Systematic review and meta-analysis of myopia prevalence in Brazilian school children

Revisão sistemática e metanálise da prevalência de miopia entre as crianças brasileiras de idade escolar

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How to cite:
Costa Neto AC, Guedes J, Mora-Paez DJ, Ferreira MA, Faneli AC, Amaral DC, et al. Systematic review and meta-analysis of myopia prevalence in Brazilian schoolchildren. Rev Bras Oftalmol. 2024;83:e0056.

doi:
https://doi.org/10.37039/1982.8551.20240056

Keywords:
Myopia; Prevalence; Child; Brazil

Descritores:
Miopia; Prevalência; Criança; Brasil

Received on:
Jul 16, 2023

Accepted on:
Oct 12, 2023

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Conflict of interest:
no conflict of interest.

Financial support:
no financial support for this study.

ABSTRACT

Introduction: Myopia is a growing global concern and there is a lack of studies on its prevalence among Brazilian schoolchildren.

Methods: This study aimed to determine the prevalence of myopia in Brazilian children aged 3–18 years through a review and meta-analysis of published studies. Eleven high-quality studies were analyzed following the 2022 PRISMA guidelines. Prevalence was calculated using a meta-analysis, considering the heterogeneity among the studies.

Results: The overall crude prevalence of myopia in Brazilian children was 7.65%. There was no significant association with the age of the children examined and no significant temporal trend was observed. Approximately one in 13 Brazilian schoolchildren had myopia.

Conclusion: Given the increased exposure of Brazilian youth to the risk factors for myopia, it is crucial to monitor myopia in the country. Further studies are required to address and prevent myopia in Brazil.

RESUMO

Introdução: A miopia é uma preocupação global crescente, estudos sobre sua prevalência entre os brasileiros ainda são escassos.

Métodos: Este estudo teve como objetivo determinar a prevalência de miopia em crianças brasileiras com idades entre 3 e 18 anos por meio de uma revisão sistemática e meta-análise. Seguindo as diretrizes PRISMA de 2022, onze estudos foram analisados. A prevalência foi calculada usando uma meta-análise, considerando a heterogeneidade entre os estudos.

Resultados: A prevalência bruta geral de miopia em crianças brasileiras foi de 7,65%. Não houve associação significativa com a idade das crianças examinadas, e não foi observada uma tendência temporal significativa. Aproximadamente um em treze escolares brasileiros tem miopia.

Conclusão: Dado o aumento da exposição da juventude brasileira aos fatores de risco conhecidos da miopia, é crucial monitorar a miopia no país. Estudos adicionais são imperativos para abordar e prevenir a miopia no Brasil.

INTRODUCTION

Uncorrected refractive errors are the most common cause of visual impairment, affecting an estimated one billion people worldwide.[1] Myopia is the most common refractive error and is a significant cause of ocular morbidity, particularly in school-aged children and young adults. Globally, myopia is reaching pandemic proportions due to changing lifestyles and modern technology, especially mobile devices.[2] In 2001, 22.9% of the world's population had myopia, which is predicted to increase to 49.8% by 2050, affecting 4.8 billion people, an increase of 117% in 50 years. According to a 2015 report, an estimated 1.89 billion people worldwide have myopia, and 170 million have high myopia.[3]

The reported prevalence of myopia in children aged 5–17 years ranges from 1.2% in Mechi Zone, Nepal, to 73.0% in South Korea.[4, 5] Within 15 years, the prevalence of myopia increased from 79.5 to 87.7% in Chinese schoolchildren with a mean age of 18.5±0.7 years.[6] In South African schoolchildren aged 5 to 15 years, the reported prevalence of myopia was only 2.9% with retinoscopy and 4.0% with autorefraction.[7] However, the authors noted that the prevalence increased to 9.6% at 15 years of age.

The increase in myopia prevalence has a significant economic impact because it is associated with other eye diseases and visual impairment. Uncorrected myopia between -1.50 D and -4.00 D can impair vision to the point that it is considered a cause of moderate visual impairment or blindness. High myopia, usually defined as spherical equivalent ≥5.00 D, has the risk of potentially blinding eye diseases such as retinal holes, retinal tears, retinal degeneration, retinal detachment, and myopic macular degeneration.[3, 8-10] Uncorrected myopia has enormous social, economic, psychological, and developmental implications.[10] The financial cost of refractive errors, including nearsightedness, is estimated to be approximately $202 billion annually, far exceeding the expense of other eye diseases.[11]

The increasing prevalence of myopia has led to research on the possible mechanisms underlying its development, with two main themes emerging. The first is the role of nature (genetic influences) and the second is an environmental influence (environmental effects, including lifestyle). Understanding the mechanisms underlying myopia development is also being explored to control myopia. However, due to significant regional differences in culture, habits, socioeconomic status, education level, and urbanization, there is uncertainty regarding the exact extent of myopia exposure in school-aged children and its development over time.[12]

Over the past few decades, urbanization has changed the lifestyles and behaviors of people worldwide. For example, in 1950, Brazil's urban population was 30 million, reaching almost 190 million by 2010. Moreover, following the emergence of technology, children spend extended periods completing school assignments and engaging in various activities on their mobile devices, including gaming.[13]

Urbanization has also changed the lifestyles and behaviors of people in Brazil. Almost 90% of Brazil's population resides in one of the 5,568 urban cities. As a result, Brazil's children and young adults participate more in indoor and nearby work activities when compared with previous generations. In addition, following the emergence of technology, children spend extended periods completing school assignments and engaging in various activities on their mobile devices including gaming. These factors are believed to contribute to myopia development and progression.[14-16]

Considering the current increase in the incidence of myopia, this systematic review and meta-analysis aimed to assess the prevalence of Myopia in Brazilian children between three–20 years old.

METHODS

The meta-analysis considered the characteristics of research that revealed the prevalence of myopia among Brazilian school-age children. We found 11 studies approaching the prevalence of myopia in school children conducted in different Brazilian states (Figure 1).

This meta-analysis was carried out following the methodological recommendations of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020.

The terms ("Refractive Error" OR "Myopia" AND "Children" OR "Prevalence" AND "Brazil") were used for the search. Search terms were used to query the Web of Science, Scientific Electronic Library Online [Scielo], and PubMed databases. The searches started on April 15, 2023 and ended on May 24, 2023. References from all the studies included, previous systematic reviews, and meta-analyses were manually searched for additional studies. Two authors independently extracted data using predefined search criteria and quality assessment. The full articles of eligible publications were then scrutinized. Only studies that met the following criteria were included in the meta-analysis.

This review included English and Portuguese studies published from 1975 to 2023 that investigated the

Table 1. Summary of studies included

First author	Age group (years)	Mean age (years)	Total sample size	Prevalence (%)	Cyclopegia	Objective refraction	Quality score
Yotsukura [17]	5-19	10.60 (2.90)	421	20.43	No	Yes	10
Salomão [18]	11-14	12.54 (1.12)	2,441	5.45	Yes	Yes	10
Lira [19]	5-18	11.45 (4.04)	778	9.64	Yes	Yes	10
Garcia [20]	5-20	-	974	13.04	Yes	No	8
Ibrahim [21]	10-15	12.4 (1.60)	1,590	3.14	Yes	No	10
Kara-José [22]	7-13	9.38 (1.70)	1,364	10.41	Yes	No	10
Ioschpe Gus [23]	5-21	12.74 (3.31)	330	17.27	Yes	Yes	9
Schimiti [24]	6-12	-	1,966	8.24	Yes	Yes	9
Couto Júnior [25]	5-18	-	1,800	1.06	Yes	Yes	9
Silva [26]	3-7	4.5	2,852	5.01	Yes	Yes	8
Estacia [27]	7	7,10 (1.38)	88	10.23	Yes	Yes	10

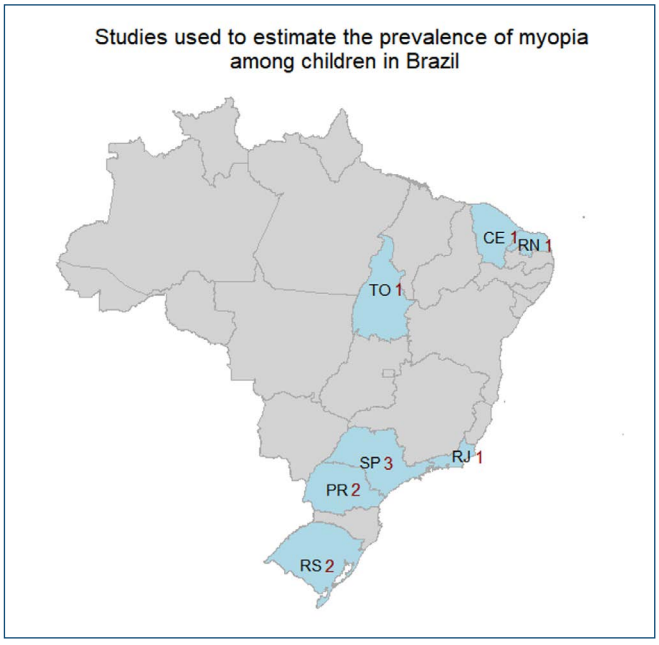

Figure 1. Number of studies of the prevalence of myopia in Brazil per state where they were conducted.

prevalence of refractive error among schoolchildren aged 5 to 18 years. In addition, the review included studies published that employed an observational cross-sectional study design, had a clear description of the sampling technique, stated the method of measuring refractive error (cycloplegic or non-cycloplegic refraction), as well as objective or subjective refraction, stated the criteria for defining myopia (spherical equivalent ≥0.50D of myopia) and were either school-based or population-based.[28-30]

The search criteria resulted in 96 articles. Subsequently, these studies were inspected and selected according to the type of population from which the sample originated, the possibility of delimitation by age, and the availability of specific myopia prevalence data. Data from people with comorbidities in their selection, data from the hospital population, and data with doubts about the delimitation of the age range were discarded, leaving the set of publications that used data from the general population or school populations.

Information on the use of cycloplegia and the method (objective or subjective) of measuring refractive error was recorded in each study, as well as the prevalence of myopia and sample size.

STATISTICAL METHODS

Meta-analysis was conducted using R version 4.2.3 (2023-03-15 curt) -- "Shortstop Beagle" (R Foundation for Statistical Computing, Vienna, Austria). The "meta" package was used to generate forest plots that show the prevalence of myopia in school children, in individual studies, and their corresponding weight, as well as the pooled prevalence with associated 95% confidence intervals (CI).[31] The tunnel plot was used to report the potential bias and minor/significant study effects. Begg's test was used to assess asymmetry[32] The prevalence was subdivided into separate datasets based on cycloplegic or non-cycloplegic refraction and the use of objective or subjective methods to evaluate the refractive error. For this purpose, the studies were classified into cycloplegic and objective refraction measures (complete method group) and non-cycloplegic and subjective refractive error evaluation (incomplete method group). Also, to study a possible variation of the prevalence of myopia related to age, the average age in the reported studies was used in a meta-regression model. A similar meta-regression model was used to investigate the variation of the prevalence according to the year of data collection.[33]

The estimation of the prevalence of myopia among Brazilian children was carried out in this meta-analysis using the "random effects" calculation method after the transformation of the original proportions into "logit" values, i.e., log(p/(1-p)) with the weights calculated by the method of the inverse of the variances of proportions.

RESULTS

Prevalence of myopia in Brazilian school-aged children

A heterogeneity test obtained for the different studies showed a high level of inconsistency (I^2=97%), indicating

the use of a Random Effect Model in all the meta-analyses conducted. The number of children aged 5–18 years included in the study ranged from 88 for a study conducted in Rio Grande do Sul to 2852 for another study conducted in Paraná. The prevalence of myopia reported in these studies ranged from 1 to 20%.

The estimated prevalence of myopia in Brazil (7.65%; 95%CI: 4.3, 13.1) was significant (p<0.05) once its confidence interval excluded the value zero (Figure 2).

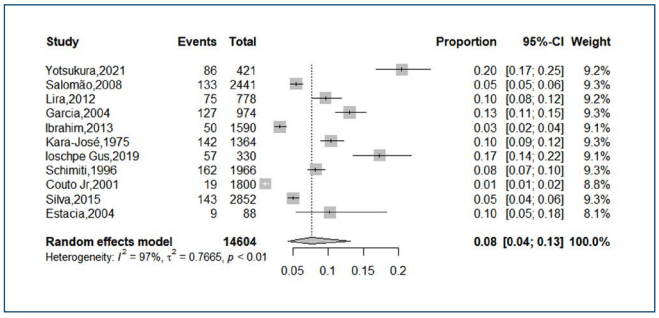

Figure 2. Forest plot of myopia prevalence among Brazilian schoolchildren aged 5 to 18.

Funnel plot and Begg's test for asymmetry indicated homogeneity (z=0.08; p=0.9379); i.e., eventual biased outliers had no significant overall effect in the estimate obtained (Figure 3).

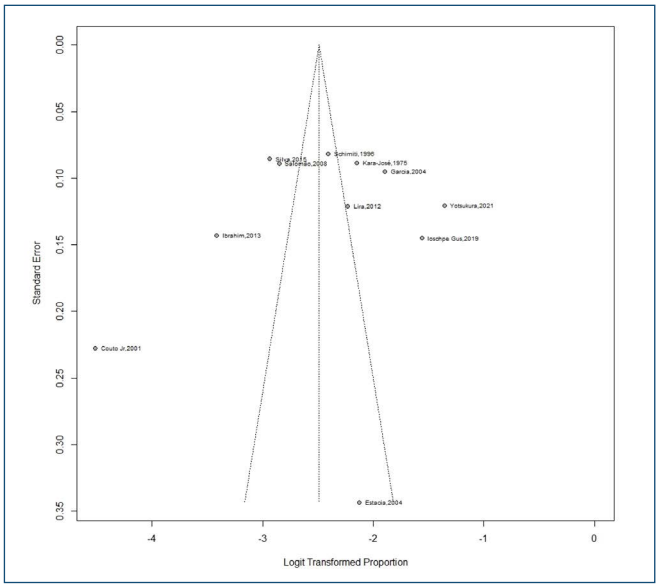

Figure 3. Funnel plot to assess asymmetry and heterogeneity in the studies included.

A meta-regression analysis of myopia showed that the proportion of myopia increased as the date of the studies advanced. Still, this relationship was not statistically significant (p=0.6886) (Figure 4).

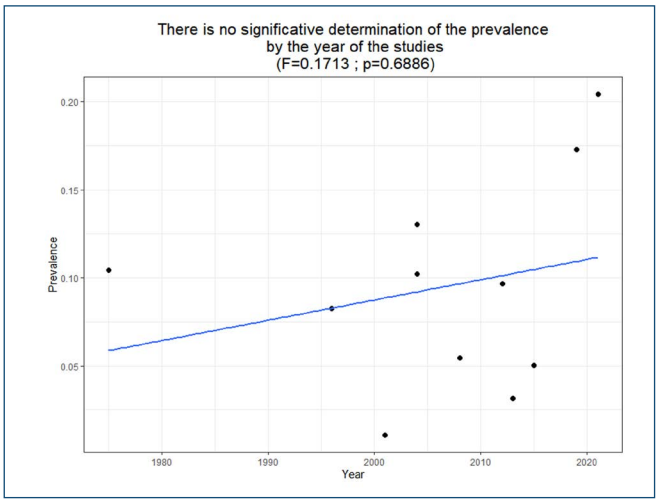

Figure 4. According to meta-regression analysis, the percentage of myopia grew as the publishing year grew, but this association was not statistically significant.

In addition, meta-regression analysis of myopia by the average age of children in the studies showed that the proportion of myopia increased as age increased. Still, this relationship was not statistically significant (p=0.7815) (Figure 5).

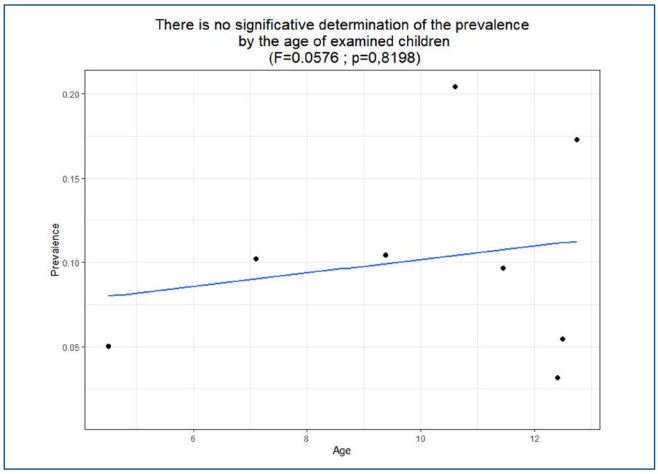

Figure 5. According to meta-regression analysis, the percentage of myopia grew as the age of examined children grew, but this association was not statistically significant.

DISCUSSION

Prevalence of myopia

The present study provides recent estimates of myopia prevalence in Brazilian children using data from 11 studies conducted over five decades. The prevalence of myopia defined as SER ≥0.50D of myopia in school children across Brazil was 7.65% (95% CI 4.35-13,14).

The variation in the reported prevalence of myopia between studies was 19.37%. Although the

regional variations in myopia prevalence found in this study are consistent with Foster and Jiang's statement that "Considerable regional difference exists from country to country even within the same geographical area", it remains unclear why these variations exist.[34] While the criteria to define refractive error is often cited as the reason for the variation in the prevalence of refractive errors, including myopia, between studies, this may not be the case in our study because only studies that defined myopia as a spherical equivalent of ≥0.50D were included.

The overall low prevalence of myopia across Brazil is consistent with other studies that reported a lower myopia prevalence in Western children than in Asian children.[35] It is worth noting that in the five studies included in the current review, the reported prevalence of myopia was greater than 10%. Of these, four studies[20, 22, 23, 27] used cycloplegic refraction, which is thought to estimate the prevalence of myopia more accurately.[17, 20, 22, 23, 27] Yotsukura reported the highest prevalence of myopia in Brazil, although the measures were performed using cyclopean.[17] The lower prevalence of myopia in Couto Júnior compared with other regions may be related to the differences in genetic predisposition to myopia development and culture.[36-38] Although the role of genetics in myopia development and progression has been reported to be small, it is believed to play a role in an individual's susceptibility to environmental risk factors for myopia.[39] In addition, several studies have shown the significant involvement of environmental factors, such as near work (writing, reading, and working on a computer), in myopia development.[36-38] In many states of Brazil, children do not start education and learning at the same early age as in other Asian countries. Therefore, Brazilian children are exposed to less near work and are more involved in outdoor activities, resulting in a lower risk of developing myopia than their Asian counterparts. This assertion is supported by the fact that, in 2020, the pre-primary school enrolment rate in the most populous state in Brazil (SP) was 79.12%, compared with 89.12% in 2012 in China (the most populous country in Asia).[13,40] However, a recent investigation has shown that more precise objective measures are required to draw definitive conclusions about the relationship between myopia and near work.[41]

Despite the relatively low prevalence of myopia among Brazilian children, there is a need to monitor the prevalence of myopia among children in this region, given the increased access to and use of mobile devices among the Brazilian population, including children. It is crucial to consider the higher reported increase in the prevalence of myopia in the last two studies.[17,23] It is assumed that nowadays, urban children have more access and exposure to near work, including mobile devices, and fewer outdoor activities than their counterparts in rural areas.

Age differences in myopia prevalence

No significant determination between the prevalence of myopia and the age of examined children was found (p=0.7815). The slightly higher prevalence of myopia between the two age groups shows a tendency for myopia prevalence to increase with age, which is consistent with previous studies from elsewhere.[42,43] This increase in myopia prevalence is thought to be associated with the increasing growth of the eyeball. The influence of gender on the prevalence of myopia has not been unequivocal in the literature,[44-47] with some suggesting that the slightly higher prevalence in females may be related to the different ages of onset of puberty between boys and girls.[48] Other factors that could account for the reported apparent higher prevalence of myopia in girls include limited outdoor activity time than in boys.[49]

Prevalence of myopia by refraction technique (cycloplegic and non-cycloplegic)

The present study demonstrated that cycloplegic refraction resulted in significantly lower estimates of myopia prevalence than non-cycloplegic refraction, consistent with previous studies.[50-52] It has been reported that non-cycloplegic refraction overestimates the prevalence of myopia, yields a non-reliable measurement of the association of myopia risk factors,[51,53] and hence cycloplegic refraction is regarded as the gold standard for measuring myopia. Over half of the studies in this review utilized cycloplegic refraction, which is particularly important in this age group where the difference between cycloplegic and non-cycloplegic refraction is relatively high.[52,54] The fact that non-cycloplegic refraction often results in the overestimation of myopia may have, in part, accounted for the high prevalence reported in Yotsukura.[17] Unfortunately, we could not demonstrate that cycloplegic refraction results in a lower variability of measured refractive error than non-cycloplegic refraction. Non-cycloplegic refraction may reflect the variable accommodative state during the refraction of children of different ages.[55] This finding underscores the need to appropriately control accommodation when performing refraction, especially in young children with a higher amplitude of accommodation and in whom accommodation is more active.

Implications of the study: consequences of the research

For the first time, a systematic review and meta-analysis have been conducted to determine the prevalence of myopia among Brazilian schoolchildren and how it varies with age and refraction method. As previously mentioned, compared to other regions like Southeast Asia, the frequency of myopia in Brazil seems to be low. Future prevalence studies might use the baseline data from this study as a baseline for comparison to establish a trend in myopia epidemiology in this group. This review also supports that, in contrast to cycloplegic refraction, non-cycloplegic refraction overstated the prevalence of myopia and produced more variable estimations of refractive errors. Researchers and decision-makers may be misled by how myopia prevalence data from non-cycloplegic refraction are interpreted. Therefore, it is advised that any studies examining the prevalence of myopia in children employ cycloplegic refraction.

Strengths and limitations of the review

There are some restrictions on this review. First, due to the small number of research results published, this review did not prove the trend in the prevalence of myopia among Brazilian schoolchildren. Second, the results were probably biased toward studies in states where the results were provided in subjective refraction and non-cycloplegic measures. Thirdly, due to the lack of prevalent studies of myopia in Brazil, the current review did not establish the prevalence of epidemiology of myopia in this population. The selection of studies that employed a consistent definition of myopia (i.e., 0.50DS of myopia) allowed for a better comparison in the reported prevalence of myopia, despite these limitations. Additionally, studies conducted in unselected groups were not included in the analysis, including hospital-based studies and those that failed to provide proof of sampling. Finally, the robustness of the study designs used in each chosen study was also assessed.

CONCLUSIONS

In conclusion, this study's systematic review and meta-analysis revealed that myopia is less common among Brazilian kids than in other places of the world. It can be misleading to estimate the prevalence of myopia using non-cycloplegic refraction because the results are more significant and less consistent. As more youngsters in this region are exposed to known risk factors for myopia development, such as access to mobile devices, increased near work, increased online or remote learning, and limited outdoor time, keeping an eye on the myopia trend is crucial. Future research is required to understand the impact of ethnicity on the prevalence of myopia in Brazil, as the comparison and inclusion of the various ethnic groups (Black, White, Asian) in the same area would add valuable information about any differences in the prevalence of myopia among the different ethnic groups in Brazil.

AUTHORS' CONTRIBUTION

All authors made substantial contributions to the conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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