

Original Research Article

RELATIONSHIP BETWEEN REFRACTIVE ERROR AND INTRAOCULAR PRESSURE IN CHILDREN ATTENDING THE UNIVERSITY OF PORT-HARCOURT TEACHING HOSPITAL EYE CLINIC

ABSTRACT

Objectives: To assess and compare the refractive status and intraocular pressures of children attending the University of Port Harcourt Teaching Hospital Eye clinic

Materials and methods: The study was a hospital-based comparative cross-sectional study in children aged 5- 18 years attending the University of Port Harcourt Teaching Hospital Eye clinic. Participants were sampled in 2 groups of equal numbers: children without refractive error (emmetropes) and children with refractive error. Each group had cycloplegic refraction, intraocular pressure measurement using Pulsair tonometer, and a full ocular examination.

Results: A total of 234 children with 117 in each group. Myopia was the more common refractive error, accounting for 75.2% and 77.8% in the right and left eyes respectively.

The mean intraocular pressure was 14.72mmHg for emmetropia, 15.97mmHg for myopia, and 14.93mmHg for hyperopia in the right eye while 15.02mmHg for emmetropia, 16.05mmHg for myopia, and 13.78mmHg for hyperopia on the left eye.

A significant positive correlation was obtained between myopia and intraocular pressure (Pearson correlation, $r = 0.151$, $p = 0.010$ for the right eye and $r = 0.201$, $p=0.001$ for the left eye).

Conclusion: The higher levels of mean IOP seen in myopia compared to emmetropia and hyperopia demonstrates that children with myopia may likely develop glaucoma earlier compared to others. Therefore, more emphasis should be placed on glaucoma surveillance among myopic children.

Key Words: Refractive error, Intraocular pressure, Children, Port Harcourt

1. INTRODUCTION

Refractive error refers to a defect in the optical state of the eye that prevents parallel rays of light from coming to a single focus on the retina thereby leading to a blurred image. It is one of the common causes of visual impairment and the second leading cause of treatable blindness worldwide.¹ Refractive error is the most common ocular problem that affects all age groups, and therefore it is of public health importance. Globally, refractive error accounts for 12 million out of the 19 million visually impaired children.²

Intraocular pressure (IOP) is an important variable for the physiology of the eye.³ It is the tension exerted by the aqueous humour on intraocular tissues as a result of the balance between its production and drainage.⁴ It is one of the factors implicated in the pathogenesis of refractive error especially myopia.^{3,5} The normal range of the intraocular pressure in humans is 10-21mmHg.⁶ Raised intraocular pressure in children is thought to cause scleral stress leading to sclera stretch and axial elongation.^{7,8} This could result in axial myopia.

An association between refractive error and intraocular pressure has been reported among children and adults.^{9,10} Increasing levels of intraocular pressure has been found in individuals with myopia as opposed to those with emmetropia or hypermetropia.^{4,11} Myopic eyes have been shown to have higher intraocular pressures than non-myopic eyes and it has

been hypothesised that a higher intraocular pressure may affect the development of myopia in children.⁹ The Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) study found that IOP differed among refractive error categories, with higher IOP in children with low/moderate myopia than those with high hyperopia.¹² The Anyang Childhood Eye Study also found that higher intraocular pressure was associated with myopia.¹⁰ This shows that there may be an association between refractive error and intraocular pressure. It is also known that the elevated ocular pressure found in congenital glaucoma is associated with the higher rate of axial elongation in infant eyes resulting in axial myopia.¹³ However, a study by Dusek et al among Austrian children found no association between intraocular pressure and refractive error.¹⁴

Myopia is a recognised risk factor for primary open angle glaucoma and intraocular pressure is the only modifiable risk factor associated with glaucoma.⁴ The ascending levels of intraocular pressure seen with increasing degree of myopia demonstrate that Primary Open Angle Glaucoma occurs earlier in individuals with high myopia than in hyperopia and accentuates the seriousness of glaucoma surveillance in the myopic population.¹¹

Therefore, this study aims to determine the relationship between refractive error and intraocular pressure with a view to obtaining information that may be useful in glaucoma surveillance.

2. Materials and Methods

The study was a hospital based comparative cross-sectional study carried out among children aged 5 -18 years attending University of Port Harcourt Teaching Hospital Eye clinic. Exclusion criteria were history of previous corneal or intraocular surgery, previous ocular trauma, use of steroids (topical/systemic) and use of antiglaucoma medications. Others

were presence of ocular conditions like cataract, glaucoma, allergic conjunctivitis, corneal infection or abnormalities, red eyes.

The minimum sample size was calculated based on the formula for comparison of two proportions¹⁵:

$$n = \frac{(Z_{\alpha/2} + Z_{1-\beta})^2 (S_1^2 + S_2^2)}{d^2}$$

n = minimum sample size for each single group

$Z_{\alpha/2}$ = standard deviation at 95% confidence limit is equivalent to 1.96

$Z_{1-\beta}$ = standard deviation at 90% power of study is equivalent to a standard normal deviate of 2.576

S_1 = standard deviation of IOP of emmetropic children¹⁶ = 2.61

S_2 = standard deviation of IOP of children with refractive error (myopic)¹⁷ = 2.78

d = difference between mean IOP of myopic and emmetropic children¹⁶⁻¹⁷ = 18.0-16.3 = 1.7

$$n = \frac{(1.96 + 2.576)^2 (2.78^2 + 2.61^2)}{(1.7)^2}$$

$$n = \frac{4.536^2 \times (7.73 + 6.81)}{2.89}$$

$$n = \frac{20.575 \times (14.54)}{2.89}$$

$$n = \frac{299.164}{2.89}$$

n=103.52 approx 104 persons in each group

To account for non-response (NR) of 10%

$$N = \frac{n}{1 - NR}$$

$$N = \frac{104}{1 - 0.1}$$

$$N = \frac{104}{0.9}$$

N= 116.5 approx. 117 participants in each study group

Therefore, the minimum sample size was 117, with equal number (117) as a control group.

The participants were recruited using systematic sampling technique.

Ethical approval was obtained from the Health Ethics and Research Committee of University of Port Harcourt Teaching Hospital. The study was conducted in conformity with the Helsinki Declaration on the use of Human Subjects for Research. Informed written consent was obtained from all the subjects.

Visual acuity was tested one eye at a time using the Snellen chart or E-chart for distance and the Near Reading Chart for near vision.

All participants had cycloplegic refraction done. Cycloplegia was achieved by instilling Cyclopentolate 1% into both eyes every 15minutes and then refraction done 1 hour later. Prior to instillation of cyclopentolate, proparacaine was instilled into the eyes to reduce the stinging effect of cyclopentolate. Refraction was done using Welch Allyn Streak Retinoscope (Welch Allyn Inc., New York, USA) REF 901024. The objective endpoint was used to determine the type of refractive error.

Intraocular pressure measurement was done for all participants using Keeler Pulsair Tonometer (SL4 4AA, SERIAL NO:2414/i7878). IOP was performed on both eyes, right eye first with the child seated and the eyes in primary position. Three readings were taken, and the average obtained. Intraocular pressure measurements were done between 8am and

12noon to avoid the effects of diurnal fluctuations on IOP. The pachymetry adjusted IOP was used for the study.

The participants were categorized into 2 groups based on their refractive status: Emmetropes group and refractive error group. The refractive error group was further categorised into myopia and hyperopia.

Emmetropia was defined as the spherical equivalent of the refractive correction -0.50 to +0.50DS.

Myopia was defined as the spherical equivalent of the refractive correction of greater than -0.50DS.

Hypermetropia was defined as the spherical equivalent of greater than +0.50DS.

Astigmatism was converted to the spherical equivalent power.

Data was analysed using Statistical Package for Social Sciences (SPSS) version 24. Data including age, gender, intraocular pressure, and refractive error was presented using tables and graphs. Means and standard deviation was used to summarize quantitative variables such as IOP while frequencies and proportions were used for categorical variables such as age groups, and refractive error. Bivariate analysis was performed using Chi square statistics for comparison of proportions and One-way ANOVA test for comparison of means. Confidence intervals was determined at the 95% level and statistical significance set at $p < 0.05$. Pearson's correlation coefficient was done to study the relationship between the continuous variables.

3. RESULTS

A total of 234 children were enrolled into the study, of which 117 children had refractive error and 117 children were without refractive error (emmetropes). The age range was 5-18

years with mean age of 11.9 ± 3.2 years for emmetropes and 12.6 ± 3.4 years for children with refractive error. Male: Female ratio was 1:1.1 and 1:1.7 for the emmetropes and refractive error groups respectively. See table 1

Children with refractive error indicate that majority of them had myopia (75.2% in the right eye and 77.8% in the left eye). See table 2

The mean IOP was higher the eyes with myopia, followed by the emmetropic eye and then the hyperopic eyes. See table 3 and Figure 1. There was a statistically significant difference in the mean IOP of children across the three groups using an ANOVA test ($p=0.01$ right eye; $p=0.011$ left eye). See table 3

The mean IOP was highest in children with high myopia in both eyes. This difference was not statistically significant ($p = 0.761$ for the right eye and 0.673 for the left eye). See table 4.

There was a statistically significant positive relationship between myopia and intraocular pressure in both eyes ($p= 0.010$ right eye; $p=0.001$ left eye). A negative relationship between hyperopia and intraocular pressure was observed in both eyes though this relationship was only statistically significant in the right eye. See table 5, and Figures 2 & 3

4. DISCUSSION

In this study, Myopia was the most prevalent type of refractive error. This is similar to reports by Olusanya et al, Megbelayin et al and, Adegbehingbe et al.¹⁸⁻²⁰ Opubiri et al also observed that myopia was the most common refractive error, followed by astigmatism and hyperopia.²¹ The higher proportion of myopia in this study could be due to differences in methodology. These studies classified refractive error into many sub classes as opposed to this present study that classified refractive error as myopia and hyperopia and converted astigmatism into the spherical equivalent power.

There was a statistically significant difference in the mean IOP across the different refractive states, with the highest mean IOP noted in myopia, followed by emmetropia and the lowest in hyperopia. This agrees with the findings reported by Shuning et al in the Anyang Children Eye study and the Collaborative Longitudinal Evaluation of Ethnicity and Refractive Error (CLEERE) Study.^{10, 12} Manny et al in their study on the associations between intraocular pressure, ethnicity and refractive error found that intraocular pressure varied with refraction.¹² Higher intraocular pressure was more common in children with low and medium myopia than in those with high hyperopia.¹² The higher mean IOP in myopes could be due to the hypothesis postulated by Mathapati et al that the ciliary body in myopic eyes is in a relatively posterior position in relation to the canal of schlemm which makes it more difficult for the ciliary body to mechanically widen the trabecular meshwork during accommodation.⁴ It could also be due to the increased shearing forces exerted by scleral tension across the lamina cribrosa.⁴ Elevated intraocular pressure also causes an increase in the axial length seen in myopic eyes. This is because of the inherited biomechanical weakness of the sclera that allows it to stretch in response to stress and increased intraocular pressure could be the mediator of stress. In addition, myopic eyes have been shown to have decreased peripapillary retinal perfusion compared with emmetropic eyes²², this might increase susceptibility to vascular-related eye diseases. However, this contradicts the findings in the Jinan city eye study where higher IOPs were seen among emmetropes compared to myopes.²³ On further analysis of the intraocular pressures in different degrees of myopia, it was observed that the higher the degree of myopia, the higher the mean IOP. This finding was consistent with findings by Megwas *et al*¹⁷, Yang *et al* and Das *et al*.^{17,24} In this study, there was a significant positive relationship between myopia and intraocular pressure. This implies that as myopia increases, the intraocular pressure also increases. This

is consistent with findings by Osaiyuwu et al¹¹ and Megwas et al.¹⁷ Tham et al²⁵ in Singapore, Sowjanya et al²⁶ in India and Jin et al²⁷ in Korea also obtained similar findings. However, Chinawa et al reported no correlation between myopia and intraocular pressure.²⁸ Lee et al also did not support an association between intraocular pressure and refractive error.⁵ This may be as a result of different study populations and various definitions of myopia.

On the other hand, there was a negative relationship between hyperopia and intraocular pressure in both eyes though this relationship was statistically significant only in the right eye. This implies that as hyperopia increases, the intraocular pressure decreases. This is similar to reports by Manny et al and Shuning et al who found that higher degrees of hyperopia was associated with lower intraocular pressures.^{19, 29}

The main limitation of this study is that it is a cross-sectional study so the relationship between IOP and refractive error may not imply a causal relationship. Also, axial length and corneal curvature were not measured in this study. These factors have confounding effects on the eventual refractive power of the eye. This study included only children between 5 -18 years. This therefore limits extrapolation of the findings of this study to children of all age groups.

5. CONCLUSION

The findings in this study showed a significant positive relationship between myopia and IOP. This implies that as myopia increases, intraocular pressure also increases. Myopia was associated with higher mean IOP compared to emmetropia and hyperopia. High myopes (> -6.00DS) had higher mean IOP compared to low and medium myopes. So, with increasing severity of myopia, IOP increased.

The higher levels of IOP seen in myopia compared to emmetropia and hyperopia shows that glaucoma may occur earlier in children with myopia compared to others. Therefore, more emphasis should be placed on glaucoma surveillance among myopic children.

6. REFERENCES

1. Dandona R, Dandona L. Refractive error blindness. 2001;79:237–243.
2. Abner G, Mario SP, Myhill C et al. EFA Global Monitoring Report Regional Overview- Monitoring the Education for All goals:Sub-saharan Africa. J Vis Impair Blind 2002;1:1–14.
3. Yang DY, Guo K, Wang Y, Guo YY, Yang XR, Jing XX, et al. Intraocular Pressure and Associations in Children . The Gobi Desert Children Eye Study. PLOS ONE 9(10): e109355. <https://doi.org/10.1371/journal.pone.0109355>.
4. Mathapathi RS, Patil SS. Association of refractive errors with intraocular pressure and its relationship with age and gender. Indian J Clin Anat Physio 2016;3:419-422.
5. Lee AJ, Saw S, Gazzard G, Cheng A, Tan DTH. Intraocular pressure associations with refractive error and axial length in children. Br J Ophthalmol 2004; 88:7–9.
6. Khaw PT, Elkington AR. Glaucoma—1: Diagnosis. BMJ 2004;328:97-99.
7. Province H, South C, Province H. Biomechanics of the sclera and effects on intraocular pressure. Int J Ophthalmol. 2016;9:1824-1831.
8. Iomdina E, Tarutta E, Markossian G, Aksenova J, Smirnova T, Bedretdinov A. Sclera as the target tissue in progressive myopia * Twardówka jako tkanka docelowa w postępującej krótkowzroczności. Pom J Life Sci 2015;61:146–152.
9. Joseph DS, Thampi B, Joosadima A, Mohan A, Joseph DS. A study on association between intraocular pressure and myopia. Int J Res Med Sci 2016;4:2202–2205.

10. Li S, Li S, Wang X, Kang M, Liu L, Li H, et al. Distribution and associations of intraocular pressure in 7- and 12-year-old Chinese children : The Anyang Childhood Eye Study. *PLoS ONE* 12(8): e0181922. [https://doi.org/ 10.1371/journal.pone.0181922](https://doi.org/10.1371/journal.pone.0181922)
11. Osaiyuwu AB, Edokpa GD. Original Research Article A comparative study of intraocular pressure in myopia and hyperopia among a Nigerian population just diagnosed with primary open angle glaucoma in Benin City. *Int J Res Med Sci* 2018;6(7):2234–2247.
12. Manny RE, Mitchell GL, Cotter SA, Jones-jordan LA, Kleinstein RN, Donald O et al. Intraocular pressure, Ethnicity and Refractive error. *Optom Vis Sci*. 2011;88(12):1445-1453.
13. Bach A, Villegas VM, Gold AS, Shi W, Murray TG. Axial length development in children. *Int J Ophthalmol* 2019;12(5):815–819.
14. Dusek WA, Pierscionek BK, McClelland JF. Age variations in intraocular pressure in a cohort of healthy Austrian school children. *Eye* 2012;26(6):841–845.
15. Kish, L. Survey Sampling . *BIMJ*. 1968;10(1):88-89.
<https://doi.org/10.1002/bimj.19680100122> Accessed March 28,2020.
16. Baran R, Baran S, Toraman N, Filiz S, Demirbilek H. Evaluation of intraocular pressure and retinal nerve fiber layer, retinal ganglion cell, central macular thickness, and choroidal thickness using optical coherence tomography in obese children and healthy controls. *Niger J Clin Pract*. 2019;22(4):539–545.
17. Megwas A, Onuoha S, Ugwoke G et al. Intraocular Pressure Changes in Different Degrees of Myopia. *Int J Sci Health Res* 2020;5(3):153–157.
18. Olusanya BA, Ugalahi MO, Ogunleye OT, Baiyeroju AM. Refractive Errors Among Children Attending a Tertiary Eye Facility in Ibadan, Nigeria: Highlighting the Need for School Eye Health Programs. *Ann Ibadan Postgrad Med* 2019;17(1):49–59.
19. Abraham E, Megbelayin E. Pattern of refractive errors among ophthalmic outpatients

- of University of Uyo Teaching Hospital, Uyo, Nigeria. *Niger J Ophthalmol* 2015;23(2):39-43.
20. Adegbehingbe BO, Oladehinde MK, Majemgbasan TO, Onakpoya HO, Osagiede EO, Unit O. Screening of adolescents for eye diseases in Nigerian High Schools. *Ghana Med J* 2005;39(4):138–142.
 21. Opubiri I, Adio A, Emmanuel M. Refractive error pattern of children in South-South Nigeria : A tertiary hospital study. *Sky J Med Med Sci* 2013;1(3):10–14.
 22. Wang X, Kong X, Jiang C, Li M, Yu J, Sun X. Is the peripapillary retinal perfusion related to myopia in healthy eyes? A prospective comparative study. *BMJ Open*. 2016;6(3):1–7.
 23. Wei W, Fan Z, Wang L, Li Z, Jiao W, Li Y. Correlation Analysis between Central Corneal Thickness and Intraocular Pressure in Juveniles in Northern China : The Jinan City Eye Study. *PLOS ONE* 9(8): e104842. <https://doi.org/10.1371/journal.pone.0104842>.
 24. Das P, Das R, Shrivastava PK, Mondal A. A Clinical Study on the Correlation Between Axial Length , Intraocular Pressure and Central Corneal Thickness in Myopic Eyes. *Int J Contemporary Med Res* 2016;3(4):1141–1144.
 25. Tham Y, Aung T, Fan Q, Saw S, Siantar RG. Joint Effects of Intraocular Pressure and Myopia on Risk of Primary Open-Angle Glaucoma : The Singapore Epidemiology of Eye Diseases Study. *Sci Rep*. 2016 13;6:19320. doi: 10.1038/srep19320. PMID: 26758554; PMCID: PMC4725834.
 26. Sowjanya M, Sathyavaty K, Biradar KG, Babu G, Gandhi R. A Study on the Association of Intraocular Pressure Changes with refractive errors in Bidar population. *Int J Curr Res Acad Rev*. 2015;3:320–327.
 27. Choi JA, Han K, Park Y, Park CK. Age-Related Association of Refractive Error with

Intraocular Pressure in the Korea National Health and Nutrition Examination Survey. .

PLoS ONE 9(11): e111879. doi:10.1371/journal.pone.0111879 .

28. Chinawa NE, Adio AO, Chukwuka IO. Is There a Causal Relationship between Myopia and Intraocular Pressure. *J Adv Med Med Res* 2017;20:1–7.
29. Edwards MH, Brown B. IOP in myopic children: the relationship between increases in IOP and the development of myopia. *Ophthalmic Physiol Opt* .1996;16:243-246.

Table 1: Sociodemographic Characteristics of Study Groups

Sociodemographic characteristics	Emmetropes	Refractive error	p-value
	(N = 117)	(N = 117)	
Age (mean ± SD)	11.9 ± 3.2	12.6 ± 3.4	0.108
Age groups	Frequency (%)	Frequency (%)	
5- 9 years	27 (23.1)	28 (23.9)	0.055
10-14 years	66 (56.4)	50 (42.7)	
15-18 years	24 (20.5)	39 (33.3)	
Sex			
Female	74 (63.2)	59 (50.4)	0.048*
Male	43 (36.8)	58 (49.6)	

Table 2: Refractive status of study participants

	Emmetropia	Myopia	Hyperopia
	Frequency	Frequency (%)	Frequency (%)
RIGHT EYE	117	88(75.2%)	29 (24.8%)
LEFT EYE	117	91 (77.8%)	26 (22.2%)

Table 3: Comparison of mean intraocular pressure and refractive status among the children

	ALL	Controls	Refractive error		p-value ^a
		Emmetropia	Myopia	Hyperopia	
Right Eye	N=234	N=117	N=88	N=29	
Mean IOP	15.2	14.7	16.0	14.4	0.01*
(95% CI)	(14.7-15.7)	(14.2-15.2)	(15.3-16.7)	(13.5-15.3)	
Left Eye	N=234	N=117	N=91	N=26	
Mean IOP	15.3	15.0	16.0	13.8	0.011*
(95% CI)	(14.8-15.8)	(14.4-15.6)	(15.1-16.9)	(12.8-14.8)	

^a*using a one-way ANOVA test to compare the mean IOP between the three refractive states*

Figure 1: Plot of mean intraocular pressure against refractive error for right and left eye

Table 4: Comparison of the mean intraocular pressures with degrees of myopia

	Degree of Myopia			p-value*
	Low (< -3.00DS)	Medium (-3.00 to -- 6.00DS)	High (> -6.00DS)	
Right Eye				
Mean IOP (SD)	15.60 (3.07)	16.56 (3.01)	17.46 (5.98)	0.761
Left Eye				
Mean IOP (SD)	15.58 (4.18)	16.40 (3.57)	18.59 (6.63)	0.673

* *Using a one-way ANOVA test to compare the mean IOP with degrees of myopia*

Table 5: Correlation between refraction and intraocular pressure stratified by refractive status

		Pearson's correlation		
	Refractive status	N	coefficient(r)	p-value
Right eye	Emmetropia	117	0.015	0.411
	Myopia	88	0.151*	0.010*
	Hyperopia	29	-0.125*	0.028*
Left eye	Emmetropia	117	0.216*	0.033*
	Myopia	91	0.201*	0.001*
	Hyperopia	26	-0.074	0.721

*r – Pearson's correlation coefficient; * significant at the 0.05 level*

Figure 2: Correlation between IOP and Myopia

Figure 3: Correlation between IOP and Hyperopia