Original Article

Predictors of Posture Induced Intraocular Pressure Variations in Normal Subjects and Glaucoma Patients. Evidence from Abakaliki

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Abstract

Background: Intraocular pressure (IOP) is affected by factors like age, gender, body mass index (BMI), and blood pressure among others. Studies have investigated the relationship between IOP and age, gender, BMI, and refractive error (3-5). There has been conflicting results as some studies have reported a correlation between IOP and age, gender, BMI, and refractive error while results from other studies found no such association. **Aim:** The aim of this study was to determine the relationship between IOP and age, gender, body mass index and refractive status in the primary open angle glaucoma (POAG) and non-glaucomatous eyes. **Methods:** A case controlled study involving consecutive newly diagnosed POAG and non-glaucomatous patients conducted in the eye clinic of Alex Ekwueme Federal University Teaching Hospital, Abakaliki. Demographic data included age, gender, and occupation. Height and weight were measured using a Standing Scale with calibrated metal rule. BMI was calculated as Weight (kg) / [Height (m)] 2). IOP was measured with Perkins hand-held applanation tonometer. Correlation and regression analysis was used to determine the relationship between IOP and age, gender, BMI and refractive status. **Results:** There was a direct relationship between age and IOP in non-glaucomatous subjects which was statistically significant ($P < 0.001$; r = 0.8). Intraocular pressure also increased with increasing age in POAG but this was not statistically significant ($P = 0.18$; r =0.3). There was no statistically significant difference between mean IOP in males and females of both POAG and non-glaucoma patients, with $P = 0.72$ and $P = 0.50$ respectively. BMI had a linear relationship with intraocular pressure which was statistically significant in POAG ($P = 0.01$; r value = 0.3) but showed no such relationship in non-glaucomatous patients ($P = 0.38$; r value = 0.1). The relationship between mean IOP and refractive status was not statistically significant in non-glaucomatous ($P = 0.19$; r = 0.2) and POAG patients ($P = 0.5$; r = 0.09) respectively. **Conclusion:** IOP has linear correlation with increasing age in both non-glaucomatous patients and POAG. A statistically significant relationship was found between IOP and BMI in POAG but not in non-glaucomatous eyes. There was no relationship between either the gender, or refractive status and IOP in non-glaucoma and POAG subjects respectively.

Keywords: *Age, BMI, gender, IOP, refractive error*

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Introduction

Intraocular pressure is determined by the equilibrium between the rate of aqueous formation by the ciliary body and the rate of fluid drainage from the eye through the trabecular meshwork and uveo-scleral outflow

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pathways.[1] It is a major risk factor for the development and progression of glaucoma.[1] Intraocular pressure is affected by factors such as age, gender, body mass index (BMI), and blood pressure among others.[2,3] Studies[4-6] have investigated the relationship between IOP and age, gender, BMI, and refractive error. There have been conflicting results as some studies[4,6] have reported a correlation between IOP and age, gender, BMI, and refractive error while results from other studies[5,7] found no such association.

Age has been established as one of the risk factors for glaucoma.[8] Previous cross-sectional studies based in Europe and America (the Beaver Dam Eye Study and the Barbados Eye Study) have reported increase in intraocular with age in white and blacks.[9,10] Other studies conducted in the Asian population found no positive correlation between intraocular pressure and age[11-13] while Ejimadu *et al*.[14] reported a weak association between intraocular pressure and age and no relationship between intraocular pressure and gender. These conflicting results could be attributed to ethnic and geographical influences.

Regarding intraocular pressure and gender, Jeelani *et al*.[6] found intraocular pressure to be higher in females than males while other studies,[7,15] reported no positive association between intraocular pressure and gender but found that increasing age was a risk factor for raised IOP and hence for glaucoma.[15] Other factors that affect intraocular pressure include refractive error and BMI. Myopia has been associated with an increased incidence of primary open-angle glaucoma.[1] However, a cross-sectional study done in children reported no association between intraocular pressure and refractive error.[16] Another study evaluated the distribution of IOP and its association with age, gender, and refractive error in non-glaucoma participants in Saudi, and found no statistically significant relationship between IOP with age, gender, and refractive error.[7] Contrary to the result of the above study, Roopa *et al*.[17] in India reported that high myopia (> -6D) and advancing age were associated with an increase in IOP.

BMI has been used as an indicator to correlate body fat.[18] People with high BMI have a higher risk of systemic diseases such as heart disease, hypertension, stroke, and type II diabetes.[18] There have been conflicting published literature on the association between BMI and intraocular pressure. A cross-sectional study in a population screened for glaucoma in Nigeria showed that most obese and overweight subjects had normal IOP.[5] On the contrary, Huma *et al*.[4] in Pakistan reported a significant positive relationship between IOP and BMI in all genders, $p < 0.01$.[4]

However, most of the published literature were on non-glaucoma subjects. Up to date, there has not been published literature on the relationship between posture-induced IOP variation with age, gender, refractive error, and BMI among glaucoma patients. These factors, age, gender, refractive error, and BMI may have a dynamic relationship with intraocular pressure among glaucoma patients.

Subjects and Methods

Study population

The study was conducted under the guidelines of the Declaration of Helsinki and approved by the Research and Ethical Committee of AEFUTHA with REC APPROVAL NUMBER 16/01/2017 – 09/03/2017.

The study participants were enrolled from the patients attending the glaucoma clinic and general Ophthalmology clinic in the Department of Ophthalmology Alex Ekwueme Federal University Teaching Hospital, Abakaliki (AEFUTHA), Ebonyi State, which has been described in detail elsewhere. In brief, the cohorts included newly diagnosed primary open- angle glaucoma patients aged 30–70 years who were aged-matched with non-glaucomatous patients attending the same clinics.

Sample size calculation

This was part of a larger study that compared the posture induced intraocular pressure variations in normal subjects and glaucoma patients. The detailed report on the study population, sampling technique, and ethical issues has been reported in comparing posture- induced intraocular pressure variations in normal subjects and glaucoma patients. A detailed report on the study population, sampling technique, sample size calculation, and ethical issues has been reported in the comparing posture induced intraocular pressure variations in normal subjects and glaucoma patients already published.[19]

Data collection

The study was conducted between July and September 2017. Detailed physical and ophthalmologic examinations, as well as interviewer-administered questionnaire, were conducted. Height, weight, and blood pressure were measured according to standardized protocols and BMI was calculated. Comprehensive medical, surgical, ocular, and systemic history was obtained. Auto refraction and subjective refraction were conducted and spherical equivalents were recorded. The intraocular pressure was measured using Perkin's handheld applanation tonometer and Pachymetry was conducted to ascertain the central corneal thickness. The actual IOP was recorded.

Statistical analysis

All data analysis was performed with IBM SPSS (Special Package for Statistical Sciences) version 23.0. Pearson's Chi-Square test was performed for categorical

variables. One way analysis of variance (ANOVA) was used to determine the relationship between intraocular pressure variations and age, refractive status, and BMI. These variables were subjected to regression analysis and presented in scatter diagrams. Calculations were based on a significance level of $p < 0.05$.

Results

The correlation between intraocular pressure and age was plotted in a scatter diagram and shown in Figure 1. There was a positive significant correlation between age and intraocular pressure among non-glaucoma subjects with r value =0.8, $p < 0.001$.

The relationship between IOP and age among POAG is shown in Figure 2. The scatter plot showed a linear increase in intraocular pressure with increasing age but this was not positively significant with r value =.0.3, $p = 0.06$.

Figure 3 shows the relationship between the mean intraocular pressure variations in non-glaucoma males and females during different postures. The mean IOP during sitting was 11.81 ± 1.32 in males and 12.23 ± 2.96 in females, $p = 0.50$ which was not statistically significant. The difference in the mean IOP variations between males and females during SF (15.58 ± 1.36 in males and 16.70 ± 2.37 in females, $p = 0.08$) and SP (13.08 ± 1.52 in males and 13.87 ± 2.01 in females, $p = 0.12$) were not statistically significant.

The relationship between intraocular pressure and gender among POAG patients during various postures is shown in Figure 4. There were no statistically significant differences in the mean IOP variations between males and females during sitting (27. 47 ± 4.68 in males and 27.92 ± 4.85 in females, $p = 0.72$), SF (34.77 ± 5.88 in males and 35.88 ± 4.99 in females, $p = 0.45$), and SP (29.67 ± 5.41 in males and 30.40 ± 5.10 in females, $p = 0.61$).

Figure 5 shows the relationship between intraocular pressure and BMI among non-glaucoma patients. Out of 55 non-glaucoma subjects, none was underweight, 19 had normal weight, and 28 were overweight while 8 subjects were obese. The scatter plot showed a linear

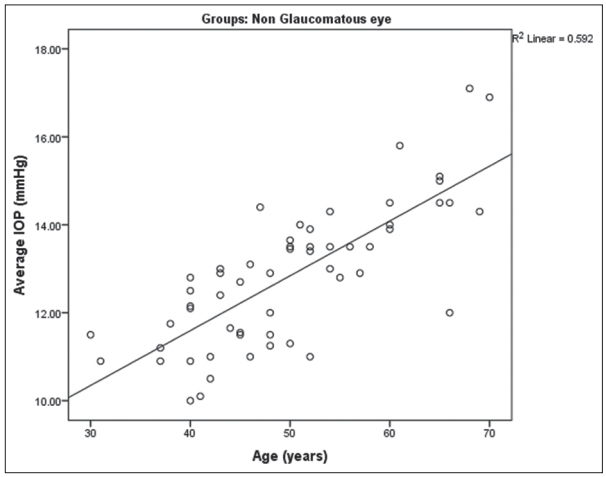

Figure 1: Mean IOP with age in years in non-glaucoma subjects

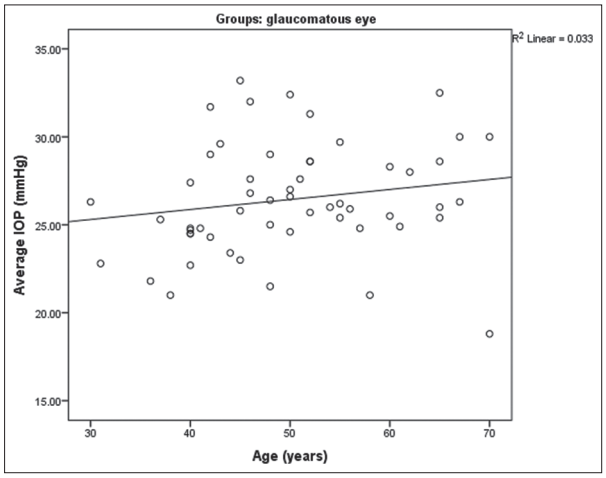

Figure 2: Mean IOP with age in years in POAG subjects

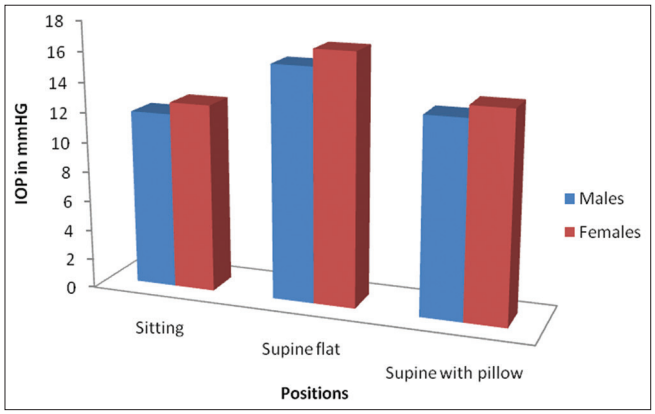

Figure 3: Mean IOP and gender in non-glaucoma subjects

Figure 4: Mean IOP and gender among POAG subjects

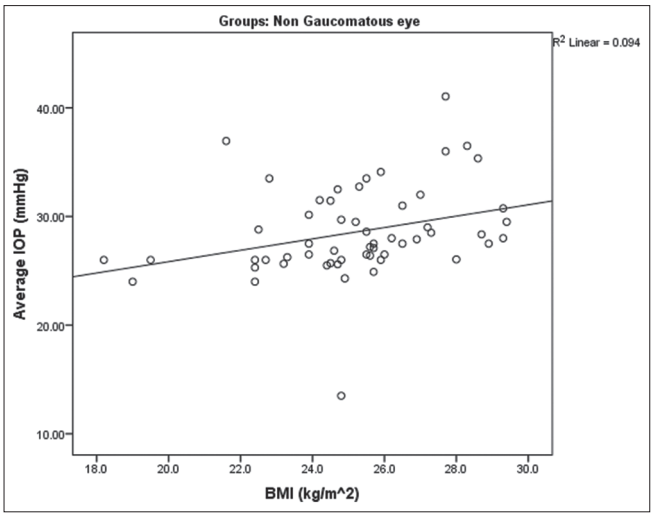

Figure 5: Mean IOP and BMI among non-glaucoma subjects

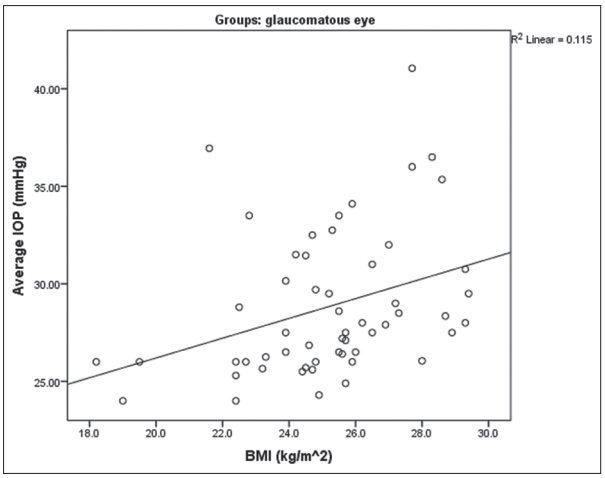

Figure 6: Mean IOP and BMI among POAG subjects

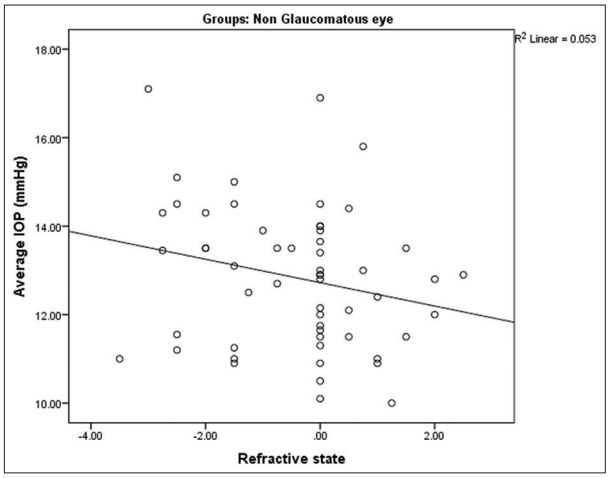

Figure 7: Mean IOP and refractive error (spherical equivalent) among non-glaucoma subjects

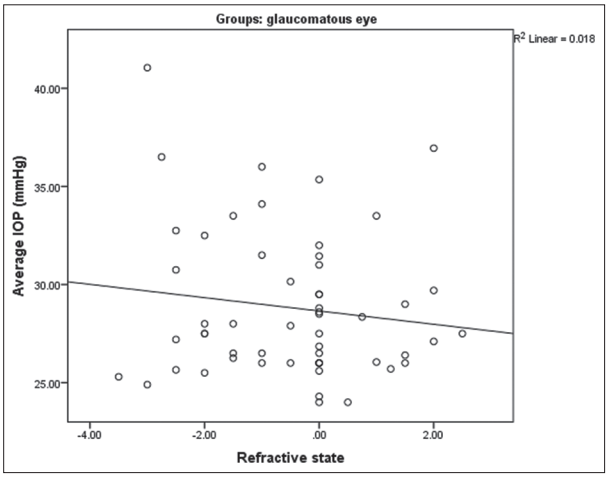

Figure 8: Mean IOP and refractive error (spherical equivalent) among POAG subjects

increase in intraocular pressure with higher BMI but this was not positively significant with r value =0.1, p = 0.4.

The relationship between IOP and BMI among POAG was plotted in a scatter graph as shown in Figure 6. Out of 54 POAG patients, none was obese, 1 patient was underweight, and 24 patients had normal weight while 30 were overweight. There was no positive correlation between intraocular pressure and BMI among POAG subjects (p = 0.8, r value =0.3.

The relationship between IOP and refractive error (spherical equivalent) among non-glaucoma subjects are shown in Figure 7. There was no statistically significant relationship between IOP and refractive error (spherical equivalent) with r value =0.2 as was determined by linear regression analysis.

Figure 8 showed the relationship between IOP and refractive status (spherical equivalent) among POAG. Myopes as well as myopes who were presbyopic had mean IOP of 1–3 mmHg higher than other categories of refractive error. However, there was no statistically significant relationship between IOP and refractive error (spherical equivalent) with r value =0.5.

Discussion

This study showed a positive correlation between intraocular pressure and age. Intraocular pressure increased with increasing age in both on-glaucoma and glaucoma groups. While there was a positive statistically significant correlation between age and intraocular pressure in non-glaucoma subjects, such a significant positive correlation was not found in subjects with glaucoma. This contradicting finding between glaucoma and non-glaucoma subjects in this study could be a result of varying degrees of severity of structural damage seen in glaucoma subjects. However, the mean differences in intraocular pressure variations were not statistically significant among different age groups during sitting, supine flat, and supine with pillow positions in POAG

as well as non-glaucoma subjects. The findings from this study corroborated those from other studies.[6,7] Yassin and Al-Tamimi[7] reported no correlation between variations in intraocular pressure with age among non-glaucoma subjects of Saudi origin; although they found that the median overall intraocular pressure was slightly higher in females than the male participants.

This study also found no statistically significant difference in intraocular pressure variations with posture changes vis-a-vis the gender, BMI, and refractive status of the primary open- angle glaucoma and non-glaucomatous patients. However, logistic regression showed that the female patients may be 1.4 times more likely to have glaucoma more than their male counterparts but this was not statistically significant (95% C.I of 0.606–3.122). This implied that gender may not be a significant risk factor for having glaucoma. Similarly, Shikha *et al*.[15] reported that increasing age was associated with an increase in IOP but found no statistically significant difference in intraocular pressure between males and females even though the intraocular pressure was not measured in different positions as was done in this study.

The findings from this study were in agreement with the study by Pedro-Egbe[5] who reported no correlation between intraocular pressure and BMI. In contrast to the results of this study, some studies[4-6] have established a positive relationship between intraocular pressure, refractive error, and BMI. Huma *et al*.[4] investigated the relationship between intraocular pressure and BMI and found a positive statistically significant correlation between intraocular pressure and BMI for which they postulated that there may be excess intraorbital fat tissue leading to an increase in episcleral venous pressure. Roopa *et al*.[17] reported that intraocular pressure was significantly higher in high myopes greater than -6 D compared to other types of refractive error. These contradictory results may be a result of a smaller sample size and different study protocols used in the present study. In addition, the refractive errors of subjects used in this study were less than -6 D compared to the high myopes used in Roopa *et al*.'s study.

Conclusion

Intraocular pressure has positive correlation with increasing age in non-glaucomatous patients which did not occur in POAG. A statistically significant relationship was found between intraocular pressure and BMI in POAG but not in non-glaucomatous eyes. There was no positive relationship between gender, refractive status, and intraocular pressure in non-glaucoma and POAG subjects, respectively.

List of Abbreviations

Abbreviation	Definition
BMI	Body mass index
IOP	Intraocular pressure
POAG	Primary Open-Angle Glaucoma

Authors' contributions

The authors equally contributed to the conception, design of the study, definition of intellectual content, data collection, analysis and interpretation as well as manuscript writing. All the authors gave approval for the final submitted version of this article.

Ethical policy and institutional policy review board statement

The study was conducted under the guidelines of Declaration of Helsinki and approved by the Research and Ethical Committee (REC) of AEFUTHA with REC APPROVAL NUMBER 16/01/2017 – 09/03/2017.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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