Content available at: https://www.ipinnovative.com/open-access-journals

IP International Journal of Ocular Oncology and Oculoplasty

Journal homepage: https://ijooo.org/

Original Research Article

Reading performance in school going children with visual function anomalies

Nilufa Akter[1], Masihuzzaman[1], Syeed Mehbub Ul Kadir[2]*, Gaurav Kumar Bhardwaj[1], Mastura Khatun[3], Sunanda Sarkhel[1], Sayantan Chakraborty[4], Rajendra Prakash Maurya[5]

[1]*Dept. of Optometry and Vision Science, Amity Medical School, Amity University, Gurugram, Haryana, India*
[2]*Sheikh Fazilatunnesa Mujib Eye Hospital and Training Institute, Gopalganj, Bangladesh*
[3]*Dept. of Pediatric Ophthalmology and Strabismus, Ispahani Islamia Eye Institute and Hospital, Dhaka, Bangladesh. Fax: India*
[4]*Dept. of Public Health Science, Amity Medical School, Amity University, Gurugram, Haryana, India*
[5]*Regional Institute-Ophthalmology, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India*

ARTICLE INFO

Article history:
Received 01-12-2023
Accepted 30-12-2023
Available online 01-02-2024

Keywords:
Binocular Vision Anomalies
Reading Difficulty
Reading performance
Reading Speed

ABSTRACT

Aim: To compare reading performance in children with and without visual function anomalies.
Materials and Methods: This cross-sectional study was carried out from May 2021 to April 2022 in a tertiary eye hospital of Bangladesh. This study included patients with 6-15 years of age who visited at Vision Therapy clinic. CISS-score was used to identify the asthenopia complaints and reading difficulties while having a normal vision and normal retinal function only selected for recruitment. Reading error, accuracy and reading speed were assessed with an N-notation chart with an N6 target size and the time taken to complete the task was recorded with a stopwatch. Both univariate and bivariate tables are used for analysis. Statistics analysis was performed accordingly, and the level of significance used was at 0.05.
Results: Out of 200 subjects, 46.5% boys and 53.5% girls. Of the total, 15.5% had NVF. The mean age of the participants was 12.04 (±2.44) years. Children with AVF had a higher number of reading errors and non-significant negative correlation (AVF=7.64 (±5.19); NVF 6.55 (±3.67); (r = -1.00, p=0.157). Lower Reading accuracy was noted in AVF as correlated to NVF and non-significant negative correlation (AVF=86.11 (±14.84); NVF=86.43 (±13.12); (r= -0.008, p=0.912). Similarly, lower reading speed was noted in AVF as correlated to NVF and non-significant negative correlation (AVF=79.47 (±39.20) wpm; NVF=84.51±36.84 wpm; (r= -0.047, p=0.507). A statistically significant difference was seen between AVF and NVF (p=0.001 at a 95% Confidence Interval of the differences). Children in the 1^{st} to 5^{th} grades presented a higher risk of reading impairment than the 6^{th} to 10^{th} grades. Higher reading speed (112±20.69wpm) was noted in 10^{th} grade.
Conclusion: In this study, it was observed that poor reading performance is linked to abnormal visual function in school-aged children, but visual function and reading performance are not positively related.

1. Introduction

Reading is one of the most visually demanding tasks we do daily,[1] including various psychological tasks as well as quick movements of both eyes in the same direction (saccades) from one word to the next or, on occasion, backward to previously read the literature.[2,3] Binocular coordination ensures that a steady, unified percept of the text is maintained across eye movements during reading and other visually demanding tasks, helping visual processing to occur without interruptions produced by diplopia.[4–7]

* *Corresponding author*.
E-mail address: mehbubkadir@gmail.com (S. M. U. Kadir).

https://doi.org/10.18231/j.ijooo.2023.038

Furthermore, reading is a visuo-cognitive mechanism, and single-vision perception is essential for this process to occur and function appropriately in today's world.[7] Reading involves coordinating several visual functions that provide coordinated information to the visual cortex, including refraction, accommodation, visual acuity, saccades, convergence, and fusion.[8] When children start school, their most crucial education element is learning through reading. Many myths about reading issues come from the importance of the eyes in reading.[9] Low levels of academic performance and educational outcomes can be linked to health (dyslexia, lower intellectual ability, binocular vision anomalies, and speech sound disorders)[10–12] as well as the familial, social, physical, and economic environment in which children and teenagers live.[11]

Reading includes both accommodative and vergence mechanisms. An imbalance between the sensory-motor integrated functions leads to non-strabismic accommodative and/or binocular vision anomalies. As a result, any abnormalities in the visual system will impact children's cognitive and educational performance.[13] Poor reading performance and binocular vision abnormalities have been linked in the literature. These problems include poor pursuits, abnormal convergence,[14] insufficient amplitude of accommodation,[15] accommodative infacility,[14–16] weak fusional vergence reserves, and abnormal fixation disparity.[17]

In India, the reported prevalence of specific learning difficulties among 8–11 years-old children are 15.17%.[18] Carla Costa et al.[19] reported that 16.4% of all school-age children in Portugal showed poor academic performance due to visual function anomalies. Accommodation and vergence anomalies affect approximately 80% of the children with learning disabilities, including convergence insufficiency(CI), the reduced amplitude of accommodation(AOA), accommodative and vergence facility, fusional ranges and low accommodative convergence/accommodation(AC/A) ratio.[20,21] In addition, children with reading and writing difficulties have impairments in accommodation and vergence parameters compared to age-matched controls who do not have reading and writing problems.[15,22–24] Several studies have found that children with reading and learning problems have a higher incidence of hypermetropia and non-strabismic binocular vision problems than normal readers.[17,25–29] Appropriate spectacles prescription and vision therapy are important in relieving symptoms in these children.[30–32]

From an optometrist's perspective, a decrease in reading ability may be associated with Visual function anomalies. To the best of our knowledge, there are no prevalence data in the Bangladeshi literature for binocular vision anomalies. Therefore, we attempt to determine the correlation of reading performance (error, accuracy, and reading speed) in children with and without visual function anomalies.

2. Materials and Methods

This observational cross-sectional study was carried out at the Vision Therapy Clinic of a multispecialty eye hospital in Dhaka, Bangladesh, from May 2021 to April 2022. The study subjects (6 -15 years) with asthenopia symptoms (Reading impairment) were selected by simple random sampling. All patients had 6/6 BCVA in each eye.

A written questionnaire (CISS-score) was used to identify the asthenopia complaints along with reading difficulties while having a normal vision and normal retinal function only selected for recruitment. We excluded from the study who were not willing to participate, subjects previously diagnosed with VFA, Neurocognitive disability, Dyslexia, Speech sound disorder, any ocular surface disorder, systemic illness, previous history of any intraocular surgery, strabismus, or previous surgery to correct strabismus, amblyopia, and nystagmus.

All participants had undergone complete ophthalmic and binocular vision examination, including visual acuity, dry and wet retinoscopy, pupillary reaction examination, Stereopsis, ocular alignment, extraocular motility, Cover and alternate cover test, AC/A-ratio, NPC (Push into-double), amplitude of accommodation (push-into-blur), MEM dynamic retinoscopy, NRA, PRA, NFV, PFV, accommodative facility, vergence facility. Reading error, accuracy and reading speed were assessed with an N-notation chart with an N6 target size. The time taken to complete the task was recorded with a stopwatch.

2.1. Reading performance test

Reading error, accuracy and reading speed were assessed with a list of 140-150US English/Bangla words N-notation (reduced Snellen) chart with N6 target size and time taken to complete the task was recorded with a stopwatch. The reading speed is the number of words the child reads per minute (wpm). The number of incorrect words reads noted and accuracy (A) was calculated with the following equation:[19]

$A = \frac{NCW}{WR} \times 100$

Where NCW is the number of correct words and

WR is the total number of words read.

The result is a percentage with three levels of performance which are published and validated:[19]

1. 1st – independent level reading (accuracy of 96% to 100%).
2. 2^{nd} –instructional level reading (accuracy of 90-95%).
3. 3^{rd} –Frustration level reading (accuracy <90%.

2.2. Statistical analysis

All collected data were analyzed with SPSS program (version 16.0 for Windows; SPSS In., Chicago, IL, USA). Both univariate and bivariate tables are used for analysis.

Statistical analysis was including frequency distribution, measurement of central tendency (mean, median, and mode), measures of dispersion (Standard deviation), and non-parametric tests (Chi-square, Cramer's V). The level of significance used was at 0.05.

3. Results

In this study, we evaluated 200 children with complaining asthenopia symptoms with reading; the mean age of participants was 12.04 (±2.44) years, ranging from 6-15 years. Most of them study in secondary school (12-15 years) than primary school (6-11 years). Of all, boys were 46.5% (N=94) and girls were 53.5% (N=106). Among the study subjects, the most frequent range of uncorrected visual acuity (UCVA) in the Right eye and Left eye had 0.00LogMAR (Snellen's 6/6) and the percentage was 80.5% in the right eye and 81.50% in the left eye, which was strongly statistically significant (p=0.001). The Mean, Median and standard deviation of UCVA in the right eye and left eye in Table 1 are shown:

Table 1: Status of visual acuity in right eye and left eye

Variables	Right eye	Left eye
Mean	0.371LogMAR	0.374LogMAR
Median	0.00LogMAR	0.00LogMAR
St. Deviation	±0.085	±0.086

All subjects acquired had the best corrected visual acuity (BCVA) in both eyes, 0.00 Log MAR (Snellen's6/6). About 99.5% of subjects were able to read N6 letters comfortably. Only 0.5% of subjects were able to read N8 letters. On sensory evaluation, all subjects presented with BSV at both near and distant. About 85.5% had normal 40-60 seconds of arc and 14.5% had reduced 120 seconds of arc in the stereopsis evaluation. Orthophoria was noted as 30.5% on motor evaluation at the near cover test and 71.5% at the distance cover test, respectively. About 66% were exophoric at the near cover test and 28.5% at distance cover test, respectively. Only 3.5% were esophoria at the near-cover test. By prism cover test, Orthophoria was 31% and 73% at near and distance, respectively.

We also found that 48.5% and 15% of study samples had (2-6PD) Exophoria at near and distant. 9% and 1% were (8-12PD) Exophoric at near and distance, respectively. About 8% and 11% were (14-20PD) Exophoria near and distant, respectively. 3.5% were (2-6PD) Esophoria at near cover test.

AC/A-ratio was normal at 70.5%, high at 11.5% and low at 18%. Out of 200 subjects, NPC was normal in 58.50%, reduced in 21.50% and defective in 20% of subjects. The Mean NPC subjective and objective values are shown in Table 2.

Among all subjects, MEM retinoscopy findings were normal in 49.5%, Low in 43% and High in 7.5%, ranging from (-1.00 to+1.50DS). In relative accommodation, NRA was normal at 26%, Low at 66.50% and high at 7.5%. Also, PRA was normal among 32%, Low 19.50% and high among 48.50% of subjects.

Table 2: Mean and standard deviation of NPC (Subjective and Objective values)

Parameters	Break Point ±SD	Recovery Point ±SD
NPC Subjective	11.50±5.24	14.25±5.92
NPC Objective	12.16±5.53	15±6.35

The amplitude of accommodation was normal in 95.5% and reduced in 4.5% of subjects. The mean amplitude of accommodation was 11.77±1.9D in the right eye, 11.78±1.9D in the left eye and 11.77±1.89D in both eyes, with ranged from (4-16.5) D. The vergence facility was normal (10-12cpm) among 24% and low (<8cpm) among 76% subjects. The mean AF was 8.42±3.19cpm in the right eye and 8.46±3.34cpm in the left eye, while in binocularly 7.06±3.31cpm respectively. The mean NFV BI to break/recovery at near was 11.35/7.95PD (SD=3.24/2.57), while at a distance was 7.40/5.05PD (SD=1.96/1.86), respectively. Similarly, the mean PFV BO to break/recovery at near was 15.79/11.96PD (SD=5.68/5.26), while at a distance, mean values were 9.49/6.53PD (SD=3.07/2.63) respectively. The results of the distribution of reading performance per NVF and AVF are mentioned in Table 3.

Of all 200 subjects, 15.5% (n=31) was NVF and 84.5% (n=169) was AVF. Among all AVF, convergence insufficiency was 31% (n=62), followed by Convergence excess (3%), fusional vergence dysfunctions (25%), accommodative insufficiency (4.5%), accommodative excess (3.5%), accommodative infacility (6.5%), divergence excess (10%) and basic exophoria (1%). Children with AVF had higher reading errors (AVF=7.833±5.08; NVF= 6.55±3.67; p=0.001). Children in first to fifth school grades presented a higher risk of having reading impairment when compared with 6^{th} to 10^{th} grades. Among them, the Mean ± SD reading speed of the 10^{th} grade was 112 ± 20.69 wpm which was higher than the 6th to 9^{th} grade (Table 4).

Out of 200 subjects, 81% (n=162) were emmetropes and 19% (n=38) had refractive error only. Among the students with refractive error, 3% (n=6) had simple myopia, 2.5% simple hyperopia, 3.5% simple myopic astigmatism, 2.5% simple hyperopic astigmatism, 6% compound myopic astigmatism, 0.5% compound hyperopic astigmatism and 1% mixed astigmatism. Reading performance was worst in compound hyperopic astigmatism and simple hyperopic astigmatism compared to others. Among all participants, only 16.5% students did not need any management; 3% were treated with only spectacles; 35.5% with only convergence exercise; 20% only fusional exercise; 9% only accommodative exercise; 9% with spectacles along

Table 3: Distribution of Reading performance Per NVF and AVF

Diagnosis of study subjects	Reading Performance	Mean ±SD	Median	P-value
Normal Visual Functions(n=31)	Error	6.55±3.67	7	0.001
	Accuracy	86.43±13.12	92	0.001
	Reading Speed	84.51±36.84	100	0.001
Convergence Insufficiency(n=62)	Error	6.8±4.13	7	0.001
	Accuracy	87.08±12.79	93	0.001
	Reading Speed	84.98±41.11	85	0.001
Convergence excess(n=6)	Error	5.83±3.6	5	0.001
	Accuracy	90.75±5.88	89.95	0.001
	Reading Speed	76.66±31.86	69	0.001
Fusional vergence dysfunction(n=50)	Error	6.66±3.50	6	0.001
	Accuracy	84.75±15.60	89.50	0.001
	Reading Speed	73.26±41.28	65.5	0.001
Accommodative Insufficiency (n=9)	Error	6.88±2.57	7	0.001
	Accuracy	82.55±16.83	88.88	0.001
	Reading Speed	74.44±44.69	72	0.001
Accommodative Excess(n=7)	Error	6.28±4.23	5	0.001
	Accuracy	78.78±31.95	92	0.001
	Reading speed	79.57±32.13	74	0.001
Accommodative Infacility (n=13)	Error	6.46±4.07	6	0.001
	Accuracy	88.49±11.74	92.5	0.001
	Reading speed	81±28.21	95	0.001
Divergence excess (n=20)	Error	5.6±2.70	6	0.001
	Accuracy	89.18±12.84	94.47	0.001
	Reading speed	83.75±36.60	93	0.001
Basic Exophoria(n=2)	Error	8±5.65	8	0.001
	Accuracy	72±16.97	72	0.001
	Reading speed	42±45.25	42	0.001

with convergence exercise, 5% with spectacles along with fusional exercise; and 2% with spectacles along with accommodative exercise.

4. Discussion

This study compared the reading performance in children with normal and abnormal visual functions. Children with visual function anomalies have poor reading performance (higher number of errors, similar accuracy, and lower reading speed). Our results are supported by earlier research showing that children with visual function anomalies may suffer with reading, writing, and academic performance.[1,15,19–24,33–36] Our study found that children with the reading problem have a higher frequency of AVF (84.50%) and normal visual function 15.5%, which was strongly statistically significant (p=0.001). Also, a significant association between reading and non-strabismic anomalies of binocular vision has been reported in the literature.[1,15] Poor reading comprehension was more common in the group of adolescents with vision anomalies (n=109, 31.2%) than in those without vision anomalies (n=80, 18.8%; p=0.05).[37] A cross-sectional study by Ragnarsdottir et al.[38] showed that no correlation was found between reading speed and binocular accommodative amplitude, binocular accommodative facility, positive and negative relative accommodation, MEM retinoscopy and cross card. A prospective study by Stifter et al.[39] found significant differences in binocular maximum reading speed (MRS) between children with micro strabismic amblyopia and normal controls (p=0.03). There were no significant differences between the two groups in terms of binocular log MAR visual acuity and reading acuity (p=0.05). Another cross-sectional study found that poor readers had nearly two prism diopter lower mean distance base-in break and base-in recovery values (p<0.01) than the control group.(1)Muriel Dysli et al.[40] found that acute changes in horizontal and vertical vergence tone did not affectreading performance or reading-related eye movements. Prisms have little effect on reading performance on healthy people. This finding contradicts the role of phoria in dyslexia. Their result contradicts the suggestion for correcting small angle heterophorias in dyslexic children.

Studies reported a high frequency of AVF (63% - 69.9%) in children with reading problems in India and Norway.[13,37,41] Our results are very high (84.5%). Hussaindeen JR et al.[41] showed that NSBV anomalies in urban and rural areas were 31.5% and 29.6%, respectively, which was lower than our study. It could be because of the

Table 4: Distribution of Reading Performance per children's groups and grade (1^{st} to 10^{th} grade)

Children groups and grades	Reading Performance	Mean±SD	Median	P-value
1st grade(n=9)	Error	6.25 ± 2.43	5.50	0.001
	Accuracy	77.56 ± 17.21	78.12	0.001
	Reading speed	44.26 ± 35.93	36	0.001
2nd grade(n=10)	Error	8.3 ± 3.62	7	0.001
	Accuracy	72.65 ± 22.47	78.25	0.001
	Reading speed	51.20 ± 41.22	38.50	0.001
3rd grade(n=28)	Error	7.64 ± 4.05	6.50	0.001
	Accuracy	78.48 ± 19.84	82.67	0.001
	Reading speed	58.21 ± 31.42	46.50	0.001
4th grade(n=28)	Error	8.10 ± 3.31	9	0.001
	Accuracy	81.08 ± 13.43	86	0.001
	Reading speed	61.21 ± 32.01	61.50	0.001
5th grade(n=21)	Error	8.14 ± 3.63	7	0.001
	Accuracy	85.67 ± 11.48	90	0.001
	Reading speed	77± 33.28	72	0.001
6th grade(n=25)	Error	6.40±3	6	0.001
	Accuracy	89.43±9.75	94	0.001
	Reading speed	84.56±34.35	92	0.001
7th grade(n=11)	Error	6.81±5.32	6	0.001
	Accuracy	92.36±7.05	94	0.001
	Reading speed	98±32.80	95	0.001
8th grade(n=19)	Error	6.10 ±4.37	6	0.001
	Accuracy	91.25 ±9.75	94.50	0.001
	Reading speed	99.10± 31.79	104	0.001
9th grade(n=28)	Error	6.10± 4.74	5	0.001
	Accuracy	90.87± 10.94	94.61	0.001
	Reading speed	99.25± 39.80	106	0.001
10th grade(n=21)	Error	3.6±2.01	3	0.001
	Accuracy	96.60± 2.41	97.50	0.001
	Reading speed	112± 20.69	114	0.001

participants' age and study areas.

In our study, Convergence insufficiency was highly prevalent 31%, followed by fusional vergence dysfunctions 25% in school-going children. Almost similarly, Magdalene et al.[13] reported Convergence insufficiency at 37.10%. However, a study from India[41] showed that accommodative infacility was highly prevalent (67%), followed by convergence insufficiency (25%) which is different from our study. A similar trend has been reported in other populations (20–22 years) wherein the prevalence of AIF ranged between 26 and 31.7% and CI between 14 and 38%.

In this study, children with AVF had a higher reading error (7.833±5.08). A study from Portugal showed a higher number of reading errors (3.00 errors), but our results were very high.[19] We also found lower reading accuracy (AVF=86.11±14; NVF=86.43±13.12) and reading speed (AVF=79.47±39.20 wpm; NVF=84.51±36.84 wpm). Similar trends were reported on reading accuracy (AVF=91.18%; NVF=97.06%) and reading speed (AVF=24.71 wpm; NVF=27.39 wpm).[19] Our findings also demonstrate that Reading speed was so much lower in basic exophoria (42.0±45.25), followed by accommodative insufficiency (74.44±44.69), but Lanca CC et al,[19] found lower reading speed in convergence insufficiency (29.30±0.99) that is opposite in our results. At the same time, Husssiandeen and colleagues[42] and Maples and colleagues[43] have correlated AI and CI as factors affecting the academic performance of school-age children. Simons et al.[44] reviewed 34 studies of vision anomalies and reading skill and showed that hyperopia, exophoria at near, vertical phoria, anisometropia, and aniseikonia are associated with below average reading performance. Several studies have indicated that children with reading and learning problems show a higher incidence of hypermetropia[22–25,43] and non-strabismic binocular vision disorders than normal readers.[14,41,44] Myopia and esophoria and esophoria at far are associated with average and above-average reading performance.[45] In the present study, we also found similar results. A retrospective study by Christian et al.[46] identified no significant refractive error in 81% of children and our present study. We also found the same result. Previous research on refractive status and reading performance

suggested that myopic children are better readers than hyperopic children,[44,47] we also have the same results. However, other studies[24,29] do not find any association between refractive error and reading in children and have no relation between ocular function and academic performance.[45,48,49] The association between visual skill level and reading outcomes is controversial because of a perceived lack of scientifically rigorous evidence.[1]

We also compared the three measurements of reading performance by children's grade ($1^{st}$to 10^{th}). Children in first to fifthgrades presented a higher risk of reading impairment than sixth to tenth grades. In the first to fifth grades' first and second grades presented a higher risk of having low reading performance. Another study compared the three measurements of reading performance by children's only grade (first to fourth), and they showed that second, third, and fourth grade presented a lower risk of having a low reading performance when compared with the first grade.[19] David Grisham et al.[20] found that high numbers of poor readers in high school may be at high risk of visual skills dysfunction, which is also opposite to our study.

The tenth grade has a higher reading speed of 112 ± 20.69 wpm than the sixth to ninth grade. So, we assume that as one gets older, the reading problems of a younger age due to visual anomalies appear to be overcome or somehow compensated by other strategies. In our study, 3% of subjects were treated with only spectacles; 35.5% with only convergence exercise; 20% with only fusional exercise; 9% with only accommodative exercise; 9% with spectacles along with convergence exercise, 5% with spectacles along with fusional exercise; and 2% with spectacles along with accommodative exercise.

The limitations of this study include limited sample size, not including all children, only hospital attended school going children included in study, and preschool children were excluded from the study. This study recommended a comprehensive eye examination for school-aged children with a reading problem to ensure proper diagnosis and management.

5. Conclusion

Poor reading performance is strongly significant to abnormal visual function in school-aged children. Abnormal visual functions can decrease children's quality of life and impact school performance and near activities. As a result, this study concludes that accurate binocular vision evaluation, early detection, and treatment are essential for addressing reading problems and providing the best opportunity for academic success in the school-age group.

6. Ethics Approval and Consent to Participate

The study received ethical clearance from the Institutional Ethical Review Committee of Ispahani Islamia Eye Institute and Hospital, Dhaka-1215, Bangladesh. Informed written consent was obtained from all patients or patient's guardians. All methods were performed in accordance with the relevant guidelines and regulations adhered to the tenets of the Declaration of Helsinki as amended in 2008.

7. Consent for publication

Not applicable

8. Availability of data and materials

The data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

9. Author's Contributions

NA, MK and GKB designed the study, procured the samples, and performed the experiments; NA, SS and MM designed and performed the statistical analyses; NA, SS, and SMK provided critical input NA and GKB interpreted the results; MM, SMK, RPM and SC conducted the critical appraisal of the manuscript; NA, and SMK edited final manuscript; all authors reviewed and approved the final version of the manuscript prior to submission.

10. Abbreviations

NPC=Near Point of Convergence, NPA=Near point of Accommodation**,** NRA=Negative Relative Accommodation, PRA=Positive Relative Accommodation, NFV=Negative Fusional Vergence**,** PFV=Positive Fusional Vergence, AC/A-ratio=Accommodative Convergence by Accommodative ratio, MEM-Retinoscopy=Monocular Estimation Method Retinoscopy, BSV=Binocular Single Vision, LogMAR=Log unit of Minimum Angle of Resolution, NVF=Normal Visual Function, AVF=Abnormal Visual Function, WPM=Word Per Minute**,** SD=Standard Deviation, SPSS=Statistical Package for Social Science, CISS=Convergence Insufficiency Symptoms Survey, NA=Nilufa Akter, MK=Mastura Khatun, GKB=Gaurav Kumar Bhardwaj, MM=Mohammad Masihuzzaman, SMK=Syeed Mehbub Ul Kadir, SC=Sayantan Chakraborty, SS= Sunanda Sarkhel, RPM=Rajendra Prakash Maurya.

11. Conflict of Interests

None of the authors has proprietary interests or any potential conflicts of interest.

12. Source of Funding

There was no financial support in terms of grants orfunds for this study from any source.

13. Acknowledgement

The authors would like to express gratitude and thanks to the management of Ispahani Islamia Eye Institute and Hospital, for their help in collecting the data. We are also grateful to our patients for their willing participation in this study.

References

1. Palomo-Álvarez C, Puell MC. Binocular function in school children with reading difficulties. *Graefes Arch Clin Exp Ophthalmol*. 2010;248(6):885–92.
2. Rayner K. Eye Movements in Reading and Information Processing: 20 Years of Research. *Psychol Bull*. 1998;124(3):372–422.
3. Rayner K. Eye movements and attention in reading, scene perception, and visual search. *Q J Exp Psychol*. 2009;62(8):1457–506.
4. Blythe HI, Liversedge SP, Findlay JM. The effective fusional range for words in a natural viewing situation. *Vision Res*. 2010;50(16):1559–70.
5. Blythe HI, Liversedge SP, Joseph H, White SJ, Findlay JM, Rayner K. The binocular coordination of eye movements during reading in children and adults. *Vision Res*. 2006;46(22):3898–908.
6. Jainta S, Hoormann J, Kloke WB, Jaschinski W. Binocularity during reading fixations: Properties of the minimum fixation disparity. *Vision Res*. 2010;50(18):1775–85.
7. Nuthmann A, Beveridge M, Shillcock RC. A binocular moving window technique to study the roles of the two eyes in reading. *Vis cogn*. 2014;22:259–82.
8. Thurston A, Thurston M. A Literature Review of Refractive Error and Its Potential Effect on Reading Attainment in the Early Years of School. *Optom Visual Performance*. 2013;1(1):25–31.
9. Granet DB, Castro EF, Gomi CF. Reading: Do the Eyes Have It? *Am Orthoptic J*. 2006;56(4):133–44.
10. Anthony JL, Aghara RG, Dunkelberger MJ, Anthony TI, Williams JM, Zhang Z. What factors place children with speech sound disorders at risk for reading problems? *Am J Speech-Language Pathol*. 2011;20(2):146–60.
11. Basch CE. Healthier students are better learners: a missing link in school reforms to close the achievement gap. *J Sch Health*. 2011;81(10):593–601.
12. Carroll JM, Snowling MJ. Language and phonological skills in children at high risk of reading difficulties. *J Child Psychol Psychiatry*. 2004;45(3):631–671.
13. Magdalene D, Dutta P, Choudhury M, Deshmukh S, Gupta K. Clinical profile of nonstrabismic binocular vision anomalies in patients with asthenopia in North-East India. *TNOA J Ophthalmic Sci Res*. 2017;55(3):182–182.
14. Flax N. Visual function in dyslexia. *Am J Optom Arch Am Acad Optom*. 1968;45(9):574–86.
15. Palomo-Álvarez C, Puell MC. Accommodative function in school children with reading difficulties. *Graefes Arch Clin Exp Ophthalmol*. 2008;246(12):1769–74.
16. Hennessey D, Iosue RA, Rouse MW. Relation of symptoms to accommodative infacility of school-aged children. *Am J Optom Physiol Opt*. 1984;61(3):177–83.
17. Simons HD, Grisham JD. Binocular anomalies and reading problems. *J Am Optom Assoc*. 1987;58(7):578–87.
18. Mogasale VV, Patil VD, Patil NM, Mogasale V. Prevalence of specific learning disabilities among primary school children in a South Indian city. *Indian J Pediatr*. 2012;79(3):342–349.
19. Lanca CC. Reading Performance in Children with Visual Function Anomalies. *Int J Ophthalmol Clin Res*. 2014;1(1).
20. Grisham D, Powers M, Riles P. Visual skills of poor readers in high school. *Optometry*. 2007;78(10):542–551.
21. Muzaliha MN, Nurhamiza B, Hussein A, Norabibas AR, Mohd-Hisham-Basrun J, Sarimah A. Visual acuity and visual skills in Malaysian children with learning disabilities. *Clin Ophthalmol*. 2012;6(1):1527–1560.
22. Dusek WA, Pierscionek BK, Mcclelland JF. An evaluation of clinical treatment of convergence insufficiency for children with reading difficulties. *BMC Ophthalmol*. 2011;11(1).
23. Kdzia B, Tondel G, Pieczyrak D, Maples WC. Accommodative facility test results and academic success in Polish second graders. *J Am Optom Assoc*. 1999;70(2):110–6.
24. Dusek W, Pierscionek BK, Mcclelland JF. A survey of visual function in an Austrian population of school-age children with reading and writing difficulties. *BMC Ophthalmol*;10(1).
25. Available from: https://psycnet.apa.org/record/2001-11282-00.
26. Rosner J, Rosner J. The relationship between moderate hyperopia and academic achievement: how much plus is enough? *J Am Optom Assoc*. 1997;68(10):648–50.
27. Eames TH. The Influence of Hypermetropia and Myopia on Reading Achievement. *Am J Ophthalmol*. 1955;39(3):375–382.
28. Grisham JD, Simons HD. Refractive error and the reading process: a literature analysis. *J Am Optom Assoc*. 1986;57(1):44–55.
29. Latvala ML, Korhonen TT, Penttinen M, Laippala P. Ophthalmic findings in dyslexic schoolchildren. *Br J Ophthalmol*. 1994;78(5):339–382.
30. Scheiman M, Mitchell GL, Cotter S, Cooper J, Kulp M, Rouse M. A randomized clinical trial of treatments for convergence insufficiency in children. *Arch Ophthalmol*. 1960;123(1):14–24.
31. Scheiman M, Cotter S, Rouse M, Mitchell GL, Kulp M, Cooper J. Randomised clinical trial of the effectiveness of base-in prism reading glasses versus placebo reading glasses for symptomatic convergence insufficiency in children. *Br J Ophthalmol*. 2005;89(10):1318–1341.
32. Abdi S, Rydberg A. Asthenopia in schoolchildren, orthoptic and ophthalmological findings and treatment. *Doc Ophthalmol*. 2005;111(2):65–72.
33. Cornelissen P, Bradley L, Fowler S, Stein J. 1992. Available from: https://pubmed.ncbi.nlm.nih.gov/1572515.
34. Available from: https://www.healio.com/news/optometry/20180222/reduced-reading-performance-linked-to-binocular-vision-anomalies.
35. Toledo CC, Paiva A, Camilo GB, Io RSMM, Leite I, Guerra MR. Early detection of visual impairment and its relation to academic performance. *Rev Assoc Med Bras*;56(4):415–424.
36. Quaid P, Simpson T. Association between reading speed, cycloplegic refractive error, and oculomotor function in reading disabled children versus controls. *Graefes Arch Clin Exp Ophthalmol*. 2009;251(1):169–87.
37. Hagen L, Gilson SJ, Baraas RC. Vision status and reading test results in Norwegian adolescents. *J Optom Visual Sci*. 2020;13(2):2–7.
38. Liang H, Vuong AM, Xie C, Webster GM, Sjödin A, Yuan W. Childhood polybrominated diphenyl ether (PBDE) serum concentration and reading ability at ages 5 and 8 years: The HOME Study. *Environ Int*. 2019;122:330–339.
39. Stifter E, Burggasser G, Hirmann E, Thaler A, Radner W. Monocular and binocular reading performance in children with microstrabismic amblyopia. *Br J Ophthalmol*. 2005;89(10):1324–1333.
40. Dysli M, Vogel N, Abegg M. 2014. Available from: https://pubmed.ncbi.nlm.nih.gov/24987346.
41. Hussaindeen JR, Shah P, Ramani KK, Ramanujan L. Efficacy of vision therapy in children with learning disability and associated binocular vision anomalies. *J Optom*. 2018;11(1):40–48.
42. Hussaindeen JR, Rakshit A, Singh NK, George R, Swaminathan M, Kapur S. Prevalence of non-strabismic anomalies of binocular vision in Tamil Nadu: report 2 of BAND study. *Clin Exp Optom*. 2017;100(6):642–650.
43. Maples WC. Visual factors that significantly impact academic performance. *Optometry*. 2003;74(1):35–49.
44. Simons HD, Gassler PA. Vision anomalies and reading skill: A meta-analysis of the literature. *Am J Optom Physiol Opt*. 1988;65(11):893–

904.
45. Helveston EM, Weber JC, Miller K, Robertson K, Hohberger G, Estes R. Visual function and academic performance. *Am J Ophthalmol*. 1985;99(3):346–55.
46. Christian LW, Nandakumar K, Hrynchak PK, Irving EL. Visual and binocular status in elementary school children with a reading problem. *J Optom*. 2018;11(3):160–166.
47. Grosvenor T. Are visual anomalies related to reading ability? *J Am Optom Assoc*. 1977;48(4):510–517.
48. Blika S. Ophthalmological findings in pupils of a primary school with particular reference to reading difficulties. *Acta Ophthalmol*. 1982;60(6):927–961.
49. Kiely PM, Crewther SG, Crewther DP. Is there an association between functional vision and learning to read? *Clin Exp Optom*. 2001;84(6):346–53.

Author biography

Nilufa Akter, M. Optom Student https://orcid.org/0000-0001-5023-6116

Masihuzzaman, Assistant Professor https://orcid.org/0000-0001-5023-6116

Syeed Mehbub Ul Kadir, Assistant Professor https://orcid.org/0000-0002-2077-6784

Gaurav Kumar Bhardwaj, Associate Professor & Head https://orcid.org/0000-0002-3542-8977

Mastura Khatun, Professor https://orcid.org/0000-0001-7821-2829

Sunanda Sarkhel, Teaching Associate https://orcid.org/0000-0001-6350-4407

Sayantan Chakraborty, Assistant Professor https://orcid.org/0000-0001-8853-1620

Rajendra Prakash Maurya, Associate Professor https://orcid.org/0000-0001-9343-6003

Cite this article: Akter N, Masihuzzaman, Kadir SMU, Bhardwaj GK, Khatun M, Sarkhel S, Chakraborty S, Maurya RP. Reading performance in school going children with visual function anomalies. *IP Int J Ocul Oncol Oculoplasty* 2023;9(4):170-177.