Systematic review and meta-analysis of the prevalence of myopia among school-age children in the Eastern Mediterranean Region

Saif Hassan Alrasheed[1,2] and Waleed Alghamdi[1]

[1]Department of Optometry, College of Applied Medical Sciences, Qassim University, Buraydah, Saudi Arabia (Correspondence to SH Alrasheed: s.rasheed@qu.edu.sa). [2]Department of Binocular Vision, Faculty of Optometry and Visual Sciences, Al-Neelain University, Khartoum, Sudan.

Abstract

Background: The recent increase in myopia is a major public health concern worldwide, including in the Eastern Mediterranean Region (EMR).

Aim: To provide data on the prevalence of myopia among school-age children in the EMR.

Methods: This study was conducted using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) protocol. We searched the Web of Sciences, Scopus, Index Medicus for the Eastern Mediterranean Region, ProQuest, PubMed, and Medline for studies on the prevalence of myopia in the EMR published from January 2000 to May 2022. The data were analysed using MedCalc version 19.6.1 and myopia was defined as refractive error ≥ 0.50 D. The overall pooled prevalence of myopia was estimated using a random-effects model and its associated 95% confidence intervals.

Results: The meta-analysis included 27 quality-assessed studies from 13 countries among 51 111 school-age children. The overall pooled prevalence of childhood myopia from 2000 to 2022 was 5.23%, which was significantly higher among females than males (4.90% vs 3.94%). The prevalence of myopia was significantly higher among children aged 11–17 years than among those aged 5–10 years (7.50% vs 3.90%). There was a higher prevalence of myopia with cycloplegic refraction than noncycloplegic refraction (5.95% vs 3.73%). There was highly significant heterogeneity between the studies.

Conclusion: Prevalence of myopia among school-age children in the EMR was high, particularly among older children, and it was more common among females. Early intervention to slow myopia progression is essential in the EMR to protect children from irreversible vision loss.

Keywords: myopia, school-age children, refractive error, visual impairment, vision loss, global health, Eastern Mediterranean

Citation: Alrasheed HS, Alghamdi W. Systematic review and meta-analysis of the prevalence of myopia among school-age children in the Eastern Mediterranean Region. East Mediterr Health J. 2024;30(4):312–322. https://doi.org/10.26719/2024.30.4.312.

Received: 06/02/23; Accepted: 15/01/24

Introduction

The current increase in myopia among school-age children is a major public health concern worldwide. This could be because of the significant amount of time that children spend in near-vision activities such as reading and using computers or smartphones (*1–3*). Recent studies have indicated that genetic and environmental factors, such as time spent outdoors, are the main reasons for the high prevalence of myopia in East Asia (*3*, *4*). Holden et al. (*5*) reported that ~1.4 billion individuals had myopia in 2000, and it is expected that by 2050 the number would have increased to 4.8 billion. Gilmartin revealed in 2004 that almost 1 in 6 of the world's inhabitants had myopia (*6*). This high prevalence of myopia poses a significant burden globally, with a considerable unmet need for correction of poor vision, particularly in developing countries (*7*).

Myopia is a leading cause of avoidable visual impairment in developed countries among adults and children and the most common cause of treatable blindness in poor nations (*8*,*9*). Recent global estimates showed that > 90% of persons with refractive errors live in developing countries, and myopia remains the leading cause (*10*, *11*). In response to this concern, the global initiative to eliminate preventable visual impairment is focused on the cause, prevalence, prevention and treatment of 5 eye diseases, including refractive errors (*11*, *12*). Untreated myopia is the leading cause of ocular morbidity among children and adults, and it has reached an epidemic level in some regions, such as East Asia (*13*).

The Eastern Mediterranean Region (EMR) comprises 22 nations and territories, with a total population of 597 million. The estimated prevalence of visual impairment, blindness and low vision in the region in 2012–2014 was 8.2%, 12.5% and 7.6%, respectively (*14*, *15*). Accurate information about the prevalence and causes of childhood visual impairment is crucial for developing a well-coordinated approach to identify and treat promptly the underlying causes (*16*). Consequently, this systematic review and meta-analysis aimed to estimate the prevalence of myopia among school-age children in the EMR.

Methods

Search strategy and quality assessment of studies

This study used the PRISMA framework (Preferred Reporting Items for Systematic reviews and Meta-Analyses) (*17*). We searched Web of Sciences, Scopus, Index Medicus for the Eastern Mediterranean Region, ProQuest, PubMed and Medline for studies on the prevalence of myopia in the EMR published from January 2000 to May 2022. The quality of each included study was assessed using the worksheet developed by Downs and Black, and each selected article was evaluated and scored on a 10-item scale (Table 1) (*18*). This review was limited to articles published in English, available online, in peer-reviewed journals, and mentioning the prevalence of myopia in the EMR. The MeSH search terms were: (Prevalence OR rate OR incidence OR frequency OR proportion OR distribution OR epidemiology) AND myopia AND children. In addition, for several repetitions of these search terms used AND/OR in the EMR

Table 1 Characteristics of studies reporting the prevalence of myopia among school-age children in the Eastern Mediterranean Region

First author and year of study	Country	Age group (yr)	Age, mean (SD)	Sample size	Cycloplegia	Refraction assessment	Prevalence of myopia (%)	Quality assessment score
Chebil 2016 *(19)*	Tunisia	6–14	10.1 (1.8)	6192	Yes	Objective	3.71	9
Yamamah 2015 *(20)*	Egypt	6–17	10.7 (3.1)	2070	yes	Objective	3.1	10
Alrasheed 2016 *(21)*	Sudan	6–15	10.8 (2.8)	1678	Yes	Objective	6.8	10
Abdi 2020 *(22)*	Somalia	6–15	11.2 (2.5)	1204	No	Objective	9.1	10
Al Wadaani 2013 *(23)*	Saudi Arabia	6–15	9.4 (2.3)	2002	YES	Objective	9.0	10
Aldebasi 2014 *(24)*	Saudi Arabia	6–13	9.5 (1.8)	5176	Yes	Objective	5.8	10
Yekta 2010 *(25)*	Islamic Republic of Iran	7–15	10.9 (2.3)	1872	Yes	Objective	4.4	9
Ullah 2020*(26)*	Pakistan	5–12	8.1 (2.3)	2288	No	Objective	2.3	8
Rezvan 2012 *(27)*	Islamic Republic of Iran	6–17	11.2 (2.4)	1551	Yes	Objective	4.3	9
Mohamed 2017*(28)*	Sudan	5–15	12.41 (1.9)	822	No	Objective	1.7	8
Jamali 2009*(29)*	Islamic Republic of Iran	6	—	902	Yes	Objective	1.7	9
Hameed 2016 *(30)*	Pakistan	5–15	—	1644	No	Objective	3.4	8
Fotouhi 2007 *(31)*	Islamic Republic of Iran	7–15	—	5544	Yes	Objective	3.4	10
Elmajri 2017 *(32)*	Libya	7–11	9.5 (1.5)	920	Yes	Objective	1.7	7
Alrahili 2017 *(33)*	Saudi Arabia	5–10	—	1017	No	Objective	1.1	9
Alghamdi 2020 *(34)*	Saudi Arabia	6–13	9.2 (1.9)	417	No	Objective	7.7	10
Gilal 2022 *(35)*	Pakistan	6–15		400	Yes	Objective	7.8	8
Bataineh 2008*(36)*	Jordan	12–71	13.2 (2.1)	1647	Yes	Objective	15.5	8
Ostadi 2008 *(37)*	Islamic Republic of Iran	6–17	11.2 (2.6)	2132	No	Objective	2.4	9
Al-Rowaily 2010 *(38)*	Saudi Arabia	5–8	—	1319	No	Objective	2.5	9
Fotouhi 2011 *(39)*	Islamic Republic of Iran	8–14	10.7 (2.3)	2957	Yes	Objective	0.4	10
Hashemi 2016 *(40)*	Islamic Republic of Iran	7	—	4072	Yes	Objective	3.04	8
Hashemi 2018 *(41)*	Islamic Republic of Iran	5–15	10.0 (3.2)	602	yes	Objective	2.6	10
Hussam 2018 *(42)*	Iraq	6–8	6.1 (0.34)	735	YES	Objective	19.6	8
Kandi 2021*(43)*	United Arab Emirates	6–10	—	733	Yes	Objective	5.2	9
Al Nuaimi 2010 *(44)*	Qatar	5–15	—	670	No	Objective	7.4	8
Anera 2009 *(45)*	Morocco	6–16	—	545	Yes	Objective	6.1	9
All			10.52 (1.63)	51111			5.23	

SD = standard deviation.

(Afghanistan, Bahrain, Djibouti, Egypt, Islamic Republic of Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestine, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, State of Palestine, and the United Arab Emirates).

Inclusion and exclusion criteria

Inclusion criteria were: articles published between January 2000 and May 2022; studies assessing the prevalence of myopia among male and female children aged 5–17 years; epidemiological studies that used an observational cross-sectional design; studies with a clear description of the method used for data collection, such as sampling method; studies that reported the technique used for measuring refractive error (cycloplegic or noncycloplegic refraction), in addition to objective or subjective refraction; and studies that mentioned the benchmarks for defining myopia as spherical equivalent ≥ 0.50 D of myopia. Exclusion criteria were: editorial discussions, conference papers, meeting abstracts, articles without basic data gathering, and retrospective hospital-based studies.

Data extraction

The title and abstract of each selected article were carefully assessed by the author, and the following information was extracted: first author's name; year of publication; country of study; study subjects' characteristics (age, sample size); technique used for refractive error measurement (cycloplegic or noncycloplegic); benchmarks for defining myopia; and prevalence of myopia (Table 1).

Data analysis

The meta-analysis was conducted using MedCalc version 19.6.1. The study data were entered individually from a predesigned format that recorded the author's name, date of publication, study population, mean age, sample size, method for assessment of refraction, and prevalence of childhood myopia. Heterogeneity among studies was assessed using a Q statistic that was distributed as χ^2 under the assumption of homogeneity of effect sizes, and I^2 index (0–75%,) which represented none to high heterogeneity. The analysed data presented the prevalence of myopia among children by age, gender and refraction method and the corresponding weight for each study. The overall pooled prevalence of myopia was estimated using a random-effects model and its associated 95% confidence intervals (CIs). $P < 0.05$ was statistically significant. The prevalence of myopia among children was divided into separate datasets regarding overall prevalence, cycloplegic or noncycloplegic refraction, male or female, and age.

Results

Study characteristics

The literature search identified 12 705 articles. After removing duplicates, we reviewed the titles of 6457 articles. We excluded 6350 articles after reading their abstracts because they did not meet the inclusion criteria, and we excluded 80 articles after reading their full texts because the required information could not be extracted. The final meta-analysis included 27 quality-assessed studies from 13 countries (Table 1). Publication years were 2007–2021, and the overall sample size of the studies was 51 111 children with a mean age of 10.52 (1.93) years.

Prevalence of myopia among school-age children in the EMR

The overall pooled prevalence of myopia in the EMR was 5.23% (95% CI: 4.0–7.0%; $P < 0.001$) (Table 2). Ten of the reviewed studies reported a higher prevalence of childhood myopia and 17 reported a lower prevalence than the pooled estimate across the EMR. The study conducted by Hussam et al. (*42*) showed the highest prevalence (19.6%) of myopia, among Iraqi children in Baghdad (95% CI: 17.0–22.0%), whereas Fotouhi et al. 2011 (*39*) reported the lowest prevalence, among Iranian children (0.41%, 95% CI: 0.0– 1.0%). The pooled prevalence estimates of myopia in this review were similar to the study by Kandi and Kandi (*43*), (5.18%, 95% CI: 4.0–7.0%) among children in the United Arab Emirates.

Prevalence of myopia by gender among school-age children in the EMR (2000–2022)

Prevalence of myopia was highly significantly different between male and female children ($P < 0.001$, per sex), and the overall pooled prevalence of myopia was 4.90% (95% CI: 3.0–6.0%) among females compared with 3.94% (95% CI: 3.0–5.0%) among males (Table 3). The prevalence of myopia among females was comparable with the overall pooled estimate of 5.23% and the prevalence among males was lower.

Prevalence of myopia by age of school-age children in the EMR (2000–2022)

The pooled estimated prevalence of myopia among children aged 5–10 years was 3.90% (95% CI 2.0–5.0%), which was highly significantly lower than among children aged 11–17 years (7.50%, 95% CI 5.0–10.0%) ($P = 0.001$) (Table 4). The younger children had a lower pooled prevalence of myopia than the overall pooled estimation of 5.23%, whereas older children showed a higher pooled prevalence. Among children aged 5–10 years, the highest prevalence of myopia was reported in Somalia (*22*) (7.87%, 95% CI: 5.0–10.0%) and Saudi Arabia (*34*) (7.67%, 95% CI: 5.0–10.0%). The lowest prevalence was in Egypt (*20*) (0.85%, 95% CI: 0.0–1.0%). Among children aged 11–17 years, the highest prevalence of myopia was in Jordan (*36*) (15.54%, 95% CI: 14.0–17.0%), and the lowest prevalence was in Egypt (*20*) (2.21%, 95% CI: 1.0–3.0%).

Childhood myopia prevalence by refraction technique among school-age children in the EMR

Studies that used cycloplegic refraction reported a higher prevalence of myopia among school-age children (5.95%, 95% CI: 4.0–8.0%) than studies that used noncycloplegic refraction (3.73%, 95% CI: 3.0–5.0%) (Table 5). Meta-analysis showed highly significant heterogeneity between both groups of studies that used cycloplegic and noncycloplegic refraction ($P < 0.001$).

Discussion

Our meta-analysis provided recent prevalence estimates of childhood myopia in the EMR using data from 27 studies from 13 countries in 2000–2022. The benchmark for defining myopia used in this study was spherical equivalent ≥ 0.50 D. The overall prevalence of myopia among children across the EMR was 5.23%, and there were differences within and between countries. There was highly significant heterogeneity between the studies. The highest prevalence of myopia was in Iraq (*42*) and Jordan (*36*), and the lowest was in the Islamic Republic of Iran (*39*) and Saudi Arabia (*33*). In the United Arab Emirates, the prevalence of myopia was similar to the overall estimation (*43*).

Some countries, such as Saudi Arabia, reported variation in the prevalence of myopia among children of 9% (*23*), 7.67% (*34*), 2.50% (*38*) and 1.1% (*33*). Among Iranian children, the lowest prevalence of myopia was 0.41% (*39*) and the highest 4.4% (*25*). The present study showed highly significant differences in the prevalence of childhood myopia across the region, which is consistent with a previous study (*46*) that indicated significant variation among countries, even within the same geographic region. The regional and national variations in prevalence of myopia could be due to differences in environmental and genetics factors, criteria for defining myopia or techniques for assessing refractive error (some studies used dry refraction and others wet refraction). Thus, our analysis only included studies that defined myopia as spherical equivalent ≥ 0.50 D, and we calculated the prevalence of myopia for studies that used cycloplegia and noncycloplegia separately.

Table 2 Prevalence of myopia among school-age children in the Eastern Mediterranean Region

Author (year)	Country	Prevalence (95% CI)	Weight (%)
Chebil 2016 (*19*)	Tunisia	3.71 (3.0–4.0)	8.0
Yamamah 2015 (*20*)	Egypt	3.10 (2.0–4.0)	3.19
Alrasheed 2016 (*21*)	Sudan	6.80 (6.0–8.0)	1.22
Abdi 2020 (*22*)	Somalia	9.14 (8.0–11.0)	0.67
Al Wadaani 2013 (*23*)	Saudi Arabia	9.0 (8.0–10.0)	1.13
Aldebasi 2014 (*24*)	Saudi Arabia	5.80 (5.0–6.0)	4.38
Yekta 2010 (*25*)	Islamic Republic of Iran	4.4 (3.0–5.0)	2.07
Ullah 2020 (*26*)	Pakistan	2.23 (2.0–3.0)	4.85
Rezvan 2012 (*27*)	Islamic Republic of Iran	4.32 (3.0–5.0)	1.73
Mohamed 2017 (*28*)	Sudan	1.70 (1.0–3.0)	2.27
Jamali 2009 (*29*)	Islamic Republic of Iran	1.66 (1.0–3.0)	2.55
Hameed 2016 (*30*)	Pakistan	3.28 (2.0–4.0)	2.39
Fotouhi 2007 (*31*)	Islamic Republic of Iran	3.41 (3.0–4.0)	7.78
Elmajri 2017 (*32*)	Libya	1.74 (1.0–3.0)	2.49
Alrahili 2017 (*33*)	Saudi Arabia	1.10 (1.0–20)	4.39
Alghamdi 2020 (*34*)	Saudi Arabia	7.67 (5.0–10.0)	0.27
Gilal 2022 (*35*)	Pakistan	7.75 (5.0–10.0)	0.26
Bataineh 2008 (*36*)	Jordan	15.54 (14.0–17.0)	0.58
Ostadi 2008 (*37*)	Islamic Republic of Iran	2.39 (2.0–3.0)	4.22
Al-Rowaily 2010 (*38*)	Saudi Arabia	2.50 (2.0–3.0)	2.50
Fotouhi 2011 (*39*)	Islamic Republic of Iran	0.41 (0.0–1.0)	33.81
Hashemi 2016 (*40*)	Islamic Republic of Iran	3.05 (3.0–4.0)	6.37
Hashemi 2018 (*41*)	Islamic Republic of Iran	2.66 (1.0–3.0)	1.08
Hussam 2018 (*42*)	Iraq	19.60 (17.0–22.0)	0.22
Kandi 2021(*43*)	United Arab Emirates	5.18 (4.0–7.0)	0.69
Al Nuaimi 2010 (*44*)	Qatar	7.31 (5.0–9.0)	0.46
Anera 2009 (*45*)	Morocco	6.10 (4.0–8.0)	0.44
All		5.23 (4.0–7.0)	100.0
Heterogeneity between groups		$P < 0.001$	
I^2 (inconsistency)		99.18	

CI = confidence interval.

Table 3 **Prevalence of childhood myopia according to gender**

Author (year)	Country	Prevalence (95% CI)	Weight (%)
Male children			
Chebil 2016 (19)	Tunisia	3.0 (3.0–3.0)	14.98
Yamamah 2015 (20)	Egypt	3.44 (2.0–5.0)	2.22
Alrasheed 2016 (21)	Sudan	6.89 (5.0–9.0)	0.19
Abdi 2020 (22)	Somalia	8.21 (6.0–10.0)	0.62
Al Wadaani 2013 (23)	Saudi Arabia	7.25 (6.0–9.0)	1.01
Aldebasi 2014 (24)	Saudi Arabia	4.70 (4.0–6.0)	4.05
Yekta 2010 (25)	Islamic Republic of Iran	4.59 (3.0–6.0)	1.61
Ullah 2020 (26)	Pakistan	1.83 (1.0–2.0)	6.48
Rezvan 2012 (27)	Islamic Republic of Iran	3.58 (2.0–5.0)	1.31
Mohamed 2017 (28)	Sudan	1.70 (1.0–3.0)	3.46
Hameed 2016 (30)	Pakistan	2.73 (2.0–4.0)	2.52
Fotouhi 2007 (31)	Islamic Republic of Iran	3.12 (2.0–4.0)	3.74
Alrahili 2017 (33)	Saudi Arabia	0.53 (0.0–1.0)	12.57
Alghamdi 2020 (34)	Saudi Arabia	7.67 (5.0–10.0)	0.41
Fotouhi 2011 (39)	Islamic Republic of Iran	0.29 (0.0–1.0)	33.21
Hashemi 2016 (40)	Islamic Republic of Iran	2.59 (2.0–3.0)	9.24
Hashemi 2018 (41)	Islamic Republic of Iran	2.72 (1.0–5.0)	0.78
Kandi 2021 (43)	United Arab Emirates	6.08 (4.0–8.0)	0.51
All		3.94 (3.0–5.0)	10
Heterogeneity between groups		*P* < 0.001	
I^2 (inconsistency)		97.16	
Female children			
Chebil 2016 (19)	Tunisia	4.51 (4.0–5.0)	16.62
Yamamah 2015 (20)	Egypt	2.74 (2.0–4.0)	4.44
Alrasheed 2016 (21)	Sudan	6.79 (5.0–8.0)	1.53
Abdi 2020 (22)	Somalia	10.26 (8.0–13.0)	0.69
Al Wadaani 2013 (23)	Saudi Arabia	10.62 (9.0–12.0)	1.26
Aldebasi 2014 (24)	Saudi Arabia	6.88 (6.0–8.0)	4.69
Yekta 2010 (25)	Islamic Republic of Iran	4.14 (3.0–5.0)	2.53
Ullah 2020 (26)	Pakistan	3.51 (2.0–5.0)	1.85
Rezvan 2012 (27)	Islamic Republic of Iran	8.37 (7.0–10.0)	1.37
Hameed 2016 (30)	Pakistan	4.04 (3.0–6.0)	2.06
Fotouhi 2007 (31)	Islamic Republic of Iran	3.71 (3.0–5.0)	6.09
Alrahili 2017 (33)	Saudi Arabia	0.85 (0.0–1.0)	12.81
Fotouhi 2011 (39)	Islamic Republic of Iran	0.44 (0.0–1.0)	41.68
Hashemi 2018 (41)	Islamic Republic of Iran	2.60 (1.0–4.0)	1.41
Kandi 2021 (43)	United Arab Emirates	4.04 (2.0–6.0)	0.96
All		4.90 (3.0–6.0)	100.0
Heterogeneity between groups		*P* < 0.001	
I^2 (inconsistency)		97.62	

CI = confidence interval.

The overall pooled prevalence of myopia among school-age children in the EMR is slightly higher than children in the WHO/AFRO Region (47), which may be related to the variation in the hereditary tendency to the development of myopia (48). EMR includes some countries in Africa and Asia. In this review, most of the studies were from countries in Asia, which may reflect the heterogeneity among the findings and high prevalence of myopia. The high prevalence of childhood myopia may be a result of children spending a lot of time studying and reading, and more recently, increased use of computers and other smart devices. There was a highly significant

Table 4 Prevalence of childhood myopia by age group in the Eastern Mediterranean Region

Author (year)	Country	Prevalence (95% CI)	Weight (%)
Children aged 5–10 years			
Yamamah 2015 (*20*)	Egypt	0.85 (0.0–1.0)	12.13
Alrasheed 2016 (*21*)	Sudan	4.87 (3.0–6.0)	3.12
Abdi 2020 (*22*)	Somalia	7.87 (5.0–10.0)	1.23
Al Wadaani 2013 (*23*)	Saudi Arabia	7.24 (6.0–9.0)	2.46
Aldebasi 2014 (*24*)	Saudi Arabia	2.93 (2.0–4.0)	17.51
Yekta 2010 (*25*)	Islamic Republic of Iran	3.10 (2.0–4.0)	4.72
Jamali 2009 (*29*)	Islamic Republic of Iran	1.66 (1.0–2.0)	10.48
Hameed 2016 (*30*)	Pakistan	3.37 (2.0–4.0)	6.17
Fotouhi 2007 (*31*)	Islamic Republic of Iran	2.51 (2.0–4.0)	12.03
Alghamdi 2020 (*34*)	Saudi Arabia	7.67 (5.0–10.0)	1.12
Al-Rowaily 2010 (*38*)	Saudi Arabia	2.50 (2.0–4.0)	10.28
Hashemi 2018 (*41*)	Islamic Republic of Iran	0.91 (0.0–2.0)	6.92
Kandi 2021 (*43*)	United Arab Emirates	5.18 (4.0–7.0)	2.83
All		3.90 (2.0–5.0)	100.0
Heterogeneity between groups		$P < 0.001$	
I^2 (inconsistency)		94.94	
Children aged 11–17 years			
Yamamah 2015 (*20*)	Egypt	2.21 (1.0–3.0)	24.75
Alrasheed 2016 (*21*)	Sudan	8.50 (7.0–10.0)	5.51
Abdi 2020 (*22*)	Somalia	9.95 (9.0–12.0)	3.88
Al Wadaani 2013 (*23*)	Saudi Arabia	10.34 (9.0–12.0)	5.78
Aldebasi 2014 (*24*)	Saudi Arabia	8.74 (8.0–10.0)	15.14
Yekta 2010 (*25*)	Islamic Republic of Iran	5.45 (4.0–7.0)	9.95
Hameed 2016 (*30*)	Pakistan	5.50(3.0–8.0)	4.47
Fotouhi 2007 (*31*)	Islamic Republic of Iran	4.31(3.0–5.0)	21.52
Bataineh 2008 (*36*)	Jordan	15.54(14.0–17.0)	5.93
Hashemi 2018 (*41*)	Islamic Republic of Iran	4.40(2.0–7.0)	3.07
All		7.50(5.0–10.0)	100.0
Heterogeneity between groups		$P < 0.001$	
I^2 (inconsistency)		96.67	

CI = confidence interval.

difference in prevalence of myopia between male and female children (3.94% vs 4.90%). This is similar to the situation among WHO/AFRO children, who showed a higher prevalence among females, but the difference was not significant (*47*). Some authors have attributed the higher prevalence of myopia among females to different ages of onset of maturity between the sexes, or to females spending less time outside than males (*21*, *49*). In children aged 5–10 years, the prevalence of myopia was highly significantly lower than in older children aged 11–17 years (3.90% vs 7.50%). This demonstrates a trend for increased development of myopia with age, which agrees with previous studies (*8*, *21*, *50*). This increase in prevalence of myopia may be a result of the development of the eyeball or an increase in near-sight activities such as reading and writing in school.

This study revealed that studies that used cycloplegic refraction reported a significantly higher prevalence of myopia among children than studies that used noncycloplegic refraction, which is inconsistent with earlier studies (*21*, *47*). Dry refraction overestimates the prevalence of myopia and gives an unreliable assessment of the relationship between myopia risk factors; therefore, wet refraction is considered the gold standard for assessing myopia (*52*, *53*). Only 9 of the 27 studies in our meta-analysis measured refractive error by the noncycloplegic method, and the rest used cycloplegia, which may explain the high prevalence of myopia in the latter. This higher prevalence of myopia with cycloplegia than noncycloplegia disagrees with most previous studies. This could have been a methodological bias in our study sample: 18 of the studies reported using cycloplegia. This may have resulted in a high prevalence of myopia with wet refraction.

Table 5 **Prevalence of childhood myopia according to refraction technique in the Eastern Mediterranean Region**

Author (year)	Country	Prevalence (95% CI)	Weight (%)
Cycloplegic			
Chebil 2016 (19)	Tunisia	3.71 (3.0–4.0)	11.64
Yamamah 2015 (20)	Egypt	3.10 (3.0–4.0)	4.65
Alrasheed 2016 (21)	Sudan	6.80 (6.0–8.0)	1.78
Al Wadaani 2013 (23)	Saudi Arabia	9.0 (8.0–10.0)	1.64
Aldebasi 2014 (24)	Saudi Arabia	5.80 (5.0–6.0)	6.37
Yekta 2010 (25)	Islamic Republic of Iran	4.38 (3.0–5.0)	3.0
Rezvan 2012 (27)	Islamic Republic of Iran	4.32 (3.0–5.0)	2.52
Jamali 2009 (29)	Islamic Republic of Iran	1.66 (1.0–2.0)	3.71
Fotouhi 2007 (31)	Islamic Republic of Iran	3.41 (3.0–4.0)	7.12
Elmajri 2017 (32)	Libya	1.74 (1.0–3.0)	3.62
Gilal 2022 (35)	Pakistan	7.75 (5.0–10.0)	0.38
Bataineh 2008 (36)	Jordan	15.54 (14.0–17.0)	0.84
Fotouhi 2011 (39)	Islamic Republic of Iran	0.41 (0.0–1.0)	49.19
Hashemi 2018 (41)	Islamic Republic of Iran	2.66 (1.0–4.0)	1.56
Hussam 2018 (42)	Iraq	19.60 (17.0–22.0)	0.31
Kandi 2021 (43)	United Arab Emirates	5.18 (4.0–7.0)	1.0
Anera 2009 (45)	Morocco	6.06 (4.0–8.0)	0.64
All		5.95 (4.0–8.0)	100.0
Heterogeneity between groups		$P < 0.001$	
I^2 (inconsistency)		99.35	
Noncycloplegic			
Abdi 2020 (22)	Somalia	9.14 (8.0–11.0)	1.39
Ullah 2020 (26)	Pakistan	2.23 (2.0–3.0)	10.04
Mohamed 2017 (28)	Sudan	1.70 (1.0–3.0)	4.70
Hameed 2016 (30)	Pakistan	3.28 (2.0–4.0)	4.95
Fotouhi 2007 (31)	Islamic Republic of Iran	0.32 (0.0–1.0)	55.38
Alrahili 2017 (33)	Saudi Arabia	1.08 (0.0–2.0)	9.09
Alghamdi 2020 (34)	Saudi Arabia	7.67 (5.0–9.0)	0.56
Ostadi 2008 (37)	Islamic Republic of Iran	2.39 (2.0–3.0)	8.73
Al–Rowaily 2010 (38)	Saudi Arabia	2.50 (2.0–3.0)	5.17
All		3.37 (1.0–5.0)	100.0
Heterogeneity between groups		$P < 0.001$	
I^2 (inconsistency)		98.45	

CI = confidence interval.

This review had some limitations that were related to the nature of the study. These included variations in the study methods. Some studies had a large sample size and others a small sample size, which may have yielded over- or underestimation of the prevalence of myopia. Several studies were excluded from the review because they used different techniques or different age groups, which reduced the number of articles included. Our review did not examine the trend in the prevalence of myopia among children in the EMR because of the limited number of studies. Some countries had many studies, and others had none to assess the prevalence of myopia in children. This study did not explore the various factors affecting the epidemiology of myopia. Despite these limitations, our systematic review and meta-analysis estimated the pooled prevalence of childhood myopia in the EMR and how it differed with gender, age and refraction method.

Conclusion

The prevalence of myopia among children in the EMR was high, particularly among older children, and slightly more common among females. More studies are required using standardized methods in different regions where there is a lack of information on the prevalence of myopia. Early interventions to slow progression of myopia are essential in the EMR to protect children from irreversible vision loss during adulthood.

Funding: None.

Conflict of interest: None declared.

Analyse systématique et méta-analyse de la prévalence de la myopie chez les enfants d'âge scolaire dans la Région de la Méditerranée orientale

Résumé

Contexte : L'augmentation récente des cas de myopie est un problème majeur de santé publique dans le monde entier, y compris dans la Région de la Méditerranée orientale.

Objectif : Fournir des données sur la prévalence de la myopie chez les enfants d'âge scolaire dans la Région de la Méditerranée orientale.

Méthodes : La présente étude a été menée selon le protocole PRISMA (lignes directrices pour la rédaction d'analyses et de méta-analyses systématiques). Nous avons effectué des recherches dans Web of Sciences, Scopus, Index Medicus pour la Région de la Méditerranée orientale, ProQuest, PubMed et Medline pour les études sur la prévalence de la myopie dans la Région qui ont été publiées entre janvier 2000 et mai 2022. Les données ont été analysées au moyen de la version 19.6.1 de MedCalc et la myopie a été définie comme un défaut de réfraction supérieur ou égal à 0,50 D. La prévalence globale groupée de la myopie a été estimée à l'aide d'un modèle à effets aléatoires et des intervalles de confiance à 95 % qui y sont associés.

Résultats : La méta-analyse a porté sur 27 études, dont la qualité a été évaluée, réalisées dans 13 pays auprès de 51 111 enfants d'âge scolaire. Entre 2000 et 2022, la prévalence globale groupée de la myopie chez l'enfant était de 5,23 %, ce qui était significativement plus élevé chez les filles que chez les garçons (4,90 % contre 3,94 %). Cette prévalence était significativement plus élevée chez les enfants âgés de 11 à 17 ans que chez ceux âgés de 5 à 10 ans (7,50 % contre 3,90 %). De plus, elle était plus élevée avec la réfraction cycloplégique qu'avec la réfraction non cycloplégique (5,95 % contre 3,73 %). L'hétérogénéité entre les études était hautement significative.

Conclusion : La prévalence de la myopie chez les enfants d'âge scolaire dans la Région de la Méditerranée orientale était élevée, en particulier chez les enfants plus âgés, et elle était d'autant plus fréquente chez les filles. Une intervention précoce visant à ralentir la progression de la myopie est essentielle dans la Région pour protéger les enfants contre une perte de vision irréversible.

استعراض منهجي وتحليل تلوي لانتشار قصر النظر بين الأطفال في سن المدرسة في إقليم شرق المتوسط

سيف الرشيد، وليد الغامدي

الخلاصة

الخلفية: تمثِّل الزيادة الأخيرة في الإصابة بقصر النظر شاغلًا رئيسيًّا من شواغل الصحة العامة في جميع أنحاء العالم، وخاصة إقليم شرق المتوسط.

الأهداف: هدفت هذه الدراسة الى تقديم بيانات عن انتشار قصر النظر بين الأطفال في سن المدرسة في إقليم شرق المتوسط.

طرق البحث: أُجريت الدراسة باستخدام بروتوكول بنود التبليغ المفضَّلة للاستعراضات المنهجية والتحليلات التلوية (PRISMA). وبحثنا في "ويب العلوم" و"سكوبوس" و"الفهرس الطبي لإقليم شرق المتوسط" و"برو-كويست" و"بب ميد"، و"نظام استرجاع المعلومات البيليوجرافية الطبية والبيولوجية (قاعدة بيانات مدلاين)" عن الدراسات المتعلقة بانتشار قصر النظر في إقليم شرق المتوسط التي نُشرت في الفترة من يناير / كانون الثاني 2000 إلى مايو / أيار 2022. وحُللت البيانات بالإصدار 19.6.1 من برنامج Med Calc، وعُرِّف قِصَر النظر بأنه خطأ انكساري ≤ 0.50 ديوبتر. وقُدِّر معدل الانتشار الإجمالي المجمَّع لقصر النظر باستخدام نموذج التأثيرات العشوائية، وما يرتبط به من فواصل ثقة قدرها 95٪.

النتائج: شمل التحليل التلوي 27 دراسة مُقيّمة الجودة من 13 بلدًا شملت 51111 طفلًا في سن الدراسة. وبلغ معدل الانتشار الإجمالي المجمّع لقِصَر النظر بين الأطفال في الفترة من عام 2000 إلى عام 2022 نسبة 5.23٪، وكان أعلى كثيرًا بين الإناث منها بين الذكور (4.90٪ مقابل 3.94٪). وتبين أن معدل انتشار قصر النظر أعلى كثيرًا بين الأطفال الذين تتراوح أعمارهم بين 11 و17 سنة منه بين أولئك الذين تتراوح أعمارهم بين 5 و10 سنوات (7.50٪ مقابل 3.90٪). وتبيَّن أيضًا أن معدل انتشار قِصَر النظر المصحوب بالانكسار تحت تأثير موسع الحدقة أعلى من معدل الانكسار دون توسيع الحدقة (5.95٪ مقابل 3.73٪). وتبين وجود تباين كبير بين الدراسات.

الاستنتاجات: إن معدل انتشار قصر النظر بين الأطفال في سن المدرسة في إقليم شرق المتوسط مرتفع، لا سيَّما بين الأطفال الأكبر سِنًّا، وهو أكثر شيوعًا بين الإناث. لذا، فإن التدخل المبكر لإبطاء تطور قصر النظر أمرٌ ضروري في الإقليم لحماية الأطفال من فقدان البصر الذي لا رجعة فيه.

References

1. Grzybowski A, Kanclerz P, Tsubota K, Lanca C, Saw SM. A review on the epidemiology of myopia in school children worldwide. BMC ophthalmology. 2020 Jan 14;20(1):27. https://doi.org/10.1186/s12886-019-1220-0 PMID: 3193727
2. He M, Xiang F, Zeng Y, Mai J, Chen Q, Zhang J, et al. Effect of time spent outdoors at school on the development of myopia among children in China: a randomized clinical trial. JAMA. 2015 Sep 15;314(11):1142–8. https://doi.org/10.1001/jama.2015.10803 PMID:26372583
3. Wu PC, Chen CT, Lin KK, Sun CC, Kuo CN, Huang HM, et al. Myopia prevention and outdoor light intensity in a school-based cluster randomized trial. Ophthalmology. 2018 Aug;125(8):1239–50. https://doi.org/10.1016/j.ophtha.2017.12.011 PMID:29371008
4. Jin JX, Hua WJ, Jiang X, Wu XY, Yang JW, Gao GP, et al. Effect of outdoor activity on myopia onset and progression in school-aged children in northeast China: the Sujiatun Eye Care Study. BMC Ophthalmol. 2015 Jul 9;15(1):73. https://doi .org/10.1186/s12886-015-0052-9 PMID:26152123
5. Holden BA, Fricke TR, Wilson DA, Jong M, Naidoo KS, Sankaridurg P, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology. 2016 May 1;123(5):1036–42. https://doi.org/10.1016/j.ophtha.2016.01.006 PMID:26875007
6. Gilmartin B. Myopia: precedents for research in the twenty- first century. Clin Exp Ophthalmol. 2004 Jun;32(3):305–24. https://doi.org/10.1111/j.1442-9071.2004.00831.x PMID:15180846
7. Kempen JH, Mitchell P, Lee KE, Tielsch JM, Broman AT, Taylor HR, et al. The prevalence of refractive errors among adults in the United States, Western Europe, and Australia. Arch Ophthalmol 2004; 122:495–505. https://doi.org/10.1001/archopht.122.4.495 PMID:15078666
8. Rudnicka AR, Kapetanakis VV, Wathern AK, Logan NS, Gilmartin B, Whincup PH, et al. Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention. Br J Ophthalmol. 2016 Jul;100(7):882–90. https://doi.org/10.1136/bjophthalmol-2015-307724 PMID:26802174
9. Lam CS, Goldschmidt E, Edwards MH. Prevalence of myopia in local and international schools in Hong Kong. Optom Vis Sci. 2004 May 1;81(5):317–22. https://doi. org/10.1097/01.opx.0000134905.98403.18 PMID:15181356
10. Alrasheed SH, Naidoo KS, Clarke-Farr PC. Childhood eye care services in South Darfur State of Sudan: Learner and parent perspectives. Afr Vision Eye Health. 2016;75(1):a315. https://doi.org/10.4102/ aveh.v75i1.315
11. Naidoo KS, Jaggernath J. Uncorrected refractive errors. Indian J Ophthalmol. 2012 Sep–Oct;60(5):432–7. https://doi: 10.4103/0301-4738.100543
12. Alrasheed SH, Naidoo KS, Clarke-Farr PC. Attitudes and perceptions of Sudanese high-school students and their parents towards spectacle wear. Afr Vision Eye Health. 2018;77(1):a392. https://doi.org/10.4102/ aveh.v77i1.392
13. Bennett AG, Rabbetts RB. Bennett and Rabbetts' clinical visual optics. Butterworth–Heinemann; 1998.
14. Pascolini D, Mariotti SP. Global estimates of visual impairment: 2010. British Journal of Ophthalmology. 2012 May 1;96(5):614–8. https://doi.org/10.1136/bjophthalmol-2011-300539. PMID:22133988
15. Khandekar R, Kishore H, Mansu RM, Awan H. The status of childhood blindness and functional low vision in the Eastern Mediterranean region in 2012. Middle East Afr J Ophthalmol. 2014 Oct–Dec;21(4):336–43. https://doi.org/10.4103/0974-9233.142273. PMID:25371641
16. Atowa UC, Hansraj R, Wajuihian SO. Visual problems: a review of prevalence studies on visual impairment in school-age children. Int J Ophthalmol. 2019 Jun 18;12(6):1037–43. https://doi.org/10.18240/ijo.2019.06.25. PMID:31236365
17. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021 Mar 29;372:n71. https://doi.org/10.1136/bmj.n71 PMID:33782057
18. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomized and non-randomized studies of health care interventions. J Epidemiol Community Health. 1998 Jun;52(6):377–84. https://doi.org/10.1136/jech.52.6.377 PMID:9764259
19. Chebil A, Jedidi L, Chaker N, Kort F, Largueche L, El Matri L. Epidemiologic study of myopia in a population of schoolchildren in Tunisia. Tunis Med. 2016 Mar;94(3):216–20. PMID:27575506.
20. Yamamah GA, Talaat Abdel Alim AA, Mostafa YS, Ahmed RA, Mahmoud AM. Prevalence of visual impairment and refractive errors in children of South Sinai, Egypt. Ophthalmic epidemiology. 2015;22(4):246–52. https://doi.org/10.3109/09286586.2015.1056811 PMID:26218107
21. Alrasheed SH, Naidoo KS, Clarke-Farr PC. Prevalence of visual impairment and refractive error in school-age children in South Darfur State of Sudan. Afr Vision Eye Health. 2016;75(1):a355. https://doi.org/10.4102/ aveh.v75i1.355
22. Abdi Ahmed Z, Alrasheed SH, Alghamdi W. Prevalence of refractive error and visual impairment among school-age children of Hargesia, Somaliland, Somalia. East Mediterr Health J. 2020 Nov 11;26(11):1362–70. https://doi.org/10.26719/emhj.20.077 PMID:33226104
23. Al Wadaani FA, Amin TT, Ali A, Khan AR. Prevalence, and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. Glob J Health Sci. 2012 Nov 11;5(1):125–34. https://doi.org/10.5539/gjhs.v5n1p125 PMID:23283044
24. Aldebasi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. J Optom. 2014 Jul–Sep;7(3):168–76. https://doi.org/10.1016/j.optom.2014.02.001 PMID:25000873

25. Yekta A, Fotouhi A, Hashemi H, Dehghani C, Ostadimoghaddam H, Heravian J, et al. Prevalence of refractive errors among schoolchildren in Shiraz, Iran. Clin Exp Ophthalmol. 2010 Apr;38(3):242–8. https://doi.org/10.1111/j.1442-9071.2010.02247.x. PMID:20447119.

26. Ullah F, Mahsood N, Mohyuddin W, Afridi S, Rehman ZU. Prevalence of refractive error and strabismus in primary school children of tehsil Lakki Marwat, Khyber Pakhtunkhwa Pakistan. J Gandhara Med Dent Sci. 2020;7(1):11–21. https://doi.org/10.37762/jgmds.7-1.99

27. Rezvan F, Khabazkhoob M, Fotouhi A, Hashemi H, Ostadimoghaddam H, Heravian J, et al. Prevalence of refractive errors among school children in Northeastern Iran. Ophthalmic Physiol Opt. 2012 Jan;32(1):25–30. https://doi.org/10.1111/j.1475-1313.2011.00879.x PMID:22023649

28. Mohamed ZD, Binnawi KH, Abdu M. Prevalence and causes of childhood blindness and visual impairment in Quranic boarding schools in Al-Gazira state of Sudan. Sudanese J Ophthalmol 2017 Jul–Dec;9:44–9. https://doi.org/10.4103/sjopthal.sjopthal_1_18

29. Jamali P, Fotouhi A, Hashemi H, Younesian M, Jafari A. Refractive errors, and amblyopia in children entering school: Shahrood, Iran. Optom Vis Sci. 2009 Apr 1;86(4):364–9. https://doi.org/10.1097/OPX.0b013e3181993f42 PMID:19289975

30. Hameed A. Screening for refractive errors and visual impairment among. Rawal Medical J. 2016;41(4):437–40.

31. Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful, Iran. Br J Ophthalmol. 2007 Mar 1;91(3):287–92. https://doi.org/10.1136/bjo.2006.099937 PMID:17035280

32. Elmajri KA. A survey of the prevalence of refractive errors among children in lower primary schools in Darnah city, Libya. Adv Ophthalmol Vis Syst. 2017;7(5):00235. https://doi.org/10.15406/aovs.2017.07.00235

33. Alrahili NH, Jadidy ES, Alahmadi BS, Abdula'al MF, Jadidy AS, Alhusaini AA, et al. Prevalence of uncorrected refractive errors among children aged 3-10 years in western Saudi Arabia. Saudi Med J. 2017 Aug;38(8):804. https://doi.org/10.15537/smj.2017.8.20412 PMID:28762432

34. Alghamdi W. Refractive errors and binocular anomalies in primary schools in Uyoun Aljawa: a small urban town in Saudi Arabia. Glob J Health Sci. 2020;12(10):116–21. https://doi.org/10.5539/gjhs.v12n10p116

35. Gilal IA, Khanzada MA, Mirza AA, Mahesar ML, Sahito GH, et al. Magnitude of prevalence of refractive errors in school-age children: a cross-sectional study. J Pharm Res Int. 2022;34(25B):14–21. https://doi.org/10.9734/jpri/2022/v34i25B35956

36. Bataineh HA, Khatatbeh AE. Prevalence of refractive errors in school children. Sudan J Public Health. 2008 Oct;3(4):186–9.

37. Ostadi Moghaddam H, Fotouhi A, Khabazkhoob M, Shandiz JH, Yekta A. Prevalence and risk factors of refractive errors among schoolchildren in Mashhad, 2006–2007. Iran J Ophthalmol. 2008;20:3–9.

38. Al-Rowaily MA. Prevalence of refractive errors among preschool children at King Abdulaziz Medical City, Riyadh, Saudi Arabia. Saudi J Ophthalmol. 2010 Apr 1;24(2):45–8. https://doi.org/10.1016/j.sjopt.2010.01.001 PMID:23960874

39. Fotouhi A, KhabazKhoob M, Hashemi H, Yekta AA, Mohammad K. Importance of including refractive error tests in school children's vision screening. Arch Iran Med. 2011 Jul;14(4): 250–3. PMID:21726100

40. Hashemi H, Yekta A, Jafarzadehpur E, Ostadimoghaddam H, Etemad K, Asharlous A, et al. High prevalence of refractive errors in 7-year-old children in Iran. Iran J Public Health. 2016 Feb;45(2):194–202. PMID:27114984

41. Hashemi H, Yekta A, Nabovati P, Khoshhal F, Riazi A, Khabazkhoob M. The prevalence of refractive errors in the 5–15-year-old population of two underserved rural areas of Iran. J Curr Ophthalmol. 2017 May 29;30(3):250–4. PMID:30197956

42. Hatow MHU, Mirzajani A, Madhi Hasan H, Abdulameer Hussein H, Jafarzadehpur E. The prevalence of refractive errors among first grade of primary school in Amara, South of Iraq. Func Disabil J. 2018; 1(1):31–9. https://doi.org/10.30699/fdisj.01.1.31

43. Kandi SC, Khan HA. Epidemiological Findings of Refractive Errors and Amblyopia among the Schoolchildren in Hatta Region of the United Arab Emirates. Dubai Med J. 2021;4(1):3–9. https://doi.org/10.1159/000512521

44. Al Nuaimi AA, Salama RE, Eljack IE. Study of refractive errors among school children Doha. World Fam Med J. 2010;8:41–8.

45. Anera RG, Soler M, De La Cruz Cardona J, Salas C, Ortiz C. (2009), Prevalence of refractive errors in school-age children in Morocco. Clin Exp Ophthalmol. 2009 Mar37(2):191–6. https://doi.org/10.1111/j.1442-9071.2009.02001.x PMID:19723127

46. Foster PA, Jiang Y. Epidemiology of myopia. Eye. 2014 Feb;28(2):202–8. https://doi.org/10.1038/eye.2013.280 PMID:24406412

47. Ovenseri-Ogbomo G, Osuagwu UL, Ekpenyong BN, Agho K, Ekure E, Ndep AO, et al. Systematic review and meta-analysis of myopia prevalence in African school children. PloS One. 2022 Feb 3;17(2): e0263335. https://doi.org/10.1371/journal.pone.0263335 PMID:35113922

48. Ip JM, Huynh SC, Robaei D, Rose KA, Morgan IG, Smith W, et al. Ethnic differences in the impact of parental myopia: findings from a population-based study of 12-year-old Australian children. Invest Ophthalmol Vis Sci. 2007;48(6):2520–8. https://doi.org/10.1167/iovs.06-0716 PMID:17525179

49. Gong JF, Xie HL, Mao XJ, Zhu XB, Xie ZK, Yang HH, et al. Relevant factors of estrogen changes of myopia in adolescent females. Chin Med J. 2015 Mar 5;128(05):659–63. https://doi: 10.4103/0366-6999.151669 PMID:25698200

50. French AN, Morgan IG, Burlutsky G, Mitchell P, Rose KA. Prevalence and 5- to 6-year incidence and progression of myopia and hyperopia in Australian schoolchildren. Ophthalmology. 2013 Jul;120(7):1482–91. https://doi.org/10.1016/j.ophtha.2012.12.018 PMID:23522969

51. Hu YY, Wu JF, Lu TL, Wu H, Sun W, Wang XR, et al. Effect of cycloplegia on the refractive status of children: the Shandong children eye study. PLoS One. 2015 Feb 6;10(2):e0117482. https://doi.org/10.1371/journal.pone. PMID:25658329

52. Morgan IG, Iribarren R, Fotouhi A, Grzybowski A. Cycloplegic refraction is the gold standard for epidemiological studies. Acta Ophthalmol. 2015 Sep;93(6):581–5. https://doi.org/10.1111/aos. PMID:25597549

53. Fotouhi A, Morgan IG, Iribarren R, Khabazkhoob M, Hashemi H. Validity of non-cycloplegic refraction in the assessment of refractive errors: the Tehran Eye Study. Acta Ophthalmol. 2012 Jun;90(4):380–6. https://doi.org/10.1111/j.1755-3768.2010.01983 PMID:20977697