Relation between Axial Length, Refraction and Intra-Ocular Pressure among Children

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Abstract

Background: **We assessed the methods used to measure IOP, refraction, and axial length in order to determine the relation between these three variables in children.** ***Aim:*** **To estimate refractive error, AL and IOP among children of both sexes versus emmetropic age and sex matched children.** ***Methods*****: Prospective, comparative, cross sectional study involved a randomly selected two hundred and forty-six eyes (246) of 123 school-aged child. They were classified into three groups each of 82 eyes (41 children) according to refractive error.** ***Results*****: There is a positive correlation between axial length and refractive error of the studied eyes. There is a strong positive correlation (r = 0.7704, p = 0.000). We found also, a negative correlation between axial length and intraocular pressure of the studied eyes. There is a weak significant negative correlation (r = 0.2198, p = 0.038).** ***Conclusion:*** **Refractive errors, axial length and intraocular pressure may be linked together, as refractive error depends on AL, the more elongated AL, the more myopia and the more shortening of AL, the more hyperopia. Also, IOP may affect AL and AL more or less affects IOP.**

Keywords: Glaucoma, Eye development, Myopia, Hypermetropia**.**

Introduction

The reasons of refractive errors are not entirely understood, but they are produced by distinct interactions between environmental and genetic variables. Otherwise, genetic factors account for the majority of the variation in refractive error within populations. According to studies, the heritability of refractive errors is between 71% and 88%. Since most research has focused on myopia, it has been challenging to discover susceptibility genes even though the genetics of refractive problems seem to be closely regulated [(1)].

Moderate and high hyperopia in children is a group of particular clinical relevance because significant hyperopia is clearly linked to some of the most common ocular conditions that require multiple consultations at these ages, including strabismus, increased intraocular pressure (IOP), and unilateral or bilateral amblyopia, among others [(2)].

Depending on their age, children between (+0.50D and +0.75D) are more likely to develop myopia in the future due to eye growth. Consequently, it is

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challenging to classify these children into reliable controls. Eye lengthening slows down and remains constant between the ages of 13 and 18 during the second decade of life [2].

Ocular physiology and pathophysiology are significantly influenced by the intraocular pressure. Numerous previous studies have examined the distribution of IOP in the adult population of various races, IOP measuring parameters, and IOP-related variables. However, comparatively little attention has been focused on IOP in children, IOP distribution in relation to age and growing child ocular axial length, the impact of IOP measurements on different variables, and the classification of abnormally low or abnormally high IOP readings. All prior researchs on IOP in children were hospital-based studies on a relatively limited number of children, and most of them either did not undertake a multivariate analysis or did not include the majority of known characteristics associated with IOP [3].

Elevated intraocular pressure (IOP) is the key parameter and the primary risk factor for the advancement of key Open Angle Glaucoma (POAG). There have been indications of a connection between IOP and refractive error. Research has shown that individuals without glaucoma who have myopia or hyperopia are more likely to develop ocular hypertension [4].

Based on the idea that an increase in axial length is the primary cause of school myopia (AL). Although some studies have shown a beneficial correlation, others have questioned the nature of the relationship between IOP and childhood myopia. Although some clinic-based studies disagree, the majority of population-based studies in adults have discovered meaningful relationships between IOP and refractive error or myopia. Because these studies are cross-sectional and involve adults, it is impossible to determine if myopia and IOP are related on a cause-and-effect basis [5].

Methods

This prospective, comparative, cross sectional study involved a randomly selected two hundred and forty-six eyes (246) of 123 school-aged child. They were classified into three groups each of 82 eyes (41 children) according to refractive error. They are collected from the Ophthalmology Department, Faculty of Medicine, Suez Canal University Hospital at the period from October 2019 to October 2020.

Exclusion Criteria: Pre-existing corneal abnormalities, previous ocular inflammations or trauma, Glaucoma, patients who performed any previous anterior segment surgeries, contact lens wearers and smokers.

The patients who fulfilled the criteria were divided into three groups:

Group 1: 41 patients with no refractive errors

Group 2: 41 patients with myopia

Group 3: 41 patients with hypermetropia.

All Patients were gone under full ophthalmic examination. Full history taking such as previous visual complaints, medications, ophthalmologist visits, consanguinity and hereditary ophthalmic diseases.

- Evaluation of visual acuity and the best corrected visual acuity by using Snellen's chart according to (Health Resources and Services Administration). Manifest refraction using the autorefractometer (Nidek Ark-1, Japan), pre- and post-dilatation with Cyclopentolate 1% eyedrops.

• Slit lamp bimicroscopy (Nidek, 22631, 2013, Nidek Japan) to examine the anterior segment of the eye to exclude any corneal or lens abnormalities as corneal opacities, corneal dystrophy, corneal degeneration or cataract.

• Intraocular pressure measurement by Goldmann applanation tonometer.

• Fundus examination: using slit lamp and 20, 78, 90D Volk lenses to exclude any posterior segment disorder. Ultrasound biomicroscopy (Sonomed E-Z Scan AB5500+, Sonomed Escalon ©, New York, USA) performed for all subjects to measure and axial length of the eye by A-scan.

Informed written consent was obtained from all patients and included the following information.

The main objectives, methods, and time frame of the study are described in a straightforward manner.

▪ Participation could be declined by patients without impacting the medical treatment they were entitled to receive.

▪ Participants were free to withdraw from the study at any point without needing to provide a reason.

▪ The confidentiality of data and results for the entire study population was maintained by guaranteeing the anonymity of the data and limiting access to the data solely to the research team.

▪ The mobile number of the principal researcher and the phone number of the Research Ethics Committee were given to study participants for any potential future inquiries or complaints.

▪ Any potential risk associated with local medications used and their side effects was addressed promptly by the researcher, and the procedure was conducted by a qualified and experienced ophthalmologist.

▪ Any potential risk attributed to the local medications used and any side effects was managed promptly by the researcher; in addition the procedure was performed by a qualified experienced ophthalmologist.

Results

Studies have evaluated the relation between IOP, refractive errors and axal length in children, based comparisons of measuring IOP, refraction and axial length by different instrumentation.

The purpose of this study is to estimate refractive error, AL and IOP among children of both sexes. It involved 246 eyes of 123 school aged children were selected for this study. They were classified into three equal groups; group (1): 82 eyes of 41 emmetropic children, group (2): 82 eyes of 41 myopic children and group (3): 82 eyes of 41 hyperopic children. The mean ages were 10.85, 10.53 and 9.86 years in groups (1), (2) and (3), respectively. So, all groups were age and sex matched. (table 1)

The uncorrected visual acuities were 0.96 ± 0.05 (Range: 0.9 – 1.0), 0.35 ± 0.45 (Range: 0.01 – 0.5), and 0.60 ± 0.08 (Range: 0.08 – 1.0) in emmetropes, myopes and hyperopes, respectively. There is a statistically significant difference ($p = 0.024$) between the three studied groups regarding uncorrected visual acuities. This was expected logically as patients were classified into three groups; emmetropes, myopes and hyperopes. (table 2)

Also, the mean refractive errors (spherical equivalent) were 0.25 ± 0.0D (Range: 0.0 – 0.25), -9.5 ± 6.75D (Range: -1.25 – -16.5), 5.0 ± 4.25D (Range: 2.0 –12) in emmetropes, myopes and hyperopes, respectively. There is a statistically significant difference ($p = 0.002$) between the three studied groups regarding the refractive state. (table 3)

Table (1): Sex and age distribution of study population.

Group	Group (1) Emmetropes		Group (2) Myopes		Group (3) Hyperopes		Total		P
Gender	No.	%	No.	%	No.	%	No.	%	
Males	20	48.8	15	36.6	17	41.5	52	42.3	0.062
Females	21	51.2	26	63.4	24	58.5	71	57.7	
Total	41	100	41	100	41	100	123	100	
Age	Years		Years		Years		Years		
Range	8 – 18		8.5 – 18		8 – 17		8 – 18		
Mean±SD	10.85 ± 2.38		10.53 ± 3.42		9.86 ± 2.97		10.41 ± 2.9		0.794
P > 0.05 = non-significant. SD: standard deviation									

Table (2): Comparison of decimal uncorrected visual acuities of the studied eyes.

Group UCVA	Group (1) Emmetropes (N = 82)	Group (2) Myopes (N = 82)	Group (3) Hyperopes (N = 82)	t	P
Range	0.9 – 1.0	0.01 – 0.5	0.08 – 1.0		
Mean ± SD	0.96 ± 0.05	0.35 ± 0.45	0.60 ± 0.08	1.264	0.024*
*P < 0.05 = significant. t: student t-test.					

Table (3): Comparison of refractive state in the three studied groups.

Group SE (D)	Group (1) Emmetropes (N = 82)	Group (2) Myopes (N = 82)	Group (3) Hyperopes (N = 82)	t	P
Range	0 – 0.25	(-1.25) – (-16.5)	2.0 – 12		
Mean ± SD	0.25 ± 0.00	-9.5 ± 6.75	5.0 ± 4.25	2.239	0.002*
*P < 0.05 = significant. D: diopter, SE: spherical equivalent					

The axial length was 23.8 ± 2.25 mm (range: 22 – 25 mm), 26.5 ± 3.75 mm (range: 24 – 28 mm), 22.2 ± 2.35 mm (range: 19.5 – 24 mm) in emmetropes, myopes and hyperopes, respectively. There is a statistically significant difference (p = 0.031) between the three studied groups regarding the axial length. So, axial length was longer in myopes than emmetropes and shorter in hyperopes. (table 4)

The mean IOP was 16.2 ± 2.95 mmHg (range: 13 – 20 mmHg), 12.5 ± 2.25 mmHg (range: 10 – 18 mmHg), and 19.4 ± 2.61 mmHg (range: 17 – 23 mmHg) in emmetropes, myopes and hyperopes, respectively. There is a statistically significant difference (p = 0.031) between the three studied groups regarding the intraocular pressure. It was observed that there is an increase of IOP in hyperopes (with short AL) than emmetropes and myopes, while the myopes (with long AL) were the least mean of IOP. (table 5)

Table (4): Comparison of axial length (AL) in the three studied groups.

Group AL (mm)	Group (1) Emmetropes (N = 82)	Group (2) Myopes (N = 82)	Group (3) Hyperopes (N = 82)	t	P
Range	22 – 25	24 – 28	19.5 – 24		
Mean ± SD	23.8 ± 2.25	26.5 ± 3.75	22.2 ± 2.35	0.294	0.031*
*P < 0.05 = significant. D: diopter, SE: spherical equivalent					

Table (5): Comparison of intraocular pressure (IOP) in the three studied groups

Group IOP (mmHg)	Group (1) Emmetropes (N = 82)	Group (2) Myopes (N = 82)	Group (3) Hyperopes (N = 82)	t	P
Range	16 – 20	14 – 19	17 – 22		
Mean ± SD	18.2 ± 2.95	16.5 ± 2.25	19.4 ± 2.61	0.211	0.054
P > 0.05 = non-significant. IOP: intraocular pressure					

We found a positive correlation between axial length and refractive error of the studied eyes. There is a strong positive correlation (r = 0.7704, p = 0.000) (figure 1). We found also, a negative correlation between axial length and intraocular pressure of the studied eyes. There is a weak significant negative correlation (r = 0.2198, p = 0.038).(figure 2)

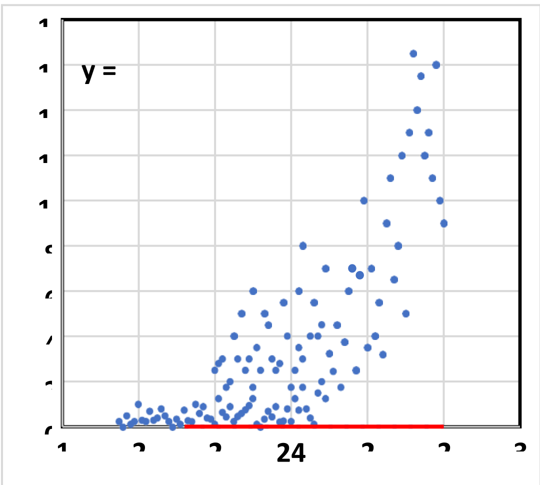

Figure. (1): Correlation between axial length and refractive error of the studied eyes. There is a strong positive correlation (r = 0.7704, p = 0.000).

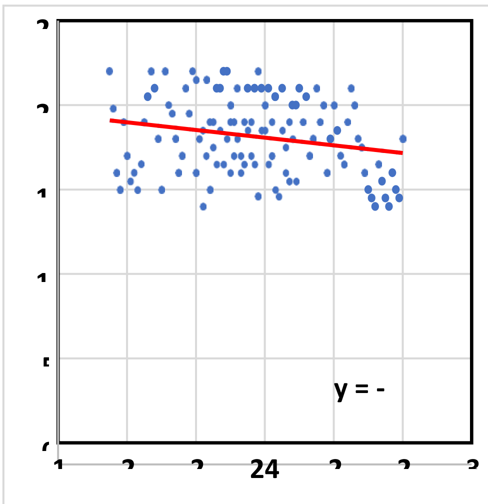

Figure. (2): Correlation between axial length and intraocular pressure of the studied eyes. There is a non-significant negative correlation (r = 0.2198, p = 0.058)

Discussion

The relationship between intraocular pressure (IOP) and other ocular biometric characteristics, such as axial length (AL) and refraction, has garnered renewed scholarly interest. These ocular biometric characteristics interact with one another in complex ways. Despite numerous investigations, the association remains elusive due to the highly variable outcomes. The correlations between different parameters can vary depending on the population under

study. To enhance the understanding of the ocular biometric characteristics of Egyptian eyes, a more comprehensive study of this population is necessary. Consequently, a prospective study was conducted to determine the relationship between IOP, AL, and refractive error. [6].
The axial length was ascertained by measuring the distance between the waveforms corresponding to the anterior corneal surface and the retina at the macula. For each patient, five precise axial length measurements were obtained using the equipment, which subsequently computed the average of all the results [7].
Axial length (AL) measurement is an essential tool in young children, demonstrating reasonable repeatability [8]. However, there are limited tools available to predict progressive disease in this age group. In contrast, older children are often capable of performing kinetic perimetry with acceptable reliability [9].
While the benefits of elevated intraocular pressure (IOP) are acknowledged, distinguishing axial length (AL) changes induced by increased IOP from those associated with aging presents challenges. The normal pattern of AL growth during the initial years of life is characterized by a non-linear trajectory, with significant increases occurring in the first two years, followed by a plateau between three and four years of age. Although it is well established that childhood glaucoma leads to exaggerated AL changes relative to age, there is limited information regarding the impact of IOP on AL. Furthermore, the sclera is observed to be thinner in patients with primary congenital glaucoma (PCG) [10]
This investigation aims to calculate refractive error, axial length, and intraocular pressure in both male and female children. For this study, 246 eyes belonging to 123 school-aged children were chosen. The subjects were divided into three equal subgroups; subgroup (1) consisting of 82 eyes of 41 children with emmetropic vision, subgroup (2) consisting of 82 eyes of 41 myopic children, and subgroup (3) consisting of 82 eyes of 41 hyperopic children. The mean ages for the groups were 10.85, 10.53 and 9.86 years in groups (1), (2) and (3), respectively. All study groups were matched for age and sex.
In agreement of our study, Jiang et al. (2014) [3] in their cross-sectional study on 5919 children, the mean age was 10.0 ± 3.3 years (median, 10.0 years; range, 4–18 years).
The IOP had a considerable effect on the curvilinear relationship between age and AL, reaching its highest point at approximately three years of age. Typically, boys exhibit an above-average aerobic lactate (AL) threshold for their age group, suggesting a notable disparity in this regard between the sexes, as referenced in research number [7].
In contrary to our research, girls appeared considerably more likely than boys to experience refractive error. For both boys and girls, AL hits a plateau at the age of three. Therefore, measuring AL after this age may not be clinically beneficial. However, the age at which the increase in AL seems cease has not been carefully investigated in other investigations [7]. In this regard, Capozzi's study data from thirty-nine healthy eyes appears to indicate a flattening of the growth in AL after three years of age [11].
Our study was comparable to Jiang et al. (2014) study as they recorded a mean refractive error (spherical equivalent) of −0.21 ± 2.10 D (median, 0.50 D; range, −11.75–10.50 D) for the right eyes and

−0.13 ± 2.08 D (median, 0.50 D; range, −11.75–11.00 D) for the left eyes.

The axial length of this study was 23.8 ± 2.25 mm (range: 22 – 25 mm), 26.5 ± 3.75 mm (range: 24 – 28 mm), 22.2 ± 2.35 mm (range: 19.5 – 24 mm) in emmetropes, myopes and hyperopes, respectively. There is a statistically significant difference (p = 0.031) between the three studied groups regarding the axial length. So, axial length was longer in myopes than emmetropes and shorter in hyperopes.

These results were parallel to Arora et al. (2019) [12] revealed that the right eye spherical refractive error is negatively correlated with axial length of right eye (r=- 0.836, p<0.01). Similarly, the spherical refractive error of left eye is also found to be negatively correlated with axial length of left eye (r=-0.859, p<0.01). accordingly, it can be concluded that as we move from myopic to hyperopic refractive error, the axial length of the eye decreases proportionately.

Before myopia started, there was a noticeable difference between emmetropic and myopic eyes in terms of refractive error, axial length, relative peripheral refractive error, and growth rates for these characteristics. Children who were not myopic for up to four years prior to developing myopia were frequently less hyperopic than emmetropes [13].

In the present study, there is a negative correlation between axial length and intraocular pressure of the studied eyes. There is a weak significant negative correlation (r = 0.2198, p = 0.038).

These results coincide with Mendez-Hernandez et al. (2020) [14] as they concluded that ocular axial length may affect IOP measurement. Other studies like Popa-Cherecheanu et al. (2017) [15] found a non-significant difference between IOP and AL.

Li et al. (2017) [16] showed that myopic eyes had a higher IOP than emmetropic or hyperopic eyes, which is contradictory to our findings. In grade 1, the absolute difference was negligible; however, in grade 2, it climbed to 1 mmHg, which would suggest a pattern. IOP and spherical equivalent were shown to be strongly negatively correlated in both child groups using univariate analysis. Only the younger children on multivariable regression showed this association. IOP had a positive correlation with a deeper anterior chamber (around 1 mm Hg/mm) in both student groups.

Conclusion

The study's findings led to the conclusion that refractive errors, axial length, and intraocular pressure could be interrelated, with refractive error influenced by AL, where a more elongated AL is associated with greater myopia, and a shorter AL is associated with greater hyperopia. The relationship between IOP and AL is bidirectional, with IOP potentially influencing AL and vice versa.

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