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Review Article

Association between Chinese eye exercises and onset of myopia: a meta-analysis

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Abstract: Myopia has emerged as a significant public health issue, worldwide. Many interventions have been carried out for myopia prevention, including Chinese eye exercises. However, the effects of these exercises on myopia prevention remain inconsistent. The aim of this study was to evaluate the association between Chinese eye exercises and myopia onset. PubMed, Embase, and Cochrane Library databases were researched from inception to July 2018. The primary outcome was association between Chinese eye exercises and onset of myopia. The secondary outcome was association between high-quality Chinese eye exercises and onset of myopia. A total of five studies, including 14,590 participants, were included in this meta-analysis. Results showed that performing Chinese eye exercises was associated with an increased risk for onset of myopia, according to a fixed-effects model [pooled odds ratio (OR) = 1.19, 95% confidence interval (CI): 1.02-1.39, $P_{heterogeneity}$ = 0.19, I^2 = 37%]. However, comparisons based on the quality and attitude of eye exercises showed that children performing high-quality eye exercises were associated with a markedly lower risk of myopia onset than those not performing high-quality exercises (pooled OR = 0.27, 95% CI: 0.11-0.71, $P_{heterogeneity}$ = 0.02, I^2 = 69%). Present findings suggest that performance of Chinese eye exercises is associated with a higher risk of myopia onset because most students performed low-quality eye exercises. However, performing high-quality Chinese eye exercises significantly lowers rates of myopia onset. Therefore, students should be encouraged to perform high-quality Chinese eye exercises.

Keywords: Chinese eye exercises, myopia, meta-analysis

Introduction

Myopia has emerged as a significant public health concern, with a rapidly increasing prevalence [1, 2]. A recent report estimated that approximately 1.4 billion individuals, worldwide, are myopic, comprising >20% of the population [3]. In addition, it has been estimated that this percentage may increase up to 50% by 2050 [3]. Although prevalence of myopia varies according to geographic location, it has already reached epidemic levels in certain areas of East and Southeast Asia [2]. In China, up to 90% of teenagers and young adults are myopic due to the high educational pressure and limited time spent outdoors [4]. Thus, myopia is often considered a Chinese problem [1].

Myopia is a risk factor for pathological ocular changes, such as cataracts, glaucoma, and myopia macular degeneration. It is an important cause of impaired vision and blindness [5]. Therefore, many interventions have been developed for the prevention and control of myopia [1, 6]. A randomized controlled trial reported that one of the most effective and efficient ways to prevent myopia is to spend more time outdoors [7]. Moreover, low-dose atropine and orthokeratology have been widely used to impede the progression of myopia [8, 9]. However, high educational pressure in East and Southeast Asia does not permit children to spend extended time outdoors [1]. Moreover, low-dose atropine and orthokeratology may only be used for myopic control, rather than prevention. Therefore, there is a need to introduce a simple and easy-to-use intervention for prevention of myopia onset.

Chinese eye exercises, an intervention for visual protection and myopia prevention, originated

from the theories of Traditional Chinese Medicine [10]. From the perspective of Traditional Chinese Medicine, Qi may be motivated in meridians through massages on acupoints, leading to subsequent relief of eye strain [11]. From the perspective of modern medicine, massages on the acupoints around the eyes may accelerate blood circulation, relax eye muscles, and eliminate eyestrain [11]. In China, these eye exercises have been a compulsory measure performed by school children for prevention of myopia since 1963 [12]. However, the effects of Chinese eye exercises on prevention of myopia remain inconsistent. Studies have suggested that these eye exercises may reduce the risk of myopia [13]. However, other studies have shown that these eye exercises may, in fact, increase the risk of developing myopia [11, 14-16]. Therefore, this meta-analysis was performed to investigate the association between Chinese eye exercises and onset of myopia.

Materials and methods

Data sources and search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement was used as a guideline for this meta-analysis [17]. PubMed, Embase, and Cochrane Library databases were searched from inception to July 24, 2018. Studies were identified using a combination of relevant keywords, including "acupoints", "exercises", "myopia" and "near-sightedness".

Inclusion and exclusion criteria

After excluding studies based on titles and abstracts, full-text articles were reviewed, independently, by two investigators (OMZ and ZR) to evaluate their eligibility for inclusion. If at least one of the investigators considered a full-text article to be eligible for inclusion, the article was selected for further consideration. Disagreements regarding inclusion were resolved through discussion between the research team until a consensus was reached.

Studies meeting all of the following criteria were included in this meta-analysis: (1) Participants (students with or without myopia); (2) Interventions (performed Chinese eye exercises); (3) Comparators (did not perform Chinese eye exercises); (4) Outcomes (risk ratio [RR] or odds ratio [OR] of outcomes was provided or could be calculated); and (5) Studies (cohort, cross-sectional, or randomized controlled trials).

Inclusion was not restricted by study size, language, or publication type. Conversely, reviews, commentaries, letters, case reports, and studies that did not meet inclusion criteria were excluded. In cases of duplication (i.e., the same group of subjects was reported more than once), the most comprehensive study with the largest population was selected.

Data extraction

Study characteristics and data were independently extracted by two investigators (LZP and TX). Extracted data included first author, year of publication, location, study design, sample size, adjusted/unadjusted OR (or RR), and adjusted factors. Conflicts in data extraction were resolved through discussion until a consensus was reached.

Quality assessment

The quality of cohort and case-control studies was assessed using the Newcastle-Ottawa Scale (NOS), while the quality of cross-sectional studies was assessed by the Agency for Healthcare Research and Quality (AHRQ). Studies with NOS scores ≥ 7 or an AHRQ scores ≥ 8 were considered high-quality.

Statistical analyses

Review Manager Version 5.3 (Cochrane Collaboration, Nordic Cochrane Centre, Copenhagen, Denmark) and STATA v12 (StataCorp, College Station, TX, USA) were used for analyses. Outcomes were summarized as pooled ORs (or RRs) with 95% confidence intervals (CIs). Subgroup analyses and comparisons, stratified according to "performed the eye exercises", "times per day", "high-quality (serious) or not", "serious times per week", "eye exercises were taught by", "speed", "acupoint acquaintance", and "perform eye exercises outside school", were also performed. Statistical heterogeneity was measured using the Chi-squared test and inconsistency index (I^2) statistics. A *P*-value 0.1 or I^2>50% indicates obvious heterogeneity. Following the observation of heterogeneity, a

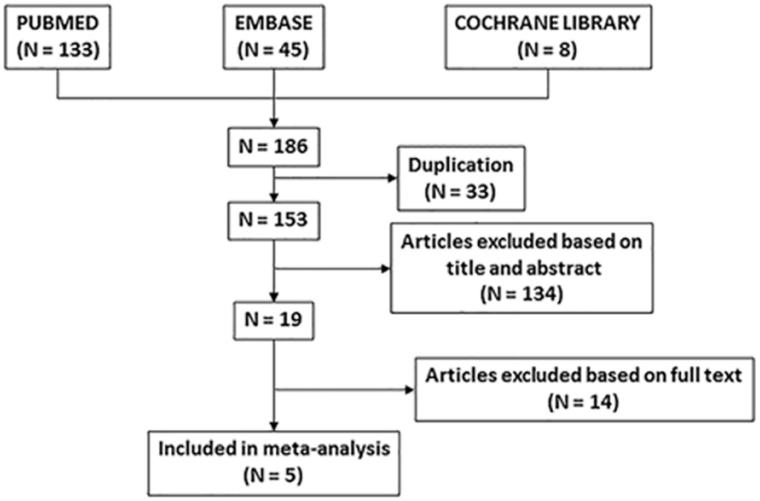

Figure 1. Study selection process.

random-effects model was selected. Otherwise, a fixed-effects model was used. A random-effects model was used for sensitivity analysis. Potential publication bias was assessed, qualitatively, through visual inspection of funnel plots and, quantitatively, through calculation of Begg's or Egger's tests [18, 19]. A *P*-value 0.05 (two-tailed) indicates statistical significance.

Results

Search results and study characteristics

Based on the search strategy, a total of 186 articles were identified. After removal of duplicates, 153 articles were screened based on titles and abstracts. A total of 19 full-text articles were reviewed, 14 of which were excluded for various reasons. Thus, a total of five studies conducted in China were included in this meta-analysis (**Figure 1**) [11, 14-16, 20]. Of those, four were cross-sectional [14-16, 20] and one was a case-control study [11]. **Table 1** summarizes the characteristics of included studies in detail.

Study quality

Information of the four cross-sectional studies was derived from surveys. Included studies listed precise inclusion and exclusion criteria [11, 14-16], except for one study [20]. However, none of the studies explained patient exclusion from analysis. For control of confounding factors, adjusted ORs were presented in four studies [11, 15, 16, 20]. However, for one study, it was necessary to calculate an unadjusted OR based on raw data [14]. For assessment of outcomes, in four studies, all participants received a cycloplegic autorefraction [11, 15, 16, 20]. However, in one study, the evaluation of participants as myopic was based exclusively on their use of myopic spectacles or contact lenses to look at objects [14]. Study quality scores of the four cross-sectional studies ranged from eight to eleven stars, according to the AHRQ, while the case-control study received a score of nine scores, according to the NOS scale (**Table 2**). Thus, the five included studies were of high quality.

Outcome results

This meta-analysis included data for a total of 14,590 participants (range: 60-11,138 participants per study) (**Table 1**). Since there was no obvious heterogeneity ($P_{heterogeneity}$ = 0.19, I^2 = 37%) observed among selected studies, a fixed-effects model was used to investigate the association between Chinese eye exercises and myopia. Overall, according to a fixed-effects model, performing Chinese eye exercises was associated with an increased risk for onset of myopia (pooled OR = 1.19, 95% CI: 1.02-1.39; **Figure 2**). After excluding a study which defined myopia based on the use of spectacles or contact lenses [14], heterogeneity values decreased significantly. There was no change observed in the significance of results (pooled OR = 1.78, 95% CI: 1.18-2.68, $P_{heterogeneity}$ = 0.73, I^2 = 0%).

Results of subgroup analyses and comparisons are shown in **Table 3**. Comparisons based on the quality and attitude (serious or not) of eye exercises showed that children that performed high-quality eye exercises were associated with a markedly lower risk of developing myopia, compared with those that did not perform high-quality exercises (pooled OR = 0.27, 95% CI: 0.11-0.71; **Figure 3**). Comparisons of additional eye exercises (outside school) revealed that

Table 1. Characteristics of included studies

First author, year	Region	Study design	Sample size	OR (95% CI) for the main intervention	Adjusted factors for the main intervention	OR (95% CI) for the secondary intervention	Adjusted factors for the secondary intervention
Lin, 2013	China, Beijing	Cross-sectional	409	Adjusted: 1.91 (0.37-9.76)	Age, gender, average parental refractive error, time spent near work and outdoors, item of eye exercises questionnaire	Adjusted: 0.71 (0.41-1.24)	Age, gender, average parental refractive error, time spent near work and outdoors, item of eye exercises questionnaire
Han, 2014	China, Qinghai	Cross-sectional	2,147	-	-	Adjusted: 0.26 (0.11-0.62)	Age, gender, grade, distance of near work, sitting posture, time spent outdoors, parental myopia
Kang, 2016	China, Henan	Cass-control	60	Adjusted: 1.35 (0.52-2.56)	Age, gender, time spent near work, time spent outdoors, parental myopia, baseline spherical equivalent refraction and axial length	0.09 (0.01-0.86)	-
Lin, 2016	China, Hebei	Cross-sectional	836	Adjusted: 1.97 (1.19-3.26)	Age, gender, average parental refractive error, times spent near work and outdoors	Adjusted: 0.12 (0.03-0.49)	Age, gender, average parental refractive error, times spent near work and outdoors
Wang, 2017	China, Inner Mongolia	Cross-sectional	11,138	1.12 (0.95-1.32)	-	-	-

Abbreviations: CI, confidence interval; OR, odds ratio. Main intervention: performed the eye exercises. Secondary intervention: performed high-quality (serious) eye exercises.

Table 2. Assessment of the quality of included studies

First author, year	Scale	Score	Quality
Lin, 2013	AHRQ	10	High
Han, 2014	AHRQ	8	High
Kang, 2016	NOS	9	High
Lin, 2016	AHRQ	10	High
Wang, 2017	AHRQ	8	High

Abbreviations: AHRQ, Agency for Healthcare Research and Quality; NOS, Newcastle-Ottawa Scale.

children that performed additional eye exercises were associated with a marginally significantly higher risk for myopia onset (pooled OR = 1.72, 95% CI: 1.00-2.97).

Sensitivity analysis and publication bias

For sensitivity analysis, a random-effects model was used. According to present findings, Chinese eye exercises showed a trend towards increased risk of developing myopia. However, this effect did not reach statistical significance (pooled OR = 1.36, 95% CI: 0.98-1.90). Funnel plots, Begg's test (P = 0.734, continuity corrected), and Egger's test (P = 0.277) did not reveal any obvious publication bias.

Discussion

Myopia has emerged as a public health concern, worldwide, becoming the second cause of blindness and impaired vision in the Chinese population [21]. Many interventions, such as spending more time outdoors and performing Chinese eye exercises, have been suggested to have a protective role against onset of myopia or progression [6, 7, 22-24]. For Chinese students, time outdoors is limited due to high educational pressure. Therefore, currently, performing these eye exercises is the most popular and realizable intervention against myopia. However, preventive interventions require scientific evaluation regarding their efficacy.

To the best of our knowledge, this is the first meta-analysis to investigate the association between Chinese eye exercises and onset of myopia. Surprisingly, present results showed that children that performed Chinese eye exercises were associated with a mild increased risk (19%) for myopia onset. Since most of the children performed the eye exercises in a suboptimal manner, the possible protective effects on myopia could not be properly demonstrated [15]. Thus, a comparison was conducted based on the quality and attitudes of exercises. However, compared with children that performed low-quality (unserious) eye exercises, those that performed high-quality (serious) eye exercises appeared to be strongly protected against onset of myopia.

Many theories have attempted to explain the relationship between high-quality eye exercises and a decreased risk of myopia. The Traditional Chinese Medicine theory suggests that myopia is caused by *Qi* and blood stagnation in the collaterals, as well as a lack of nourishment of the eyes [25]. Chinese eye exercises may regulate the *Qi* and blood of the *Zang-Fu* organs and meridians, reduce eyestrain, and improve the neural nutrition of eyes, leading to prevention of myopia [10]. Moreover, modern medicine has shown that these eye exercises exert protective effects on the eyes. First, these eye exercises may accelerate blood circulation. Research, using colour Doppler imaging, showed that the peak systolic velocity (PSV) in the central retinal and ophthalmic arteries is accelerated after performing Chinese eye exercises. The vascular resistance index is also reduced [26]. Second, eye exercises may relax the eye muscles and eliminate eyestrain. A randomized controlled trial found that children that performed eye exercises only once had a statistically significant effect in reducing accommodative lag, which was associated with elimination of eyestrain [12]. Third, after prolonged use of the eyes during study, a short rest period involving the eye exercises may also reduce visual symptoms. Thus, high-quality eye exercises may play an important role in prevention of myopia.

Similarly, stimulation of acupoints near the eyes may have a positive role in controlling the progression of myopia. An observational clinical study, including 180 adolescent myopic patients, found that patients undergoing acupuncture around the eyes had improved vision, compared with those that only wore glasses during daytime [27]. Furthermore, in a lens-induced myopia pig model, the use of electroacupuncture to stimulate acupoints near the eyes inhibited the development of myopia through decreasing levels of retinal gamma-aminobutyric acid (GABA). Upregulation of GABA has been associated with development of myopia [28].

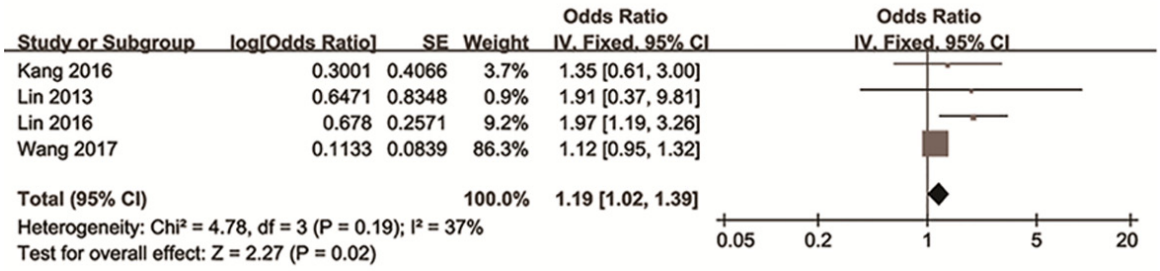

Figure 2. Forest plot of the relationship between performing Chinese eye exercises and risk of myopia onset.

Table 3. Subgroup analyses of this meta-analysis

Subgroup/comparisons	Number of studies	Poor OR (95% CI)	Heterogeneity (P; I^2)	Effects model
Performed the eye exercises	4			
No		-	-	-
Yes		1.19 (1.02-1.39)	0.19; 37%	Fixed
Times per day	2			
< 2		-	-	-
≥ 2		0.66 (0.32-1.34)	0.75; 0%	Fixed
High-quality (serious) or not	4			
No/moderate				
Yes		0.27 (0.11-0.71)	0.02; 69%	Random
Serious times per week	2			
None		-	-	-
< 3		0.70 (0.32-1.51)	0.34; 0%	Fixed
≥ 5		0.46 (0.09-2.41)	0.10; 63%	Random
Eye exercises were taught by	2			
Atlas/classmate		-	-	-
Teacher/door/health counsellor		0.87 (0.48-1.58)	0.22; 35%	Fixed
Speed	2			
Faster/slower than the instruction & at will		-	-	-
Following the instruction		1.02 (0.52-2.01)	0.32; 0%	Fixed
Acupoint acquaintance	2			
No/moderate		-	-	-
Yes		1.11 (0.65-1.88)	0.98; 0%	Fixed
Performing eye exercises outside school	2			
No		-	-	-
Yes		1.72 (1.00-2.97)	0.68; 0%	Fixed

Abbreviations: CI, confidence interval; I^2, inconsistency index; OR, odds ratio.

In contrast, low-quality eye exercises may cause harm to the eyes. Although guidelines pertaining to these exercises have been established for a long time, few students and teachers were aware and followed these guidelines [29]. First, prior to performing eye exercises, hands should be washed, thoroughly, and the fingernails should be cut. Second, eye exercises should not be performed in cases of inflammation or injury on the eyes or presence of furuncle or warts on the hands or face. Third, acupoints should be massaged at the correct location, gently and slowly. Many students consider these exercises boring and a burden, preferring to spend their time studying [30]. A study involving 409 children revealed that the quality of eye exercises was low. Moreover, 60% of the children did not know the exact locations of the eye acupoints and 54.7% did not perform the exercises seriously [15].

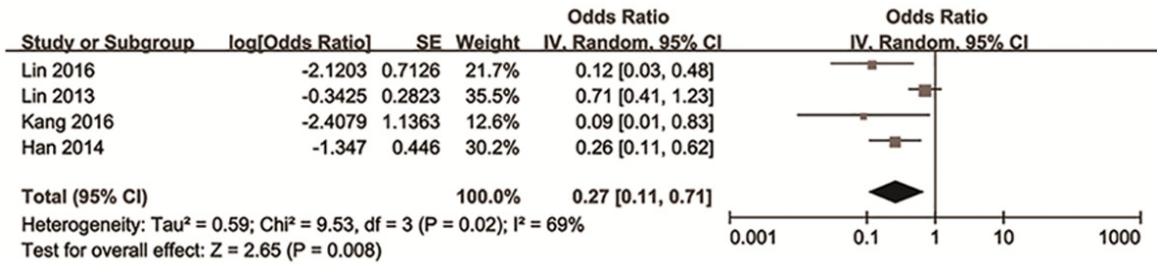

Figure 3. Forest plot of the relationship between performing high-quality Chinese eye exercises and risk of myopia onset.

Another study, involving 11,336 students in China, showed that 35.8% of these students did not know the optimal pressure to be applied on the eyes during these exercises [31]. Moreover, many students were pressing the eyeball instead of pressing the periocular acupoints. This may lead to the deformation of the cornea and refractive error [32]. In addition, a study from China indicated that 32% of students did not wash their hands prior to performing the eye exercises [31]. Neglecting hand hygiene may result in various eye infections, such as conjunctivitis and keratitis [33, 34]. Eye inflammation caused by conjunctivitis may lead to deposition of extracellular matrix and connective tissue in the scleral shell, which has been associated with onset and progression of myopia [35, 36]. Most of the students performed low-quality eye exercises, which may partly explain the increased risk of myopia. The Chinese National Education Commission and teachers should encourage students to follow guidelines regarding eye exercises for the prevention of the harmful effects observed with low-quality eye exercises [29].

Another comparison study showed that children that performed additional eye exercises had a marginally significantly higher risk of myopia onset. There are two possible explanations for this observation. First, children with a more serious refractive error may be more determined to perform additional eye exercises for prevention or control of myopia. Thus, they were more likely to have a potential risk for myopia. Second, without instruction and supervision, it may be more difficult for them to perform high-quality eye exercises. As mentioned earlier in this article, low-quality eye exercises may promote the onset of myopia.

This meta-analysis had several limitations, however. First, the number of studies included in this meta-analysis was limited. Only five studies, involving 14,590 participants, were selected, none of which were randomized controlled trials. Second, diagnosis of myopia was assessed through two different ways. Although most of the included studies used cycloplegic autorefraction for diagnosis of myopia, one study defined myopia based on the use of spectacles or contact lenses [14]. Thus, certain slightly myopic students that do not wear glasses may be have been mistakenly considered as having normal vision. This may also be a source of heterogeneity, as heterogeneity values decreased significantly after excluding this study. Third, recall bias may also be present, considering that assessment of the quality of eye exercises in the included studies was performed using questionnaires. Fourth, other confounding factors (i.e., the duration of the eye exercises and hand hygiene), which may influence the effects of these exercises, were not taken into consideration. Hence, the findings of this meta-analysis should be interpreted cautiously. Randomized and prospective studies, with large sample sizes, are warranted to confirm present findings.

In conclusion, performance of low-quality Chinese eye exercises is associated with a higher risk of myopia onset. In contrast, performance of high-quality Chinese eye exercises is linked to significantly lower rates of myopia onset. Therefore, students should be encouraged to follow the Chinese eye exercises guidelines for prevention of onset of myopia, avoiding the harmful effects associated with low-quality eye exercises.

Disclosure of conflict of interest

None.

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