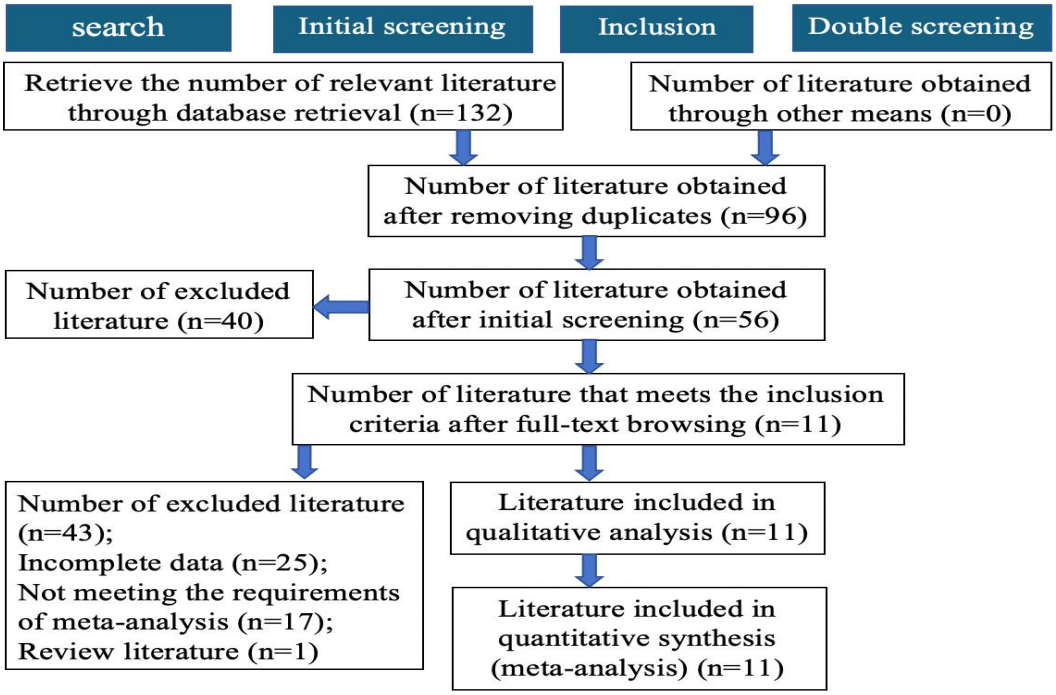

Figure 1. Literature screening process.

3.2. Basic information and quality evaluation of literature

This study includes 11 relevant references, covering a research period from 2002 to 2023. The research subjects primarily consist of primary and secondary school students from various regions in China, including Hebei Province, Sichuan Province, Shaanxi Province, Beijing, Shanxi Province, Jilin Province, Hunan Province, and Shanghai. The total number of participants is 670, with 333 in the experimental group and 337 in the control group. The included studies primarily focused on the age, gender, and educational stages of the participants, as well as the intervention measures, duration, frequency, and timing. Risk bias assessment of the included literature was performed using RevMan 5.4 and Stata 17.0 software, evaluating the potential biases in terms of random allocation, allocation concealment, implementation process, blinding, accuracy of reporting, completeness of data, and other risk factors. Each article was classified into “high risk,” “unclear risk,” or “low risk” based on the evaluation of biases. The basic characteristics of the included studies are summarized in **Table 1**. Among them, 5 articles met 4 or more low-risk criteria and were classified as high-quality (Grade A), while 6 articles met 2-3 low-risk criteria and were classified as moderate-quality (Grade B). The overall quality of the literature included was relatively high, as shown in **Figure 2**.

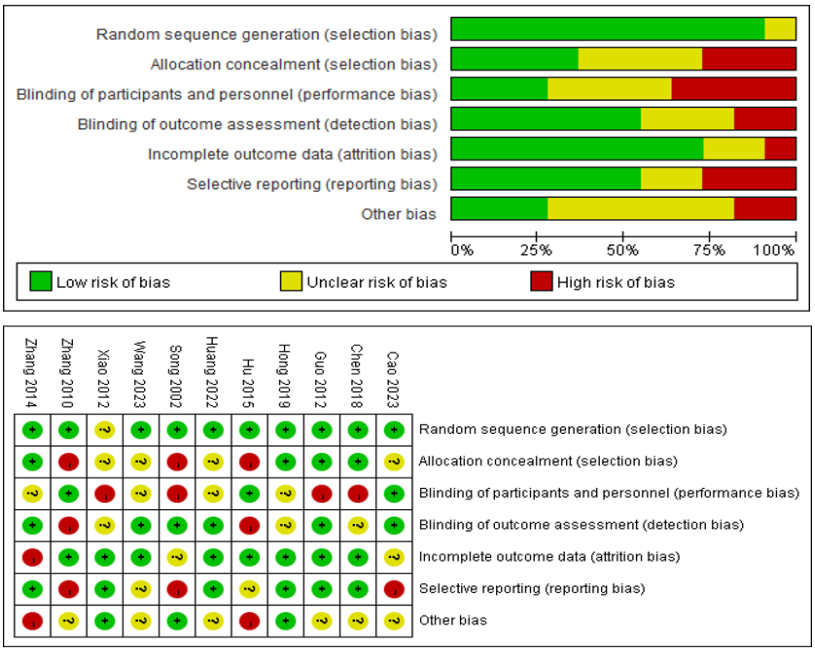

Figure 2. Evaluation of bias in included literature.

Table 1. Basic data characteristics included in the study.

Inclusion in research	Research object	Sample size (T/C)	(Intervention/Control) Measures		Intervention cycle (Week)	Intervention frequency (times/week)	Intervention duration (minutes/time)	Outcome indicators
			T	C				
Cao Kexin [14]	middle school student	15/15	Table Tennis	No intervention measures	8	2	45	Visual improvement
Chen Yuanli [15]	pupil	30/30	Table Tennis	Regular physical education classes	16	3	40	Visual improvement
Guo Xiaoping [16]	middle school student	30/30	Table Tennis	No intervention measures	80	3	120	Visual improvement
Hong Yaxiu [17]	pupil	25/25	Table Tennis	No intervention measures	80	3	120	Visual improvement
Hu Zhaoxia [18]	middle school student	40/40	Table Tennis	Regular physical education classes	80	3	120	Visual improvement
Huang Wenfei [19]	pupil	20/20	Table Tennis	No intervention measures	18	3	90	Visual improvement
Song Shaoxing [20]	pupil	35/35	Table Tennis	Regular physical education classes	120	4	90	Visual improvement
Wang Yuheng [21]	pupil	50/50	Table Tennis	Not practicing table tennis	18	3	60	Visual improvement
Xiao Baijuan [22]	pupil	30/30	Table Tennis	No intervention measures	16	4	60	Visual improvement
Zhang Jiansheng [23]	pupil	30/30	Table Tennis	No intervention measures	10	4	60	Visual improvement
Zhang Zeyu [24]	pupil	30/30	Table Tennis	Not practicing table tennis	12	3	60	Visual improvement

Note: T: Experimental group; C: Control group.

3.3. Meta-analysis of visual intervention in table tennis sports

The eligible studies were included in RevMan 5.4 software for research analysis to evaluate the intervention effect of table tennis exercise on visual acuity. A total of 670 participants from the 11 included studies were included in the meta-analysis. The standardized mean difference (SMD) and 95% confidence interval (CI) were calculated. The heterogeneity test results for the intervention of table tennis exercise on the visual acuity of the left and right eyes of primary and secondary school students were as follows: I^2 (left eye) = 86%, $P < 0.00001$ (**Figure 3**), and I^2 (right eye) = 88%, $P < 0.00001$ (**Figure 4**), indicating high heterogeneity. Therefore, a random-effects model (REM) was used for the meta-analysis of the relevant literature. The data results showed that table tennis exercise had a significant effect on the visual acuity of the left eye [SMD = 1.41, $P < 0.01$, 95% CI (0.95, 1.87)] and the right eye [SMD = 1.59, $P < 0.01$, 95% CI (1.08, 2.11)]. Both results did not cross the null line of "0" and were statistically significant (as shown in **Table 2**). Compared to the control group, table tennis exercise effectively improved the visual acuity of the left and right eyes of students, promoting visual health.

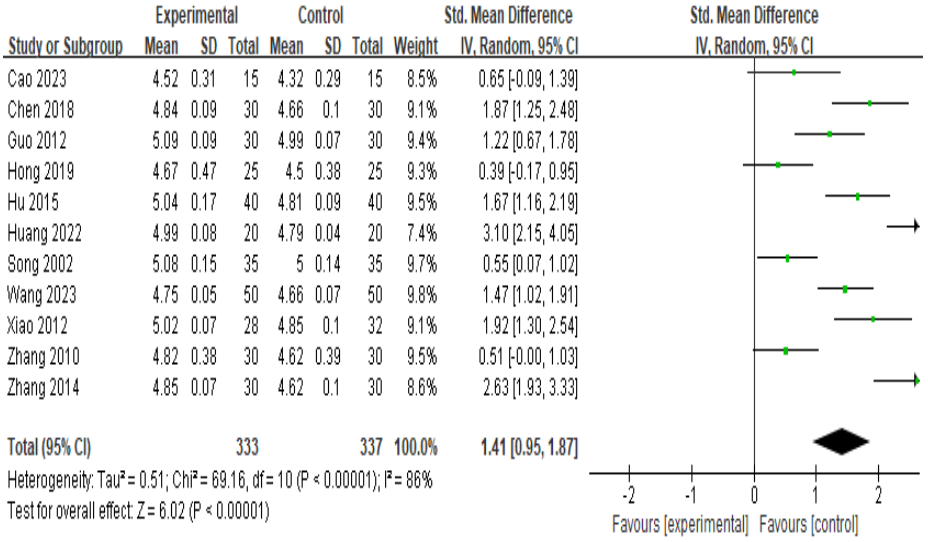

Figure 3. Vision intervention forest map (left eye).

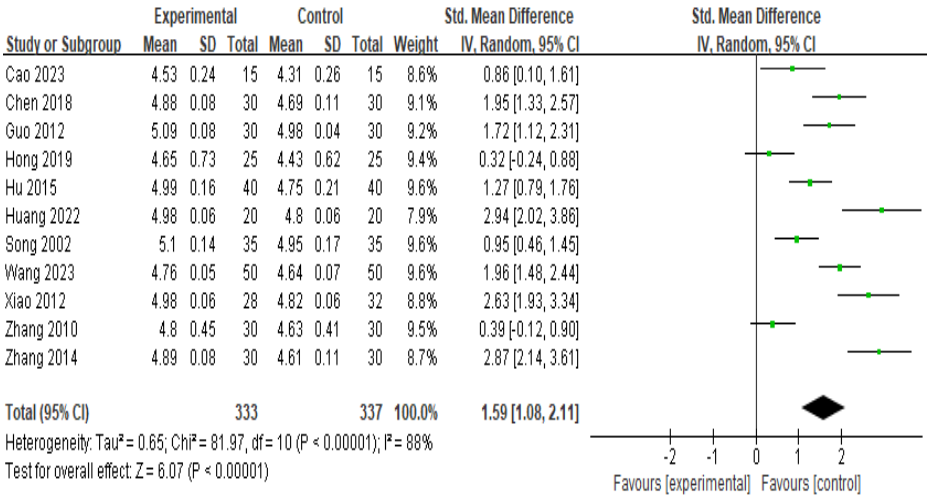

Figure 4. Vision intervention forest map (right eye).

Table 2. Summary of intervention results.

Subgroup	sample size	Heterogeneity test results		Meta-analysis results		
		I^2	*P*	SMD (95%CI)	*Z*	*P*
total						
left eye	11	86%	*P* < 0.00001	1.41(0.95, 1.87)	6.02	*P* < 0.00001
right eye	11	88%	*P* < 0.00001	1.59(1.08, 2.11)	6.07	*P* < 0.00001
crowd						
primary school student (left)	8	89%	<0.00001	1.51(0.89, 2.13)	4.77	<0.00001
primary school student (right)		91%	<0.00001	1.72(1.01, 2.42)	4.76	<0.00001
middle school student (left)	3	61%	=0.08	1.23(0.68, 1.78)	4.40	<0.0001
middle school student (right)		37%(fixed)	=0.20	1.33(0.99, 1.67)	7.76	<0.00001
Exercise cycle						
Short period (left)	7	86%	<0.00001	1.70(1.07, 2.33)	5.27	<0.00001
Short period (right)		89%	<0.00001	1.92(1.18, 2.66)	5.08	<0.00001
long period (left)	4	80%	=0.002	0.96(0.37, 1.55)	3.18	=0.01
long period (right)		76%	=0.0006	1.06(0.52, 1.60)	3.87	=0.0001
Exercise frequency						
≤3 times (left)	8	84%	<0.00001	1.59(1.05, 2.12)	5.81	<0.00001
≤3 times (right)		86%	<0.00001	1.71(1.13, 2.28)	5.81	<0.00001
>3 times (left)	3	86%	=0.0006	0.97(0.14, 1.81)	2.28	=0.02
>3 times (left)		92%	<0.00001	1.30(0.13, 2.47)	2.18	=0.03
Exercise time						
40–60 min (left)	2	84%	=0.01	1.28(0.08, 2.47)	2.09	=0.04
40–60 min (right)		79%	＝0.03	1.42(0.35, 2.50)	2.60	＝0.009
60–90 min (left)	4	88%	<0.00001	1.61(0.79, 2.43)	3.85	=0.0001
60–90 min (right)		93%	<0.00001	1.94(0.83, 3.06)	3.41	=0.0007
>90 min (left)	5	88%	<0.00001	1.32(0.57, 2.07)	3.46	=0.0005
>90 min (right)		85%	<0.00001	1.38(0.70, 2.06)	3.97	<0.0001

3.4. Overall subgroup analysis

Subgroup analysis was conducted based on the overall situation, population classification, exercise duration, exercise frequency, and exercise time. The effect of table tennis exercise on visual acuity intervention in different age groups of students was evaluated, and a meta-analysis was performed on the selected literature. For the intervention of table tennis exercise on visual acuity in primary school students, the meta-analysis showed a significant effect on the left eye [SMD = 1.51, 95% CI (0.89, 2.13), $P < 0.001$] and the right eye [SMD = 1.72, 95% CI (1.01, 2.42), $P < 0.001$]. Similarly, for high school students, table tennis exercise had a statistically significant effect on the left eye [SMD = 1.23, 95% CI (0.68, 1.78), $P < 0.001$] and the right eye [SMD = 1.33, 95% CI (0.99, 1.67), $P < 0.001$]. The heterogeneity for the intervention of table tennis exercise on the right eye of high school students was low, so the fixed-effect model (FEM) was used. The heterogeneity result showed an I^2 value of 37% and a P-value of 0.20.

The analysis considered exercise durations shorter than 24 weeks as short exercise periods and exercise durations longer than 24 weeks as longer exercise periods. For the short exercise period, the meta-analysis showed a statistically significant difference in visual acuity for the left eye [SMD = 1.70, 95% CI (1.07, 2.33), $P < 0.001$] and the right eye [SMD = 1.92, 95% CI (1.18, 2.66), $P < 0.001$]. For the long exercise period, there was a statistically significant difference in visual acuity for the left eye [SMD = 0.96, 95% CI (0.37, 1.55), $P < 0.05$] and the right eye [SMD = 1.06, 95% CI (0.52, 1.60), $P < 0.001$]. The analysis was further conducted based on exercise frequency to assess the effect of different exercise frequencies of table tennis on the visual acuity intervention in student populations. For exercise frequencies of three or fewer times per week, there was a statistically significant difference in visual acuity for the left eye [SMD = 1.59, 95% CI (1.05, 2.12), $P < 0.001$] and the right eye [SMD = 1.71, 95% CI (1.13, 2.28), $P < 0.001$]. For exercise frequencies of more than three times per week, there was a statistically significant difference in visual acuity for the left eye [SMD = 0.97, 95% CI (0.14, 1.81), $P < 0.05$] and the right eye [SMD = 1.30, 95% CI (0.13, 2.47), $P < 0.05$]. These findings indicate that engaging in table tennis exercises three times per week significantly improves the visual acuity of both the left and right eyes in primary and secondary school students.

In the subgroup analysis, exercise duration was divided into three categories: 40 min–60 min, 60 min–90 min, and greater than 90 min. Among the 11 included studies, only 2 studies examined the 40 min–60 min duration, while 4 studies and 5 studies examined the 60 min–90 min and greater than 90 min durations, respectively. For the 40 min–60 min exercise duration, there was a statistically significant difference in visual acuity for the left eye [SMD = 1.28, 95% CI (0.08, 2.47), $P < 0.05$] and the right eye [SMD = 1.42, 95% CI (0.35, 2.50), $P < 0.01$].For the 60 min–90 min exercise duration, there was a statistically significant difference in visual acuity for the left eye [SMD = 1.61, 95% CI (0.79, 2.43), $P < 0.001$] and the right eye [SMD = 1.94, 95% CI (0.83, 3.06), $P < 0.001$].For exercise durations greater than 90 minutes, there was a statistically significant difference in visual acuity for the left eye [SMD = 1.32, 95% CI (0.57, 2.07), $P < 0.001$] and the right eye [SMD = 1.38, 95% CI (0.70, 2.06), $P < 0.001$].

These findings suggest that the intervention effect of table tennis exercise on visual acuity is more significant in primary school students compared to secondary school students. Engaging in physical activities at least 3 times per week has a positive effect on the visual acuity intervention in both primary and secondary school students. Appropriate exercise duration and frequency also have a good impact on visual health. However, if the exercise duration is too short or too long, optimal exercise benefits may not be achieved. This is because human exercise patterns make it difficult to achieve a sufficient exercise volume with very short exercise durations, while excessively long exercise durations can lead to physical fatigue and have potentially negative effects on the recovery of bodily functions and overall health.

3.5. Sensitivity analysis

To eliminate the impact of individual studies on the heterogeneity of the overall

research, this study employed a sequential exclusion method to examine whether the standardized mean difference (SMD) of table tennis exercise on visual improvement in primary and secondary school students changed significantly. The intervention effect of table tennis exercise on visual acuity for the left eye was found to be [SMD = 1.41, 95% CI (0.95, 1.87)], and for the right eye, it was [SMD = 1.59, 95% CI (1.08, 2.11)]. The absence of the inclusion of 0 indicates the effectiveness of the intervention. An I^2 value of 86% and 88% indicates significant heterogeneity among the studies, with $P < 0.00001$. However, after sequentially excluding individual studies, the SMD values did not change significantly, and the intervention effect remained evident. Therefore, the selected studies in this research have relatively low sensitivity, and they do not have a significant impact on the results of the meta-analysis. The stability and reliability of the research findings are adequately demonstrated.

4. Discussions

Existing research has shown that physical exercise and outdoor activities are effective measures for preventing myopia [25,26]. It is clear that increasing physical activity can reduce sedentary behavior and time spent inactivity [27]. The core mechanism is that proper physical activity can increase choroidal blood flow and inhibit eyeball elongation, thereby preventing myopia [28]. Additionally, engaging in outdoor physical activities can reduce prolonged near work and contribute to the relaxation and recovery of the ciliary muscles [29]. Sports activities are a beneficial form of physical exercise that not only promotes overall physical well-being but also enhances blood circulation in the eyes, alleviates eye muscle fatigue, and plays a role in improving vision and preventing myopia. Relevant studies have shown that sports such as table tennis involve the alternation between distant and near vision. According to the principles of accommodative function training, these activities can improve the accommodative function of the ciliary muscles in adolescents, thereby preventing and controlling myopia. This is consistent with the findings of this study.

The results of this study indicate that table tennis exercise has a positive impact on improving the visual health of primary and secondary school students, and the effects vary based on different exercise durations, exercise times, and exercise frequencies. Exercise load, which is a reflection of exercise time and intensity, is a specific factor that affects the effectiveness of each exercise session. Subgroup analysis results show that table tennis exercise lasting 40 minutes or more has a moderating effect on the intervention, with 95% confidence intervals not containing 0, indicating statistical significance. Additionally, elementary school students who participate in table tennis training show better improvement in visual acuity compared to middle school students. Therefore, table tennis exercises should be widely implemented in elementary school physical education classes to effectively protect visual health during the sensitive period. There is a related longitudinal study conducted by Copenhagen University involving 156 first-year students over a period of 2 years. The results of the study show a negative correlation between physical activity and changes in myopia, indicating that physical activities have an improving effect on myopia in university students. Research has confirmed that there is an

inverse relationship between physical activity and myopia. Adolescents who regularly engage in physical activity have a lower prevalence of myopia [30]. The study by Smith et al. (2012) also indicates that outdoor activities among children and adolescents can protect vision. This is mainly attributed to the fact that outdoor lighting is more abundant compared to indoor lighting, and natural light expands the field of vision, thus protecting vision [31]. Factors such as the type of sports activity and exercise duration have a significant impact on the visual health of primary and secondary school students. The overall subgroup analysis indicates that the frequency, duration, and duration of table tennis exercises have statistical significance in improving the visual acuity of both eyes in primary and secondary school students. This suggests that physical exercise plays a crucial role in the visual health of children and adolescents.

At the same time, various unfavorable factors such as poor reading and writing posture, reading in a dark environment, and others can exacerbate the occurrence of myopia [32]. Therefore, in order to improve the visual health of primary and secondary school students, it is important not only to enhance physical exercise but also to pay attention to proper eye care in order to prevent the occurrence of vision problems. There is research indicating that, in the context of vision-related functions associated with exercise, apart from light sensitivity, all other aspects can be improved through training. This suggests that exercise can regulate visual functions [33]. Exercise can also lead to a series of changes in eye parameters in individuals with myopia, with the greatest immediate change observed in the axial length of the eye after exercise [34].

In summary, based on the characteristics of table tennis and the findings from the literature included in this study, the potential reasons and underlying physiological mechanisms for the negative correlation between participation in table tennis and the incidence of myopia among children and adolescents can be summarized as follows: (1) Participation in table tennis enhances the regulation capabilities of the eyes, muscles, and nerves, alleviating visual fatigue, which in turn inhibits the development of pseudomyopia and its progression to true myopia, thereby reducing the incidence of myopia. (2) Appropriate durations of table tennis activity can suppress the continuous elongation of the eye axis, control the ongoing increase in refractive error, and improve the accommodative sensitivity of both eyes, thereby delaying the progression of myopia. (3) Engagement in table tennis increases the release of dopamine, which helps inhibit the growth of the eye axis and reduces the incidence of myopia.

5. Conclusion

Research indicates that table tennis can inhibit the incidence of myopia in adolescents, reduce the conversion rate from pseudomyopia to true myopia, and control the progression of myopia, thereby having a positive impact on the visual health of young individuals. Based on the positive effects of this study’s findings, it is suggested that table tennis be considered as a potential intervention strategy for preventing myopia and lowering its incidence among adolescents, supported by government, schools, and families. Relevant government departments and

educational institutions may attempt to implement table tennis as an intervention method through small-scale experimental studies. Once the reliability and validity of the experimental results are confirmed, broader implementation can be considered. Furthermore, it is recommended that government agencies establish comprehensive regulations for myopia prevention and control, and develop a monitoring system to support research on exercise interventions aimed at reducing myopia incidence. Schools should foster a positive atmosphere for physical activity, ensuring sufficient exercise time for adolescents on campus. Parents are encouraged to actively support their children's extracurricular sports activities. The collaborative efforts of government, schools, and families are essential for constructing a robust system for the prevention and control of myopia through exercise interventions.

However, this study has certain limitations: (1) Study Population: The research subjects included in this study are primary and secondary school students aged 6 to 18, with 9 studies focusing on elementary school students, one on middle school students, and one on high school students. The total sample size of 670 participants may be insufficient, potentially leading to biased results, and the applicability of findings to non-student populations within the same age group may be limited. (2) Geographical Scope: Due to the limited number of included studies, most of which are concentrated in China, there is a lack of relevant literature from abroad, and the relatively small sample size may introduce language or cultural bias. (3) Research Content: The included studies lack detailed control over the intensity, frequency, and duration of table tennis exercise, indicating a deficiency in the intervention design. (4) Application of Findings: There is a gap in the translation and application of research findings related to the benefits of table tennis for vision protection. (5) Environmental Factors: The characteristics of table tennis allow for both indoor and outdoor play; however, indoor play may limit participants' exposure to sunlight, a factor that was not explicitly addressed in the included studies. (6) Contradictory Evidence: It should be noted that some studies have shown no correlation between the duration of physical activity and myopia, with differing opinions among scholars regarding the impact of table tennis on myopia progression and incidence. In conclusion, while this study incorporates 11 relevant studies, the overall sample size is relatively small. Variability in the research design, intervention strategies, and demographic factors has resulted in considerable heterogeneity among the data used in this paper. Future high-quality intervention studies are needed to further validate the reliability of these results.

Author contributions: Conceptualization, WS, ML, JW, HX, LL and HL; methodology, WS, ML, JW, HX, LL and HL; writing—original draft preparation, WS, ML, JW, HX, LL and HL; writing—review and editing, WS, LL and HL; supervision, HL; funding acquisition, LL. All authors have read and agreed to the published version of the manuscript.

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