*British Journal of Medicine & Medical Research*
*20(10): 1-7, 2017; Article no.BJMMR.30241*
*ISSN: 2231-0614, NLM ID: 101570965*

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# Is There a Causal Relationship between Myopia and Intraocular Pressure

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author NEC designed the study and wrote the first draft of the manuscript. Authors NEC and AOA wrote the protocol and managed the literature searches. Analyses of the study was performed by a statistician. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/BJMMR/2017/30241
*Editor(s):*
(1) Barbara Giambene, Eye Clinic, Department of Translational Surgery and Medicine, University of Firenze, Italy.
*Reviewers:*
(1) Thevi Thanigasalam, Melaka General Hospital, Melaka, Malaysia.
(2) Alahmady Hamad Alsmman Hassan, Sohag University, Egypt.
(3) Kagmeni Giles, University Teaching Hospital Yaounde (UTHY), Cameroon and University of Yaoundé I, Cameroon.
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(5) Momen Mahmoud Hamdi, Ain Shams University, Cairo, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/18562

***Original Research Article***

***Received 27th October 2016***
***Accepted 14th December 2016***
***Published 10th April 2017***

## ABSTRACT

**Aims:** To determine if there is causal association between myopia and intraocular pressure at the University of Port Harcourt Teaching Hospital (UPTH), Nigeria.
**Study Design:** A case control study.
**Place and Duration of Study:** The study was carried out at the University of Port Harcourt Teaching Hospital (UPTH) between November, 2012 and May, 2013.
**Methodology:** Eighty consecutive patients of myopes (group A) and emmetropes (group B) were sampled in two groups. Group A was subgrouped into low myopia (−3.0D<Spherical Equivalent (SE) ⩽−0.5D), moderate myopia (−3.0D⩽SE-< -6.0D) and high myopia (SE ≥ -6).
Intraocular pressures were taken between 9am -12 mid-day by Perkins applanation tonometer (MK2 Model). Autorefraction was carried out with (Carl Zeiss meditec) while Axial length was measured with A scan ultrasound machine (Pascan 300A Digital biometric reader). Full examination of the fundus was carried out.

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**Results:** 160 eyes of 80 patients each were respectively in groups A and B. The mean age of the myopes was 23.54 ± 12.74 years while that of the controls was 23.62±12.86 years (P=0.968).
Among the myopes, there were 42(52.5%) males and 38(47.5%) females while the control had 32(40.0%) males and 48(60.0%) females. There was no statistical difference in male (p=0.411) nor female (0.416) gender.
The mean axial length of the myopes was 24.03±1.68 mm while that of the control was 23.09±0.87 mm. (P=0.001).
There was no correlation between myopia and IOP (Pearson correlation coefficient: r=0.14, $r^2$=0.02, 95% CI=-0.14-0.18). There was also no correlation between IOP and axial length in both groups. There was however a linear correlation between myopia and axial length(r=0.76, $r^2$=0.57, 95% CI=0.45-0.67.
**Conclusion:** Myopes have longer axial length than emmetropes in our study, this difference was not accounted for by changes in intraocular pressure.

*Keywords: Myopia; emmetropia; intraocular pressure; axial length.*

## 1. INTRODUCTION

The refractive state of the human eye depends on a balance of change in overall eye size and refractive components namely the cornea and crystalline lens [1]. Overall, the change in axial length tends to outweigh the progressive corneal flattening with age in normal eyes [2]. The interaction between the axial length, corneal radius of curvature and lens determines the eventual refractive state of the eye rather than axial length alone [3]. Sorsby et al. considered that changes in axial length were crucial in determining the architecture of the globe and that myopia resulted from a failure of the cornea and lens to compensate for the axial elongation [4,5]. However Sowjana et al found that in addition to myopes having higher IOP, there is also a positive correlation between IOP and myopia [6]. They concluded that since subjects with refractive error are at greater risk of developing glaucoma, these subjects require regular monitoring to prevent ocular pathology and blindness.

Intraocular pressure (IOP) plays an important role in the pathogenesis of glaucoma and has been hypothesized to be one of several factors implicated in the pathogenesis of myopia [7]. Elevated IOP is said to impose scleral stress and creep, resulting in axial eye elongation with scleral stretch [8]. Several studies have evaluated the relation between IOP and myopia development with controversial results. Some studies reported a positive association [9-11], while others found no such relation between IOP and myopia [12-14]. However, the nature and extent of the influence of IOP on eye growth remains poorly understood.

Glaucoma and myopia share a common pathway. Both conditions show changes in ocular connective tissue. The changes in sclera in myopes and in lamina cribrosa and trabecular meshwork in subjects with glaucoma are similar [6]. They have a strong familial basis and may also share common genetic links [15]. Therefore, the relationship between the refractive errors, IOP and glaucoma may revolve around a concept that, an increase in the IOP can cause scleral stress and axial elongation leading to development of myopia and there is high glaucoma susceptibility in myopes [6]. Besides this, raised IOP is the only modifiable risk factor for the development of glaucoma.

It is thus necessary to embark on a study aimed at establishing the relationship between intraocular pressure and myopia especially in our environment to see if there is a causal association.

## 2. METHODOLOGY

A case control study was carried out in the eye clinic, UPTH between November, 2012 and May, 2013. Exclusion criteria were a history of corneal infection or abnormalities, ocular trauma and past ocular surgery. Others were history of contact lens wear, Glaucoma, hypermetropia, patients with cataract. Furthermore patients with systemic diseases such as diabetes mellitus were excluded. The Inclusion criteria were Spherical myopia of -0.5D and above, Cylinders of 2D or less.

The visual acuity (VA) of the patients was done with Snellen’s chart. They were then refracted using autorefractor (Carl Zeiss meditec; Germany) and subjectively with trial lens box. Children less than 10 years had cycloplegic refraction when the need arose. They were categorized into; myopes (group A) and emmetropes (group B). Group A was sub grouped into low myopia (−3.0D<Spherical Equivalent (SE) ⩽ −0.5D), moderate myopia (−3.0D⩽SE<6.0D) and high myopia (SE ≥ -6) while group B were emmetropes (plano). Eighty consecutive patients of myopes (group A) and emmetropes (group B) were respectively sampled in two groups.

Intraocular pressure was measured using Perkins applanation tonometer (MK2 Model; United Kingdom). Three readings were taken between 9 am and 12 pm and the patient's average value calculated. Patients were in sitting position and had their eye anaesthetized with topical anaesthetic agent (1% tetracaine) and then 2% fluorescein dye was instilled before taking the pressures.

The axial length was measured with an A scan ultrasound machine (Pascan 300A Digital biometric reader). Patients were in a sitting position and had their eyes anaesthetized with topical anaesthetic (1% tetracaine) agent. The axial length was taken with the probe of the A scan perpendicular to the eye. Five readings were taken and the average calculated by the instrument.

A structured interviewer administered questionnaire was used. The questionnaire was used to obtain information like age, sex, history of ocular trauma, past ocular surgery, diabetic status etc. The questionnaire was administered by the author. The questionnaire was redesigned after a pretest with a pilot group at the University of Port Harcourt teaching hospital using subjects between 10 to 50 years. This was to avoid bias because the pretest involved patients who had cataract and past ocular surgery. They were further examined by the researcher using the Keeler direct ophthalmoscope, +78D lens and slit lamp biomicroscope.

Data was collated and analyzed by a statistician using Epi-info version 6.04d statistical software. Test of significance between proportions was assessed using chi-square ($X^2$) with a p value of < 0.05 considered as significant. When some cells had 0 or < 5, Fishers Exact test was used. Test of significance between means was tested using student-t test with a p value of < 0.05 considered as significant. Correlation analysis with the Pearson test was used to study relations between continuous variables, represented by the letter "r" and a 95% confidence interval (CI) was also measured. Mantel-Haenszel chi-square test for linear trend was used for the comparison of variables with a trend. Data was presented in percentages as tables and graphs accordingly.

## 3. RESULTS

The study population included 80 myopic subjects (160 eyes) and 80 controls (160 eyes). The age range of the respondents was 10-65 years. The mean age of the myopes was 23.54 ± 12.74 years while that of the control was 23.62±12.86 years. The difference was not statistically significant (*P=0.968*).

Among the myopes, there were 42(52.5%) males and 38(47.5%) females giving a (M: F=1.1:1) while the emmetropes had 32(40%) males and 48(60%) giving a (M: F=2: 3).

The mean intraocular pressure (IOP) of myopes was 13.01±2.69 (mmHg) while that of the control was 13.68±3.19 (mmHg). Majority of subjects (>75%) in both groups had intraocular pressure of 11-18 mmHg as shown in Table 1.

**Table 1. Intraocular pressure of myopes and controls**

| IOP (mmHg) | Myopic (Both eyes) freq (%) | Control (Both eyes) freq (%) |
|---|---|---|
| 7-10 | 34(21.5) | 29(18.1) |
| 11-14 | 76(47.5) | 71(44.8) |
| 15-18 | 47(29.4) | 53(33.1) |
| 19-22 | 3(1.9) | 7(4.3) |
| Total | 160(100.0) | 160(100) |

*Mantel-Haenszel Chi-sqaure for trend, ($\chi 2=0.210$, p=0.647)*

The mean axial length of the globe in myopes was 24.03±1.68 mm while that of control was 23.09±0.87 mm. This difference was statistically significant (*P*=0.001). The range was 21.1- 31.1 mm for myopes and 21.1-24.5 mm for emmetropes.

### 3.1 Pearson's Correlations

There was a linear correlation between myopia and axial length as shown in Fig. 1. Pearson's correlation coefficient (r) =0.76, $r^2$=0.57, 95% Confidence Interval (CI) =0.45-0.67.

There was poor correlation between IOP and axial length in myopes (Pearson correlation coefficient, r=0.24, $r^2$=0.06, CI= 0.10-0.21), see

Fig. 2. Similarly there was also poor correlation between IOP and axial length in controls (r=0.06, $r^2$=0.00, CI= 0.40-0.41).

Fig. 3 shows poor correlation between myopia and IOP (Pearson correlation coefficient, r=0.14, $r^2$=0.02, 95% CI= 0.14-0.18). Similarly, there was also a poor correlation between IOP and age in both myopes (r=0.03, $r^2$=0.00, CI= 0.16-0.16) and controls (Pearson correlation coefficient, r= 0.07, $r^2$=0.0, CI= 0.39-0.41).

**Table 2. Axial length of myopes and control**

| Axial length (mm) | Myopic (Both eyes) freq (%) | Control (Both eyes) freq (%) |
|---|---|---|
| 17-20 | 1(0.6) | 21(13.1) |
| 21-24 | 131(82.4) | 135(84.8) |
| 25-28 | 25(15.6) | 4(2.5) |
| 29-32 | 3(1.9) | 0 |
| Total | 160(100.0) | 160 (100.0) |

*Mantel-Haenszel Chi-sqaure for trend,*
*($\chi$2=35.25, p=0.001)*

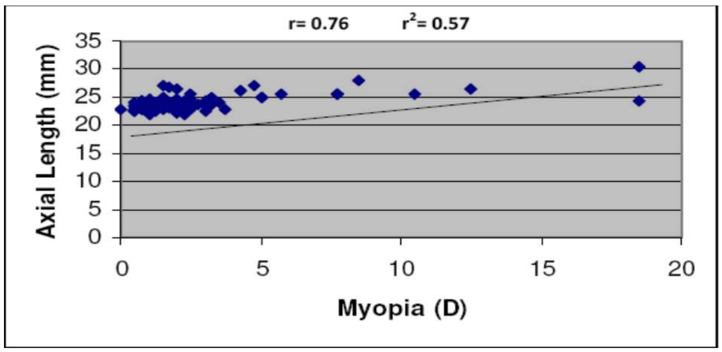


**Fig. 1. Correlation between myopia (D) and axial length (mm)**
*(Fairly strong Linear correlation. Pearson's correlation coefficient "r" is closer to "1" than "0")*

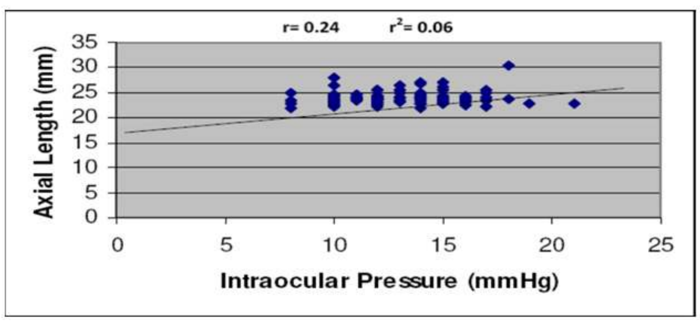


**Fig. 2. Correlation between intraocular pressure (mmHg) and axial length (mm) of myopes**
*(Poor Linear correlation. Pearson's correlation coefficient "r" is closer to "0" than "1")*

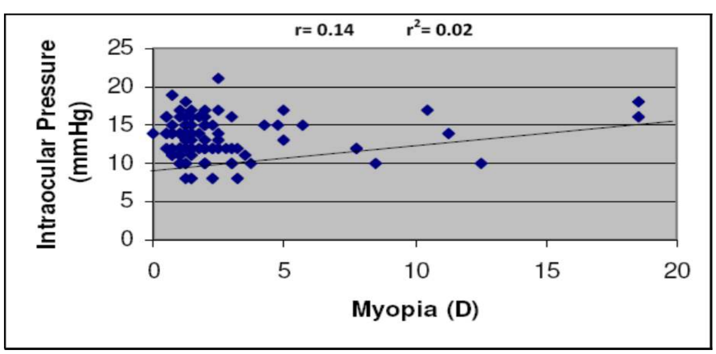


**Fig. 3. Correlation between myopia (D) and intraocular pressure (mmHg)**
*(Poor linear correlation. Pearson's correlation coefficient "r" is closer to "0" than "1")*

## 4. DISCUSSION

Myopia results either from axial elongation of the eye [4,5], increased steepness of the cornea or decreased rigidity of the outer coat of the eye [16]. Any factor that affects these could result in myopia [3].

This study showed a statistically significant difference in axial length of myopes compared to controls [4,5]. This showed that most of the myopes had axial myopia since there was no statistical significant difference in other factors such as age and sex which could affect axial length [17]. Axial length has been shown to be positively correlated with myopia [18] as was also seen in this study. It is well established that axial length is associated with refractive error [19-22] and longitudinal studies have shown that axial length increases as myopia progresses [23-26]. Some reports suggest the sclera is altered in myopia based on animal models [27-30] and human studies [31-33]. The trend in the odds of successive increasing levels of Axial Length (AL) being responsible for patients having myopia also agrees with studies which stated that the longer the axial length, the more severe the myopia [34]. Furthermore a positive association between moderate myopia and increasing axial length of eye ball have also been reported and suggested that moderate to high myopia is associated with the risk of Primary open angle glaucoma [35].

Age-related axial length differences were discovered in a study in that older people were likely to have shorter axial length than younger people [17]. The impact of age may not be contributory in this study bearing in mind that there was no statistical significant difference in age of both the myopes and the emmetropes.

Considering the impact of IOP on myopic status, a study showed that higher IOP might result in greater scleral stress and faster axial elongation translating to greater myopic progression [36]. Friedman [37] has also proposed a mathematical model that suggests the myopic eye is under greater stress than an emmetropic eye with the same IOP. This entails that under same IOP, myopic eye are more likely to stretch than emmetropic eye. This could have applied in our study where there was no statistical significance between IOP in myopes and emmetrope. However there was poor correlation between IOP and axial length in this study showing that the longer axial length of myopes could not be accounted by changes in the IOP. This agrees with previous studies which showed no relationship between myopia and intraocular pressure [12-14]. This could also explain the failure in attempts to reduce myopic progression using ocular hypotensives as observed in other studies [38].

In summary, our results suggest that though there is a positive correlation between axial length and degree of myopia but this could not be accounted for by changes in intraocular pressure. The poor linear correlation between myopia and intraocular pressure showed that changes in intraocular pressure does not affect myopic status of subjects. This is an agreement with both a long term (5 year) study by Manny et al. [39] and also a short term study by Schmid et al. [33]`who found no correlation between myopia and IOP.

## 5. CONCLUSION

Myopes have a statistically significant longer axial length than emmetropes.

There is a linear correlation between axial length and degree of myopia such that the longer the axial length, the higher the degree of myopia.

There is poor linear correlation between IOP and axial length.

There is poor linear correlation between IOP and myopia.

The following Recommendations were made based on these findings:

> Since there is poor correlation between myopia and IOP, The use ocular hypotensive in retarding myopia progression remains questionable.
>
> Since there is poor correlation between myopia and IOP, other theories of the pathogenesis of myopia acting independent of IOP should be closely considered with the aim of reducing myopic progression. For instance, it would be wise to closely consider the Myopia Consensus Statement made by the World Society of Paediatric Ophthalmology & Strabismus where they concluded that Atropine 0.01% dose appears to offer an appropriate risk-benefit ratio, with no clinically significant visual side effects balanced against a reasonable and clinically

significant 50% reduction in myopia progression. Orthokeratology contact lenses were also shown to likely slow axial length elongation though infective keratitis is a risk. Furthermore they stated that Peripheral defocusing lenses in the form of spectacles or contact lenses may both have a role in slowing the rate of myopic progression in a subset of children and further help our understanding of the physiologic control of ocular growth. Increasing daylight exposure and reducing intense periods of near work may be helpful.

Finally it is recommended that studies relating the association of myopia and outer ocular coat in our environment should be carried out so as to establish whether such relationships exist or not.

## CONSENT

All authors declare that written informed consent was obtained from the patient.

## ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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*The peer review history for this paper can be accessed here:*
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