Original Article

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Visual Status in Children with Dyslexia at the Integrated Special Education Program in Selangor, Malaysia

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Abstract

Objective: Dyslexia is a learning disorder, characterized by difficulties in recognizing, decoding, and spelling words. Studies on visual status of individuals with dyslexia have yielded mixed findings. This study aimed to assess visual acuity and refractive errors in dyslexic children in Selangor, Malaysia.

Material and Methods: A cross-sectional study was conducted in the integrated special education program (PPKI) for secondary schools across three randomly selected districts in Selangor. Children with dyslexia from 15 schools were enrolled. Distance and near visual acuity were measured, and non-cycloplegic refraction was performed to identify refractive errors. Descriptive analysis was used to describe the distribution of visual acuity and refractive errors. The Wilcoxon Signed-Rank test was used to compare habitual and corrected visual acuity (VA).

Results: 137 dyslexic children, aged 13 to 19 years, participated in the study. 60% of the participants had good habitual distance VA. Meanwhile, the percentage of good habitual near VA were higher than distance VA. The Wilcoxon Signed-Rank test showed that corrected VA was significantly better than habitual VA. The most common ametropias observed were myopia and astigmatism.

Conclusion: Dyslexic children in the PPKI program generally have good visual acuity and are emmetropic. However, uncorrected refractive error and suboptimal optical refraction were the primary causes of unsatisfactory habitual vision in some children. Findings highlight the need to screen for refractive errors and provide appropriate optical correction to this population to prevent further hindrance to their reading ability.

Keywords astigmatism, dyslexia, hyperopia, refractive error, myopia, visual acuity (VA)

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Introduction

Dyslexia is one of the most common learning disabilities, primarily affecting reading and language processing. Approximately, 10-15% of the world population suffers from dyslexia[1] with 10-15% of school children reported to show symptoms of dyslexia[2]. It is characterized by difficulties in accurate and fluent word recognition, as well as poor spelling and decoding skills[3,4], causing failure to separate the sounds from the word to match the letter[5]. The disability is thought to arise from neurobiological factors rather than intelligence level, as individuals with dyslexia were reported to have equal to or above average compared to typically developing peers[6]. The impairments in phonological are not only associated with abnormalities in cerebral connectivity, but also in cortical structure which involve the left hemisphere of the brain[5,7]. Anatomy and brain imaging studies revealed that dyslexia is associated with lower activity in the left hemisphere of the brain, the Broca area, which is responsible for articulation, naming and silent reading, and the parietal-temporal region, that is responsible for word analysis. Instead, children with dyslexia use different part of the brain, the inferior frontal gyri of both hemisphere and the right occipital-temporal word form area as the compensatory region for word analysis[3] which is less efficient in converting the written words into spoken words[3,7].

Good language processing is undoubtedly the most crucial prerequisite for successful reading, but good visual function is also essential for children when learning to read. According to Wajuihian & Naidoo[8], 75% to 90% of children's learning is mediated through the vision. Despite this, many children with visual impairments such as squints and abnormal eye movements can still read satisfactorily[9]. However, in children with dyslexia, abnormal visual function can exacerbate the existing reading difficulties and further impact their academic performance.

Previous studies have examined the link between visual function abnormalities and dyslexia, but the findings have been inconclusive. Bucci & Brémond-gignac[10] and Kapoula et al.[11] reported that visual acuity in children with dyslexia was as good as 6/9 and better, while other studies claimed that visual acuity was affected in dyslexic children compared with typically developing children[6,12,13]. On the other hand, studies by Buzzelli[14] and Goulandris et al.[9] concluded that visual acuity was comparable between children with dyslexia and typically developing children. Although visual acuity may not be directly impaired by dyslexia, it can be affected by refractive errors, which often develop in individuals with learning disabilities. Studies have shown that the most common type of refractive error found in dyslexia is hyperopia[15-17]. Additionally, a higher prevalence of astigmatism has been reported in children with dyslexia compared with typically developing children[13,18].

There have been collective studies on visual function among children with dyslexia, but these studies have predominantly focused on Caucasian populations. Two studies in Malaysia that focused on children with learning disabilities reported that myopia was the most common type of refractive error[19] and that the children generally had good vision, with only 4.8% having visual acuity poorer than 6/12[20].

However, these two studies examined children with learning disabilities in general not specifically those with dyslexia. To date, visual profiles among children with dyslexia in Malaysia have not been reported. Since dyslexia is the most common type of learning disability in Malaysia, affecting 10% to 15 % of school children, and since refractive status may vary with ethnicity, identifying the visual status of this group is crucial for clinicians to identify the common visual problems that might exacerbate existing reading and language issues in dyslexia. Therefore, this study was conducted to determine the visual profile, particularly visual acuity and refractive error, in children with dyslexia. This can give insight into whether the visual needs of children with dyslexia are being adequately met.

Material and Methods

Study design and sample population

This cross-sectional study was conducted on dyslexic students aged 13 to 19 years enrolled in the government secondary school's special education program called "Program Pendidikan Khas Integrasi" (PPKI) in Selangor. Participants were selected through purposive sampling from 15 schools across three randomly selected districts in Selangor, Malaysia, which were Kuala Selangor, Petaling Utama and Klang. All participants were identified as dyslexic based on medical records provided by certified medical experts prior to their enrolment in the program at the selected schools. All participants had no other neurodevelopmental disorders besides dyslexia, and had the ability to understand English or Malay. Participants with active ocular or corneal disease, nystagmus, strabismus, or monovision were excluded from the study.

The sample size calculation was performed using a web-based calculator by Arifin[21], using a single mean formula to estimate the visual acuity and refractive errors of dyslexic children in PPKI. The standard deviation for refractive error used in the calculation was obtained from Wajuihian & Naidoo[8] as no published studies on dyslexic children in Malaysia were found. Based on the calculation, with a standard deviation of 1.01D, a precision of 0.25D and a 20% dropout rate, the sample size required is 79 children for a 95% confidence interval. However, a larger sample size was aimed in this study as the reference used was based on dyslexic children from other countries.

Procedure

Before the research commenced, written informed consent was obtained from the parents or legal guardians, and assent was obtained from the participants. Measurements were conducted in the morning in a designated room at the schools to ensure optimal responses from the participants. This study was conducted in accordance with the Declaration of Helsinki and was approved by the ethical committee (REC/12/2023(ST/MR/289) of the authors' institution and the Ministry of Education (MoE) (KPM.600-3/2/3-eras(19051). The two standard optometric assessments performed on all participants were visual acuity and refractive assessment.

Visual acuity (VA)

Visual acuity (VA) was measured in participants' habitual conditions, with the assessments conducted on their current presenting state, regardless of whether they were wearing glasses. VA was assessed monocularly at both distance and near using a mobile Snellen chart and a reading chart which were placed at 3 meters and 40 centimetres respectively. The chosen distances were based on the availability of the rooms provided by the schools. With the non-tested eye occluded, participants were instructed to read the Snellen chart from the top to the smallest visible line. The smallest line that they could read was recorded as the distance habitual VA for that particular eye. If the participants were unable to read 6/6 line, a pin-hole was introduced and they were instructed to continue reading if the vision improved. The smallest line that they can read with the pin-hole on was recorded as VA with pin-hole. A similar procedure was repeated to measure VA for the other eye.

Near visual acuity was then measured by instructing the participants to read the smallest line that they could see on the reading chart. This was also done monocularly for each eye, with the non-tested eye covered by an occluder. Participants were allowed to pronounce the letter if they could not read the words aloud during the measurement. In the case of illiterate participants, a matching card was used, requiring them to match the letter shown by the examiner. All VA recorded were converted to the LogMAR unit for data analysis.

Refractive assessment

The refractive assessment was conducted both objectively and subjectively. Each participant underwent a non-cycloplegic retinoscopy, using a working distance lens of +2.00DS to fog the eyes during this procedure. The participants were instructed to focus on a distant target on the Snellen, chart while the examiner shone light into the eyes, sweeping it side to side to observe the reflex. Lenses were then added incrementally until the reflex was neutralized and no movement was seen.

After completing the objective measurement, subjective refraction was performed to finalize the refractive error. Subjective refraction was performed according to the standard optometric procedures, beginning with finding the best vision sphere, followed by refining the cylindrical axis and power, and assessing monocular and binocular endpoints until the best-corrected visual acuity (BCVA) was achieved.

Statistical methods

Results were analyzed using the IBM Statistical Package for Social Sciences (SPSS) version 29 for Windows (IBM Corp., Armonk, NY). Descriptive analysis was used to describe the demographic information, distribution of VA and refractive errors of the participants. The data were tested for normality using the Kolmogorov-Smirnov test. Since the data was not normally distributed, a Wilcoxon Signed-Rank Test was used to compare the habitual VA and BCVA at both distance and near to determine whether the participants were already present with the best VA. Additionally, the refractive errors of the participants were classified into groups based on the spherical equivalent of the best eye obtained from subjective refraction. The Chi-Square Goodness of Fit Test was used to compare the proportion of different types of refractive errors to determine which type was more prevalent in the sample. All tests conducted were two-tailed with an alpha value set at 0.05.

Results

Demographic

A total of 137 dyslexic students, including 100 males (73%) and 37 females (27%), with a mean age of 15.24±1.75 years were examined in this study. Majority of the participants were Malay (n=121, 88.3%), followed by Chinese (n=8, 5.8%), Indian (n=7, 5.1%) and Kadazan (n=1, 0.7%). Out of the 137 participants, 24.6% had a history of being prescribed glasses from previous eye assessments, but only 20.4% were currently wearing their glasses.

Visual acuity

For distance habitual VA, 60% of the participants had a good habitual VA of at least 6/9 on the right eye, while the remaining 40% had a habitual VA of 6/12 or worse. Similarly, for the left eye, nearly 66% had a good habitual distance VA of at least 6/9 while the other 34% had a habitual VA of 6/12 or worse that requires further evaluation. The reasons for poor VA can be further divided into several factors, with 13.9% due to uncorrected refractive error, followed by 7.3% due to under-corrected glasses, 6.4% due to amblyopia, 5% due to squint and binocular vision anomalies while the remaining 1% due to was ocular opacity.

The mean distance habitual VA for the right and left eye were +0.34 logMAR ±0.27 and +0.33 logMAR±0.28, respectively. After correction, the percentage of participants with a good distance vision of at least 6/9 or better has improved to 88% and 90% on the right eye and left eye, respectively, resulting in the mean of best corrected visual acuity (BCVA) of 0.21logMAR±0.13 and 0.20logMAR±0.13 in the right and left eye respectively. The Wilcoxon Signed Rank Test showed that the habitual visual acuity was significantly poorer than the best-corrected visual acuity in the right eye ($Z=266$, p-value<0.001), indicating that the presenting distance VA was significantly lower and inadequate. Likewise, a Wilcoxon Signed Rank Test also showed that the habitual visual acuity of the left eye was significantly poorer than the best-corrected visual acuity (Z=204, p-value<0.001) indicating that the presenting VA was lower and inadequate on the left eye too. The distribution of habitual and best-corrected distance VA is displayed in Figure 1.

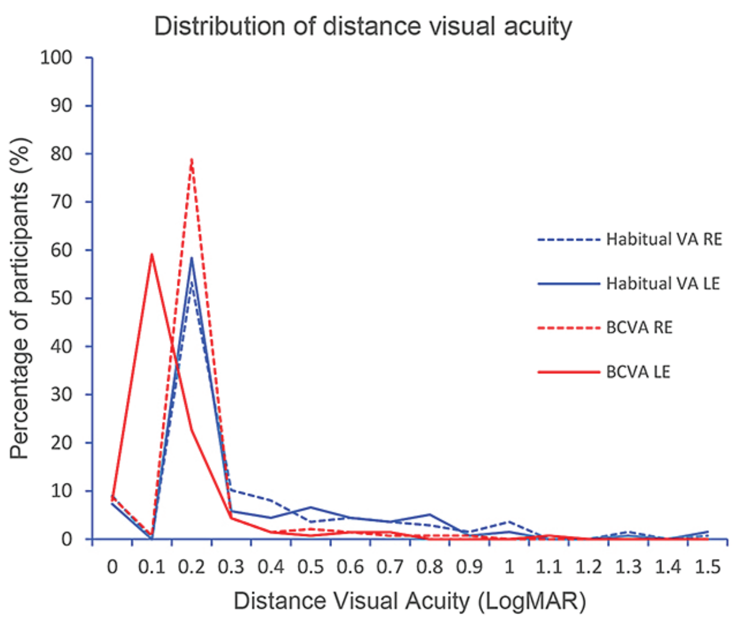
For near VA, 88% and 91% of the participants had a good near VA of N6 or better on the right eye and left eye respectively. The mean of near VA was +0.25 logMAR ±0.13 and +0.24 logMAR ±0.12 on the right and left eye respectively. After correction, the mean near VA has improved to +0.23 logMAR ±0.12 and +0.22 logMAR ±0.12 on the right and left eye respectively, resulting in the percentage of participants with a good near vision of at least N6 or better improved to 95% on the right eye and 96% on the left eye. The distribution of habitual and best-corrected near VA can be visualised in Figure 2.

A Wilcoxon Signed Rank Test showed that the habitual near visual acuity was significantly higher than the best-corrected visual acuity in right eye, (Z=0.000, p-value<0.001), as well as the left eye (Z=28, p-value<0.001). The percentage of participants with habitual and corrected VA of at least 6/9 in each eye at distance and near is summarized in Figure 3.

Distribution of refractive error

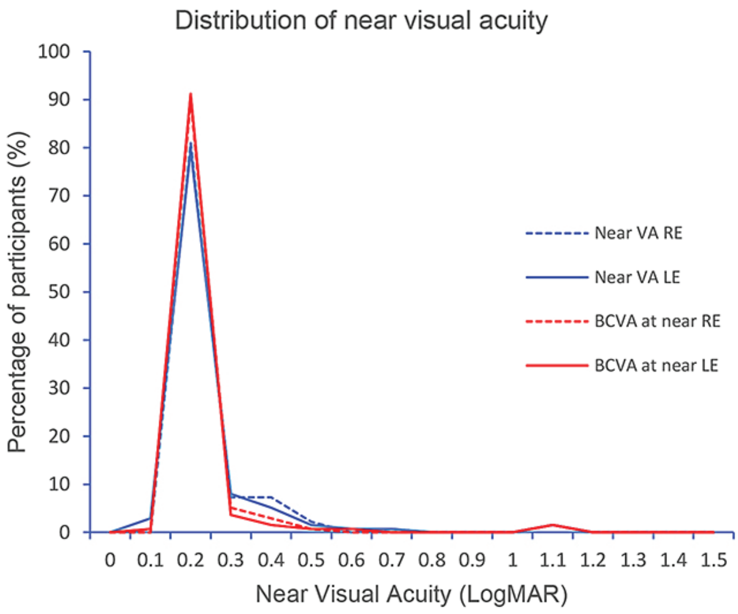
The mean spherical equivalent for the right and the left eye were -1.40D±2.76 and -1.37D±2.79, respectively. The classification of refractive error was reported based on the spherical equivalent power (sphere plus 0.5×cylinder) of the best eye following Gothwal et al.[22]. Figure 4 shows the distribution of the spherical equivalent of the best eye.

The refractive error was further classified into groups adapted from Joseph et al[21], where myopia was defined as a spherical equivalent of ≤–0.50D, while hypermetropia as a spherical equivalent of ≥+1.00D. Of the 137 participants examined, 62% were found to have emmetropia, while



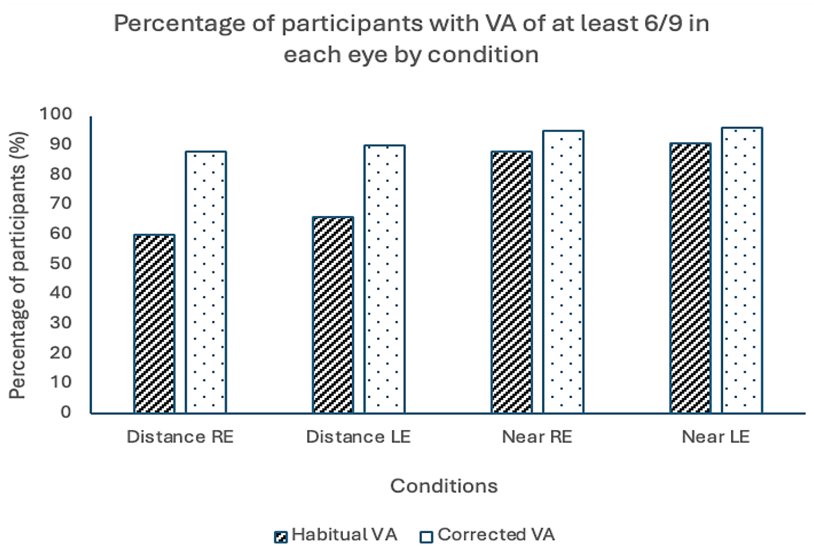
VA=visual acuity, BCVA=best corrected visual acuity

Figure 1 Distribution of distance VA for each condition. BCVA refers to the best-corrected distance VA in each eye



VA=visual acuity, BCVA=best corrected visual acuity

Figure 2 Distribution of near VA for each condition. BCVA refers to the best-corrected distance VA in each eye



VA=visual acuity

Figure 3 Percentage of participants with VA of at least 6/9 in each eye for each condition the remaining 38% had ametropia. Among the two types of ametropia, myopia was more prevalent which was observed in 35% of the participants, while only 3% had hypermetropia. A Chi-square goodness of fit test indicated that the observed frequencies in the three classifications of spherical equivalent (emmetropia, myopia and hyperopia) differ significantly ($\chi2$ (2, N=137)=57.124, p-value<0.001), indicating a significant difference in the percentage of the participants across groups (Figure 5).

Furthermore, the percentage of participants with a cylindrical power of more than -0.50DC was also calculated to determine how prevalent astigmatism is among the participants. Results showed that astigmatism was found in 72% of the participants making it the most common type of refractive error amongst all.

Discussion

The aim of this study was to report the visual status and refractive errors in children with dyslexia enrolled in the government-integrate special education program at secondary schools in Selangor. Findings indicate that astigmatism was the most prevalent type of refractive error and that a significant number of participants did not have adequate vision, with the most common reason being uncorrected refractive errors.

Previous studies have explored visual status in dyslexia, but the findings remain inconclusive. Several studies have indicated that deterioration in visual acuity is not a common feature of dyslexia[7]. For instance, Bucci & Brémond-Gignac10 and Kapoula et al.[11] reported that individuals with dyslexia generally have good visual acuity. On the other hand, Latvala et al.[13] found that while typically developing children tend to have slightly better visual acuity than those with dyslexia, 87% of children with dyslexia in their study were still able to demonstrate good visual acuity. However, Evans et al.[6] observed a reduction in visual acuity among children with dyslexia compared to typically developing children. This discrepancy may be due

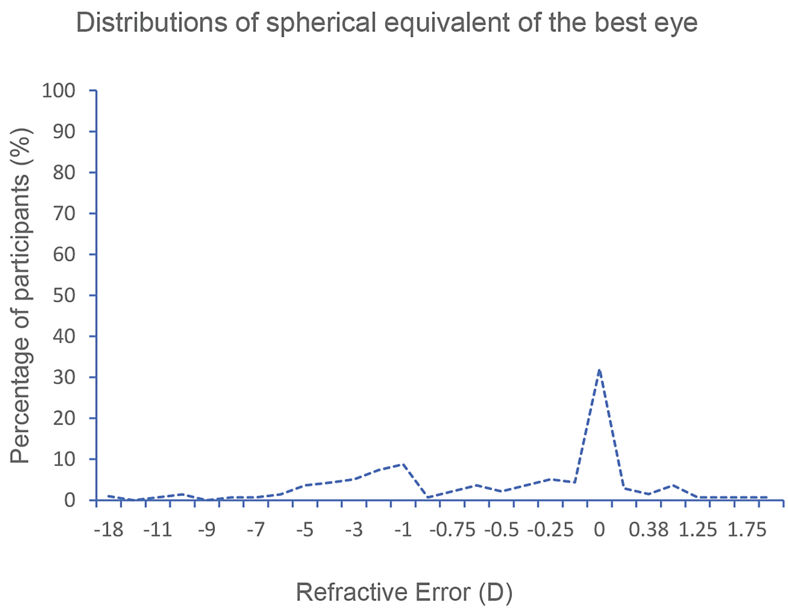


Figure 4 Distribution of spherical equivalent of the best eye

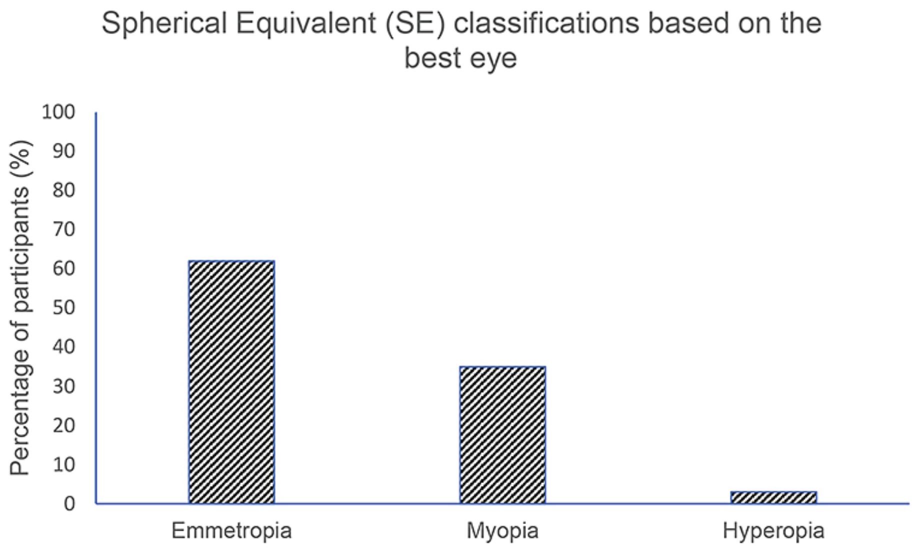


Figure 5 Spherical equivalent (SE) classifications based on the best eye, Myopia refers to SE≤−0.50D, Hypermetropia refers to SE≥+1.00D, Emmetropia refers to SE −0.25D to +0.75D (Joseph et al.[21])

to challenges in the sequential naming of the letters on different types of visual acuity charts used in various studies.

In agreement with the previous findings[10,11,13,17], the present study also found that more than half of the participants were able to achieve a minimum visual acuity of 6/9. In addition, after refractive assessments, improvement in visual acuity was seen in another one-third of the participants advocating that most individuals with dyslexia do not have significant issues with visual acuity. Moreover, the significant improvement in visual acuity observed when comparing habitual and best-corrected visual acuity suggests that a substantial number of these children had their visual needs unmet as the refractive error left uncorrected. Wajuihian & Naidoo[8] suggested that any deterioration in visual acuity among dyslexics was not due to malfunction or retinal diseases but rather due to uncorrected refractive errors. Although reduced visual acuity may not be the primary cause of literacy challenges among dyslexia, it could exacerbate difficulties in performing the task as a student if it is left uncorrected[2]. Consequently, over a six-months period, this issue might negatively impact academic performance in this group.

Myopia is more common compared with hyperopia in the current study. This finding differs from the previous studies, which reported hyperopia as the predominant refractive error among this population[8,13,15,23,24]. The difference in the common type of refractive error observed in this study compared with the previous studies may be attributed to the distinct study populations. While the earlier studies focused on European Caucasian children, this study was conducted among the East Asian population. According to Ip et al.[25], the East Asian children with a mean age of 12.7 years exhibited a more myopic mean spherical equivalent compared to their European Caucasian counterparts who showed a more hyperopic mean. This finding helps explain the types of refractive error observed in the current study.

In addition to myopia, astigmatism was present in more than half of the participants in this study. These results contrast with those of Wajuihian & Naidoo[8] and Ygge & Lennerstrand,[18] who reported that only 10% and 25% of the children with dyslexia had astigmatism, respectively. The higher prevalence of astigmatism in the current study may be related to the higher incidence of myopia found in this group, as myopia progression has been suggested to contribute to the development of astigmatism, too. In addition, considering that the current study was conducted after the COVID-19 pandemic, environmental factors such as increased screen time, particularly after the pandemic may cause an increase in astigmatism similar to what was reported in typically developing children[26].

Although the majority of the participants had good best-corrected visual acuity, there were still some who did not receive the visual correction they needed to achieve optimal vision. Alarmingly, despite having refractive errors, only 20% of these children were wearing glasses with optimal correction. This finding underscores the importance for clinicians to assess the visual acuity status of children with dyslexia. Additionally, parents and teachers play a crucial role in identifying symptoms of visual difficulties and working together to emphasise the importance of wearing glasses to children. In the future, regular eye check-ups and screening should be encouraged in children with dyslexia to ensure their vision is optimal in order to promote good literacy skills.

One of the limitations of this study is that the refraction was performed without cycloplegia; therefore, we were unable to reveal the maximum plus power of the refractive error. Despite that, the existing findings shall give some insight into the visual status and distribution of refractive errors among dyslexic children in this country. Future studies may consider having a control group to compare the distribution of refractive error between the groups and performing cycloplegic refraction or alternative techniques to cycloplegic refraction on the children to reveal the maximum plus power if any.

Conclusion

children with dyslexia generally have good visual acuity and are emmetropic. However, uncorrected refractive errors and suboptimal correction of these errors are the primary reasons for unsatisfactory habitual vision in some children, who are mostly astigmatic and or myopic. Therefore, these findings highlight the need to screen for refractive errors and provide appropriate optical correction to children with dyslexia to prevent further hindrance to their reading ability.

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Conflict of interest

There are no potential conflicts of interest to declare.

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