

Correlation between Intraocular Pressure and Systolic Blood Pressure among different Body-Mass Index in Nigeria

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DOI: <https://doi.org/10.52403/ijrr.20261009>

ABSTRACT

Background of study: Elevated intraocular pressure, a key risk factor of ocular hypertension which results to most cases of glaucoma has been seen to be associated with systemic hypertension, with obesity also being a risk factor in systemic hypertension. However, limited studies in Nigeria has correlated intraocular pressure, systolic blood pressure and body mass index, hence, this study aims at determining the correlation between intraocular pressure and systolic blood pressure among different body mass indexes in Nigeria.

Methods: 146 subjects were selected for the research. The Perkins tonometer was used to measure the intraocular pressure, the automated sphygmomanometer was used to take the readings of the systolic blood pressure and the height and weight scale was used to measure the height and weight needed to calculate the body mass index.

Results: The mean intraocular pressure across participants was 16.23 ± 3.67 ; the mean systolic blood pressure value was 112.82 ± 8.95 ; and the mean body mass index value was 23.99 ± 4.54 . SPSS version 21 package was used to analyse the data. The Pearson Product Moment Correlation Coefficient used at 0.05 level of significance and 95% confidence interval

showed that there was only a significant positive correlation between intraocular pressure and systolic blood pressure ($P 0.002 < 0.005$) while there were no significant correlations between intraocular pressure and body mass index ($P 0.344 > 0.05$) and systolic blood pressure and body mass index ($P 0.722 > 0.05$).

Conclusion: It was therefore concluded from the study that intraocular pressure significantly correlates with systolic blood pressure among patients. Further research investigations in a wider geographical area and more so, consideration of older age range population were recommended.

Keywords: Body-mass Index, glaucoma, intraocular pressure, ocular hypertension, systolic blood pressure, systemic hypertension.

INTRODUCTION

Raised intraocular pressure (IOP) has been observed to present as one of the major risks affecting the optic nerve head which resultantly leads to optic neuropathy in diseases conditions like glaucoma [1]. Glaucoma has been defined to be a group of neurodegenerative diseases of the eye characterized by ganglion cell death, axonal fibre loss, damage to the optic nerve and eventually loss of visual field with elevated

IOP being the most modifiable risk factor [1]. Some other conditions associated with systemic and local factors have been reported as linked with the incidence and continuous increasing pressure of the eye which causes conditions of glaucoma. According to Yoshida et al., the intraocular pressure proportionately increases with an increase in systolic blood pressure and body mass index [2].

Considering the Nigerian population of over 223 million, report has shown that glaucoma contributes to about 8% of irreversible blindness across this population [3]. It is essential to assess co-morbid conditions such as hypertension and obesity when evaluating intraocular pressure in glaucoma conditions [3].

Although certain studies have shown a positive relationship between intraocular pressure and systolic blood pressure [4], others have argued for an association between body-mass index and ocular perfusion pressure which indirectly impacts intraocular pressure [5]. However, these studies have been non-African based with population ages ranging above 40 years. In this regard, considering the age group of 15 -64 years dominating the Nigerian population of about 55.3% [6], it is crucial to provide a Nigerian-based study that assesses this group of the population for these associations, hence, the study aims to establish the correlation between intraocular pressure and systolic blood pressure among different body mass indexes in Nigeria, taking into consideration the young adult population. This would moreover help to rule in or out risk factors of obesity and/or hypertension while managing young adults for ocular hypertension or glaucoma.

The condition of ocular hypertension can lead to Glaucoma; this is when visible damages to the fibres of the optic nerve head and loss in the visual field are being observed [5]. Glaucoma has remained the second-leading cause of global blindness epidemiology [7]. This blindness is as a result of the increased intraocular pressure beyond the normal range. The normal range

of intraocular pressure is 10 -20mmHg [7]. Hence with intraocular pressures above 21mmHg, significant damages can occur to the optic nerve leading to visual field loss, this condition occurs in cases of high-tension glaucoma [8]. This type of glaucoma often presents in conditions of closed-angle glaucoma [8]. However, certain studies also argue that some intraocular pressure readings within the normal range can also cause damages to the optic nerve head and loss in vision, this type of glaucoma is called the normal tension glaucoma which often is present in conditions of open angle [9].

For most glaucoma cases, there is always an associated co-existence of hypertension, especially among the obese population [10]. This suggests the need for a more comprehensive co-management of glaucoma alongside hypertension and obesity for a more positive outcome. Obesity on the other continuum is one most prevalent disorder that constitute a high risk of disease conditions such as diabetes type 2, stroke, hypertension, glaucoma, and cataract among others [10]. However, the primary focus of managing glaucoma remains the reduction of intraocular pressure as the only modifiable factor in addition to co-managing its comorbid conditions like hypertension and obesity [11]. Nevertheless, in other variants of glaucoma conditions such as normal tension glaucoma where the IOP is within the normal range, there is also observable occurrence and progressive optic nerve damage due to neurotoxicity, ocular vascular dysregulation, reduced ocular blood flow and systolic blood pressure changes [7, 11]. Damages of the retinal ganglion cells occurring from neurotoxicity is comparable to the neuronal damages caused by the Beta-amyloid and Tau protein tangling in cases of Alzheimers disease [12]. The same beta-amyloid proteins are similarly seen around the ganglion nerve layer in conditions of glaucoma incidence [11]. Most studies argue that this protein is responsible for the progressive damage seen in most normal tension glaucoma where

intraocular pressure is not the threatening factor [9, 11]. Despite this occurrence, intraocular pressure remains the controllable parameter in managing normal tension glaucoma as some studies still consider the pressure as high for such patients notwithstanding its value being within the normal range of pressure for the eye [13].

In evaluating conditions of glaucoma, certain factors are taken into consideration. These include measurement of the intraocular pressure using the different types of tonometers, corneal thickness using the pachymeter, and ocular blood flow using the ocular pulse amplitude device [14]. More so, the optic nerve head has to be evaluated with the cup-disc ratio well estimated using the ophthalmoscope [14]. For better comprehensive assessment and evaluation of the optic nerve head, the Optical Coherence Tomography (OCT) machine is used for the analysis of the thickness and arrangement of the fibres of the retina and ganglion layer [15]. Additionally, the use of the visual field analyzer is necessary to evaluate the extent of nerve damage along the retinal periphery [16], however this test may be less sensitive in detecting damages in conditions of early-stage glaucoma [17]. Several studies have explored the relationship between intraocular pressure and obesity-related through calculating an individual's body mass index measurement. It was found that there was significantly raised intraocular pressure among subjects with high body mass index values, hence a positive correlation of intraocular pressure with obesity [10]. Some other studies further considered gender and obesity (body mass index) as precursors of ocular hypertension with obesity being of more significant impact [18, 19].

A study in Beijing, evaluated the relationship between conditions of arterial blood pressure, intraocular pressure and body mass index of individuals. The study was a 5 year longitudinal study which showed a positive correlation between intraocular pressure (IOP) and the mean arterial blood pressure (mABP) as well as

with body mass index [20]. This suggests a physiological link existing between ocular pressure, body weight and the blood pressure, which forms the basis for the possible theory of the pathogenesis of optic neuropathy in glaucoma [21, 22]. With gender variations being considered, intraocular pressure tends to increase with consequent rise in systolic blood pressure and body mass index for both men and women [23]. This was shown in a study conducted in Japan; however, it was not clarified if the progression was equal for both men and women [2, 23]. Such trends show the importance of improvement upon obesity while managing patients with open-angle glaucoma as such patients are more likely to suffer from normal tension glaucoma.

With IOP remaining as the key risk factor in glaucoma cases, ensuring a mean reduction of about 0.0 ± 3.1 mmHg in intraocular pressure has been observed to improve outcome in the management of glaucoma [24]. In addition, reducing systemic blood pressure shows significant support in the prognosis since the normal process of ageing and decreased systemic blood pressure are associated with reduced intraocular pressure as shown in an Asian study [24]. It is thus crucial to maintain a stable blood pressure level and normal range of body mass index especially in cases of glaucoma management. With the normal range of blood pressure being around 120/80 mmHg (systole/diastole), values very high above this can impact the eye through consequent increase in the eye pressure [25]. The raised intraocular pressure has been suggested to cause damages to the retinal cells through proposed theories of mechanical and vascular mechanisms [26]. The mechanism supports elevated IOP in causing a decrease in the ocular perfusion pressure (OPP) beyond the auto regulatory capacity, which subsequently limits blood flow to the optic nerve head [26]. There is a reduced ocular flow of blood to the optic nerve head as a result of the decreased mean arterial blood pressure which leads to vascular stasis causing optic nerve damage

[26]. In such conditions, patients with low blood pressure become more at risk of developing optic neuropathy from low tension glaucoma [26].

Conversely, optic neuropathy often occurs in cases of high-tension glaucoma in patients with elevated mean arterial pressure resulting in attenuated blood vessels limiting blood flow to the optic nerve head [27]. George et al. [28] supported the view that an increase in intraocular pressure occurs more among people with higher body mass index tending towards obesity. The increased mass of adipose tissue may explain the reduced systemic blood flow among obese population which invariably translates to reduced blood flow within blood vessels in the eye, resulting in retinal neuronal damages in most individuals with low tension glaucoma [29]. Following the various researches that have tried to explain the relationship between IOP and systolic blood pressure in relations to body mass index, many often relate the association to ocular blood flow, however only a few have considered their relationships with increasing tension, and more of these studies were done among the Europeans and Asians [14]. The aim of this study is to replicate and establish the correlation between intraocular pressure and systolic blood pressure among different body mass indexes in the Nigerian population with the black gene, as non-white races have been reported with higher prevalence of glaucoma incidence.

MATERIALS & METHODS

A clinical correlational study was carried out using a quantitative research method. The study was done in the clinic at the Department of Optometry Teaching, Federal University of Technology, Owerri, Imo State, Nigeria. All subjects gave their consents to the participation of the in the study. More so, the Ethics Committee from School of Health faculty in the University gave their approval. 146 subjects sample size was used for the study. Data was obtained through the measurement of intraocular pressure using the Perkins tonometer, two pressure readings were taken and the average value was recorded. The measurement of systolic blood pressure was done using the automated sphygmomanometer and the measurement of body mass index was done by calculation using the formula $[\text{body weight (kg)}/\text{height (m}^2\text{)}]$. The body weight was measured using the weighing scale while the height was measured using the height scale.

Statistical Analysis

The version 21 of the Statistical Package for Social Sciences (SPSS) was used to analyze the collected data. Furthermore, the Pearson Product Moment Correlation Coefficient was used to evaluate the correlation between intraocular pressure, systolic blood pressure and body mass index at a 0.05 level of significance and 95% confidence interval

RESULTS

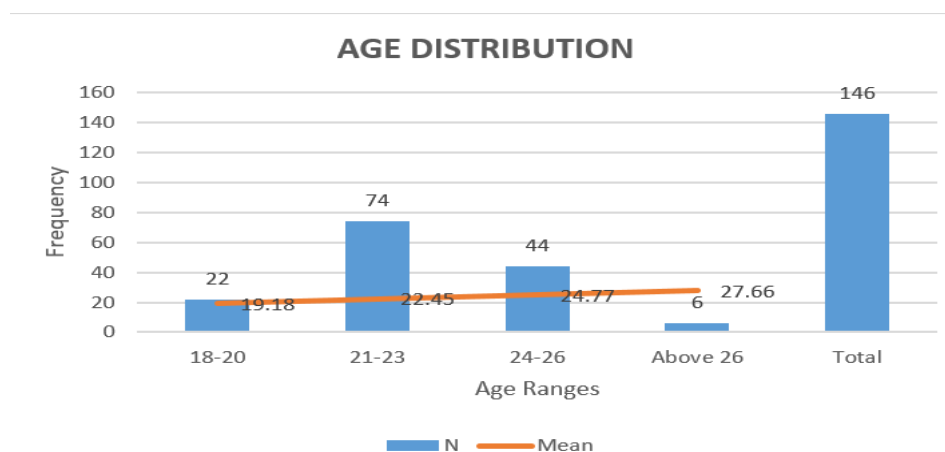


Figure 1 Age distribution of the subjects

The study consisted of a total of 146 adult males and females with an age range of 18 – 30 years and a mean age of 22.88 ± 3.67 years. The figure above showed that most of the participants of the study occurred

within the age range of 21-23 with a mean age of 21-23 years. This range was more predominant among the residents of the institution where the study was carried out.

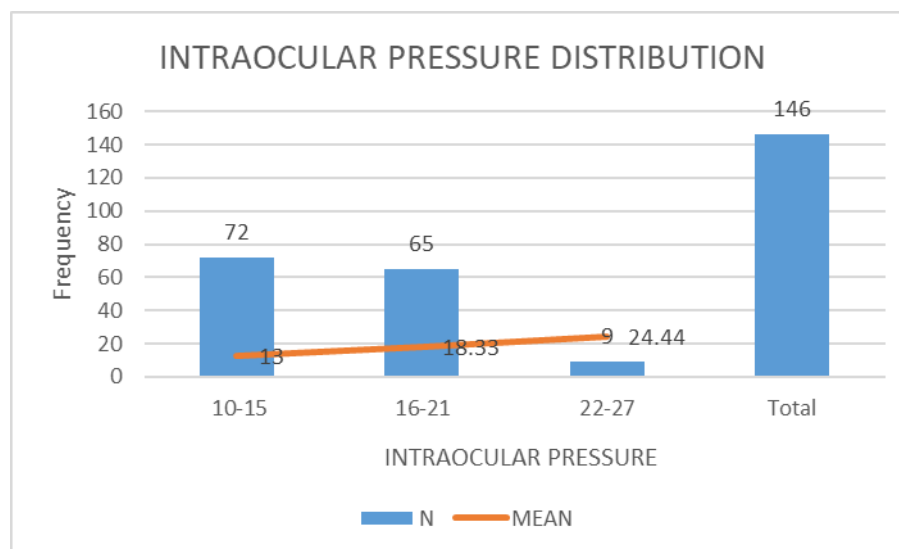


Figure2 Intraocular pressure (IOP) distribution of subjects

The figure above showed that there was a normal distribution of intraocular across the sample population with the intraocular pressure range of 10-15mmHg occurring more across 72 participants while the pressure range of 22-27 had the highest

mean value of 24.44. The mean intraocular pressure slightly increased from 13mmHg to 24.44mmHg. Only 9 participants showed intraocular pressure normal value of 21mmHg.

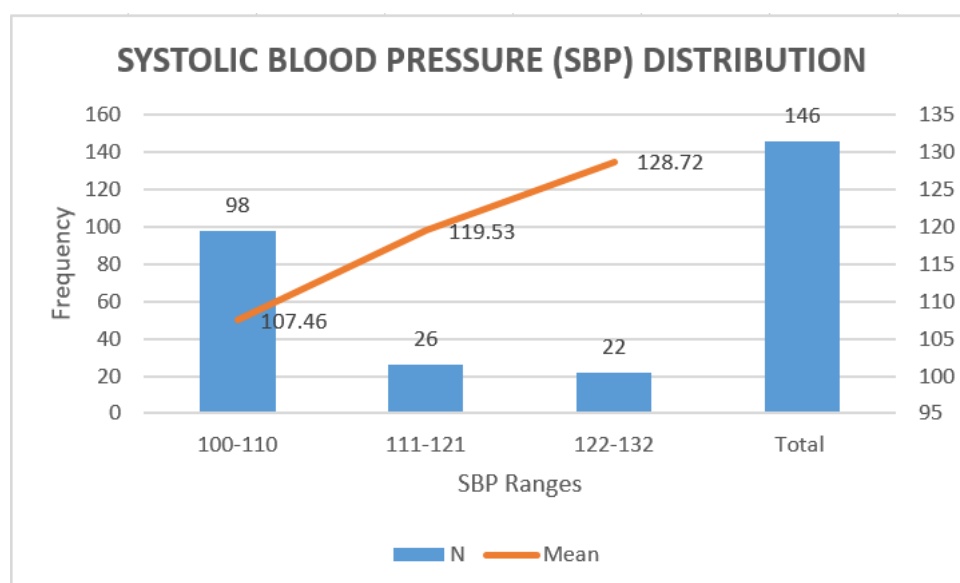


Figure 3 Systolic Blood Pressure (SBP) distribution of subjects

Similar to the IOP distribution, the systolic blood pressure also increased in mean value from 107.46 to 128.72mmHg. However, all

participants had their blood pressures within the normal range of 120mmHg systole. Only 22 participants showed a mean systole

value of 128.72mmHg slightly above range of systolic pressure. 120mmHg which is still within the normal

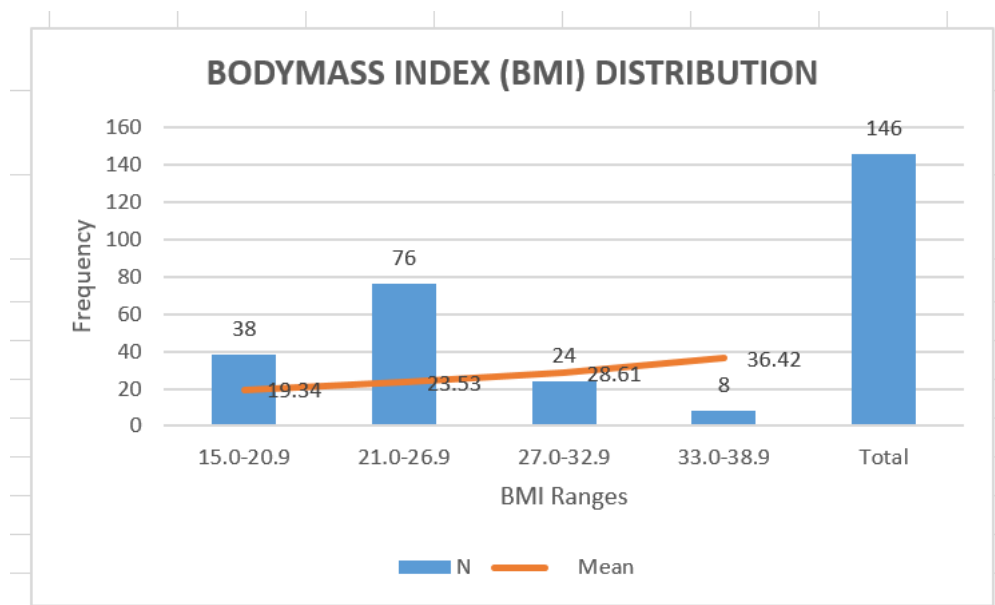


Figure 4 Body Mass Index (BMI) distribution of subjects

The figure showed that about 24 participants were overweight with 8 participants being obese. Most of the sample population were

however of normal weight. The mean body mass index slightly inclined from 19.34 to 36.42.

Table 1 Descriptive statistics of Age, Intraocular pressure, Systolic blood pressure and Body mass index of subjects

	N	Range	Min.	Max.	Mean	SD.
Age	146	10	18	28	22.88	3.67
IOP	146	17	10	27	16.23	3.67
SBP	146	30	100	130	112.82	8.95
BMI	146	21.70	16.80	38.50	23.99	4.54

IOP= Intraocular pressure, SBP= Systolic Blood Pressure, BMI = Body Mass Index.

Table 2 SPSS data analysis result showing P values for testing of correlation between Intraocular Pressure, Systolic Blood Pressure And Body Mass Index.

Variables	Pearson Correlation	P-value
IOP – SBP	0.362	0.002
BMI – IOP	0.112	0.344
BMI – SBP	0.042	0.722

Table 2 showed the data output of SPSS version 21, using the Pearson Product Moment Correlation Coefficient at 0.05 level of significance and 95% confidence interval. The P value was $0.002 < 0.05$ and a Pearson correlation value of 0.362. In this case, a statistically significant correlation was found between Intraocular pressure and systolic blood pressure. The table also showed a P value of $0.344 > 0.05$ and a Pearson correlation value of 0.112. In this

case, no significant correlation was found between body-mass index and intraocular pressure. The table also revealed a P value of $0.722 > 0.05$ and a Pearson correlation of 0.042 which showed no statistically significant correlation.

DISCUSSION

This study shows a strong positive correlation between systolic blood pressure and intraocular pressure, but no significant

association was found between systolic blood pressure and body mass index; and between body mass index and intraocular pressure. The study, more so, evaluated the risk factors for raised intraocular pressure in a Nigerian population using a clinical-based methodology, thus aiming at providing more information adding up to other related studies about intraocular pressure and factors which most likely would increase intraocular pressure such as age, blood pressure and obesity (due to increased ocular adipose tissue and reduced ocular blood flow and perfusion pressure) as related to the conditions of glaucoma [17].

Wang et al. [18] in a study examining the association of intraocular pressure, blood pressure and body mass index, found a significant association between intraocular pressure and blood pressure. In addition, Wang et al also revealed a strong association between body mass index and intraocular pressure in contrast to the findings of this study which found no significant correlation between intraocular pressure and body mass index, as well as no significant correlation between systolic blood pressure and body mass index. This could be have been observed in this study most likely due to the age range of the sample population of 18 – 30 years as compared to the age above 40 years used other studies, as the age range of this study would often tend to be healthier compared to the later age range. Noel et al [30] further supported the idea of the association of the older age population with increasing blood pressure. Johnny et al [31] however suggested a relationship between aging and risk of increased intraocular pressure. This would suggest a replication of this research in an older Nigerian population. Ahn et al. [10] further support the findings of Wang et al in observing a significant relationship between body mass index and intraocular pressure. Furthermore, the variations between their study findings and the findings of this study could be explained by the factor of insufficient body mass index data gathered from the study population herein, hence the

population may lack representative data for the obese population in Nigeria. Nevertheless, the correlation between intraocular pressure and systolic was found common across many studies.

Eytan et al. [23] findings showed a significant correlation between intraocular pressure and body-mass index which was also supported by the findings of George et al. [28] where body-mass index was strongly correlated with both intraocular pressure and systolic blood pressure having $P < 0.001$. These findings were contradictory with that of this study where intraocular pressure showed no correlation with body-mass index, this could most likely be a result of the age limit used for both studies by Eytan and George which extended upto 80 years for the study population since ageing could be associated with reduced intraocular pressure for those with low blood pressure (Chua et al. [24]), in contrast to the age limit for this study which was 28 years of maximum limit. The study of Eytan also showed a fairly large body size suggesting an effect of adipose tissue on ocular fluid flow dynamics that relates to the vascular dysregulation mechanism in glaucoma resulting from increased intraocular pressure. This was also shown in a study carried out among the obese population by Melek et al [32]. The study suggested that adipose tissue accumulation in cases of obesity causes decreased retrobulbar and choroidal blood flow, this would lead to an increased intraocular pressure predisposing the eyes to conditions of glaucoma. This was most likely the basis of their findings of a correlation between intraocular pressure and body-mass index as against the findings herein where the obese sample was fairly representative of the entirely population studied.

In this study, the mean intraocular pressure using the Perkins applanation tonometry was 16.23 ± 3.67 mmHg. This value is substantially within the range of findings of other related investigative studies using the Goldman applanation tonometry whose values were between 18.52 ± 4.46 mmHg

(Feng et al. [33]). This study showed a moderate positive Pearson correlation and a statistically significant relationship between intraocular pressure and systolic blood pressure given the positive correlation value of 0.362 and $P(0.002) < 0.05$. This suggests an association between intraocular pressure and systolic blood pressure, hence the possibility of predicting the increase of intraocular pressure following increased systolic blood in the Nigerian population.

In Karadag et al. [34] studies, the findings showed a statistically significant association between intraocular pressure and body mass index as against the findings of this study herein, which shows no statistically significant association between body-mass index and intraocular pressure. Nevertheless, the mean intraocular pressure of this study of 16.23 ± 3.67 mmHg is also found to be within the range of Karadag's study (mean intraocular pressure of 14.6 ± 1.8 mmHg). A good understanding of the correlation between intraocular pressure and body-mass index is still missing, however, studies have shown that obesity has contributed to excess intraorbital adipose tissue and increased blood viscosity leading to increased episcleral venous pressure and restricted aqueous flow resulting in raised intraocular pressure (Zhao et al. [35] and Zafar et al. [36]). However, some researchers have found results which contradict theirs and support this study herein in obtaining no significant association between body-mass index and intraocular pressure in their analysis (Geloneck et al. [37] and Albuquerque et al. [38]). In their study, there no significant association between systolic blood pressure and body mass index as the analysis showed a weak Pearson correlation value of 0.042 and a $P(0.722) > 0.05$.

Considering the number of eyes examined in this study, 9 eyes showed intraocular pressure above 21 mmHg, 65 eyes showed normal intraocular pressure and 72 showed fairly normal intraocular pressure with the female showing higher intraocular pressure than the males. The systolic blood pressure was fairly within the normal range with only

about 12 subjects falling within the suspected pre-hypertensive range and the males about 7 (9.59%) showing higher systolic blood pressure than the females 5(6.85%). Those within the normal body-mass index range were the highest and the underweight the least. The females showed a relatively higher body-mass index which agrees with the studies conducted by NCD Risk Factor Collaboration (NCD-RisC) [39] and Fahad et al. [40] in which NCD-RisC found higher weights in women than in men with the future prediction of over 18% increase in men and 21% increase in women respectively by 2025. The higher body-mass index shown among the female participants in this study have possibly explained the reason for the female participants showing relatively higher intraocular pressure than the male participants.

Concerning the findings of this study showing a positive association between systolic blood pressure and intraocular pressure, but no significant association between systolic blood pressure and body mass index; and body-mass index and intraocular pressure, it can therefore be deduced that even though there may be an association between the individual factors (systolic blood pressure, intraocular pressure and body-mass index) and glaucoma, their synergistic effect in an individual is not fully established, however, such co-morbidity should be managed side by side. The correlation lends more support to further investigations on the mechanical and vascular theory underpinning ocular hypertension, obesity and glaucoma conditions.

CONCLUSION

In conclusion, the study revealed that there was a significant correlation between intraocular pressure and systolic blood pressure, however, no significant correlation was found between body-mass index and intraocular pressure, and also between body-mass index and systolic blood pressure. Hence, this study on the Nigerian young adult population provides reproducible data

for further research investigations. This suggests that further studies should be conducted taking into consideration, a larger geographical area and older age range in Nigeria and other black countries. Therefore, this study on the Nigerian population provides data which may serve as a background for further researches on the relationship between body mass index, intraocular pressure and blood pressure across the black race.

Declaration by Authors

Acknowledgement: None

Source of Funding: None

Conflict of Interest: No conflicts of interest declared.

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How to cite this article: Macjohnson C. Onyeberechi, Anthony U. Megwas, Samuel U. Ojiaku. Correlation between intraocular pressure and systolic blood pressure among different body-mass index in Nigeria. *International Journal of Research and Review*. 2026; 13(10): 102-112. DOI: [10.52403/ijrr.20261009](https://doi.org/10.52403/ijrr.20261009)
