Is there a causal relationship between progression of myopia and IOP?

Abstract

Aims: To determine if there is causal association between myopia and intraocular pressure at the University of Port Harcourt Teaching Hospital (UPTH), Nigeria. Similar studies have been carried out but with contrasting results. Most of these studies were done away from our environment.

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≥−6.0D).

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.

Result: 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, 42(52.5%) were males compared to the 32(40.0%) of controls (p=0.411). Furthermore, 38(47.5%) of myopes were females while 48(60%) of controls were females. (p=0.416).

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, r²=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, r²=0.57, 95% CI=0.45-0.67).

Conclusion: Although myopes have longer axial length than emmetropes in our study, this difference was not accounted for by changes in intraocular pressure.

Key Words: Myopia, Emmetropia, Intraocular Pressure, Axial length
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.

Methodology:

A case control study 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) and subjectively with trial lens box. 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 ≤ -6.0D) 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). Three readings were taken between 9am and 12pm 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 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.

Result:

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(52.55%) 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 have intraocular pressure of 11-18 mmHg as shown in table 1.

In measuring Chi-square for trend, a p-value greater than 0.05 indicates no trend in the increasing levels of IOP as responsible for patients been myopic as compared to non-
myopes (controls); as a Mantel-Haenszel test for linear trend showed no statistically
significant $P=0.647$ ($\chi^2=0.210$).

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

In measuring Chi-square for trend, a p-value less than 0.05 indicates a trend in the odds of
successive increasing levels of Axial Length (AL) as responsible for patients having myopia
compared to the non-myopes (controls); as a Mantel-Haenszel test for linear trend showed a
statistically significant $P=0.001$ ($\chi^2=35.25$).

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)

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. 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[19]. 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[20].

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.
The longer axial length of myopes could however not be accounted for by higher IOP because there was poor correlation between IOP and axial length in both myopes and control. This agrees with previous studies which showed no relationship between myopia and intraocular pressure [12-14].

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.

Conclusion:
The following conclusions were made based on these findings:

- The use ocular hypotensives in retarding myopia progression may be questionable.
- 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 would however be necessary to do studies relating the association of myopia and outer ocular coat in our environment so as to establish whether such relationships exist or not.

Consent:
All authors declare that written informed consent was obtained from the patient. A copy of the written consent is available.

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.

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**Tables**

<table>
<thead>
<tr>
<th>IOP (mmHg)</th>
<th>MYOPIC (Both Eyes) Freq (%)</th>
<th>CONTROL (Both Eyes) Freq (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-10</td>
<td>34 (21.5)</td>
<td>29 (18.1)</td>
</tr>
<tr>
<td>11-14</td>
<td>76 (47.5)</td>
<td>71 (44.8)</td>
</tr>
<tr>
<td>15-18</td>
<td>47 (29.4)</td>
<td>53 (33.1)</td>
</tr>
<tr>
<td>19-22</td>
<td>3 (1.9)</td>
<td>7 (4.3)</td>
</tr>
<tr>
<td>Total</td>
<td>160 (100.0)</td>
<td>160 (100)</td>
</tr>
</tbody>
</table>

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

**Table 1:** Intraocular pressure of myopes and controls
<table>
<thead>
<tr>
<th>AXIAL LENGTH (mm)</th>
<th>MYOPIC (Both Eyes)</th>
<th>CONTROL (Both Eyes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>17-20</td>
<td>1 (0.6)</td>
<td>21 (13.1)</td>
</tr>
<tr>
<td>21-24</td>
<td>131 (82.4)</td>
<td>135 (84.8)</td>
</tr>
<tr>
<td>25-28</td>
<td>25 (15.6)</td>
<td>4 (2.5)</td>
</tr>
<tr>
<td>29-32</td>
<td>3 (1.9)</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>160 (100.0)</strong></td>
<td><strong>160 (100.0)</strong></td>
</tr>
</tbody>
</table>

Mantel-Haenszel Chi-square for trend, \( \chi^2 = 35.25, p = 0.001 \)

Table 2: Axial length of myopes and control

Figures
Figure 1: Correlation between Myopia (D) and Axial Length (mm). (Fairly strong Linear correlation. Pearson’s correlation coefficient “r” is closer to “1” than “0”)

Figure 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”)

Figure 3: Correlation between Myopia (D) and Intraocular Pressure (mmHg). *Poor linear correlation. Pearson’s correlation coefficient “r” is closer to “0” than “1”*