

## INTRAOCCULAR PRESSURE AND ITS CORRELATION WITH BODY MASS INDEX: A TERTIARY CARE HOSPITAL-BASED STUDY

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### ABSTRACT

**Background:** To assess the correlation between body mass index and intraocular pressure among patients in the age group of 20-70years attending the ophthalmology outpatient department. **Materials and Methods:** A cross-sectional study involving 160 subjects (64 males and 96 females) in the age group of 20 to 70 years who attended the ophthalmology outpatient department in Thrissur Govt Medical College during one year was conducted. The study subjects meeting the inclusion criteria (age group 20-70year, sex – males and females, IOP < 30 mm Hg, with written informed consent) were subjected to a detailed history. Height measured using a wall-mounted tape and weight with a calibrated weighing machine. BMI was calculated using Quetelet's index, i.e. Weight (in kg)/(height (in m)<sup>2</sup>.<sup>[2]</sup> Under strict aseptic precautions, a Goldmann applanation tonometer was used to measure intraocular pressure, recordings taken between 9 am to 11 am to avoid the effect of diurnal variation. The mean of the 3 successive readings was taken. **Result:** It was observed that the mean IOP of the overweight group was 13.73 ± 2.2mm of Hg. The mean IOP of the obese group was 16.61±2.6mm of Hg. A positive correlation was found, which was statistically significant p<0.001 on comparing right IOP with BMI, left IOP with BMI and mean IOP with BMI. **Conclusion:** Intraocular pressure (IOP) is found to be increased along with body mass index (BMI) in the study population. IOP is one of the risk factors for glaucoma, and measures for preventing the abnormally elevated BMI could be useful in prevention of development of raised intraocular pressure. Increased BMI is said to have strong genetic correlates, which necessitate further genetic studies. It is suggested that it will be worthwhile to screen for elevated BMI with coexisting raised intraocular pressure.

## INTRODUCTION

Intraocular pressure (IOP) is the pressure exerted over the coat of the eye ball by the intraocular fluids.<sup>[1]</sup> Glaucoma is a neurodegenerative disease of the optic nerve characterized by accelerated ganglion cell death, axonal loss, optic nerve damage, and eventually visual field loss. The regulation of the intraocular pressure is usually dependent upon certain factors such as rate of aqueous formation (F), rate of outflow(C) and episcleral venous pressure (Pv) and these factors are related to each other by Goldman equation i.e.  $IOP = F/C + Pv$ .<sup>[2]</sup>

The IOP is maintained by the equilibrium between aqueous production from ciliary body and its drainage via trabecular complex. The mean intraocular pressure varies between 10 and 21 mmHg (mean 16 ± 2.5).<sup>[3]</sup> Any abnormalities in the intra-

ocular pressure results in the dysfunction of the eye including defective vision. Glaucoma is the second leading cause of irreversible blindness after cataract. In India, approximately more than 12 million people are affected by the glaucoma alone.<sup>[4]</sup> This disease is usually classified into several categories with commonest and most epidemic one being primary open angle glaucoma (POAG). Primary open angle glaucoma can be induced due to multiple factors such as changes in IOP, BMI and diabetes etc.<sup>[5]</sup> The development and progression of open angle glaucoma has been linked with increase in IOP. IOP being a risk factor for glaucoma can be modified by contemporary intervention and if detected earlier and treated appropriately, its progression and blindness can be prevented.<sup>[6]</sup>

Body Mass Index (BMI) is a different term that measures the body fat which further depends upon

the weight and height of the person. According to Quetelets Index as per WHO, a body mass index (BMI) over 23 kg/m<sup>2</sup> is considered to be overweight, whereas a BMI of over 25 kg/m<sup>2</sup> is considered obese. Since overweight and obesity have become the global epidemics, the question arises whether there is a relationship between obesity and elevated intraocular pressure (IOP). It has been suggested that in obesity, increased orbital pressure due to excess intra orbital fat and increase in red cell count, hemoglobin and hematocrit, all of which increases the outflow resistance of episcleral veins and resulting in higher intra ocular pressure in obese subjects.<sup>[7]</sup>

There are very little data available regarding the relationship between BMI and IOP, more so in our setup, therefore, there is a need for the present study. The visual loss due to glaucoma is irreversible; therefore, early detection and timely treatment is crucial in its management. Since BMI is a modifiable risk factor, effective inexpensive lifestyle modifications that could favorably alter the risk of developing glaucoma would certainly be welcome.

## MATERIALS AND METHODS

**Research question:** Whether there is any correlation between intraocular pressure and body mass index.

### Hypothesis

Since overweight and obesity have become the global epidemics, the question arises whether there is a relationship between obesity and elevated intraocular pressure (IOP). It has been suggested that in obesity, increased orbital pressure due to excess intra orbital fat and increase in red cell count, hemoglobin and hematocrit, all of which increases the outflow resistance of episcleral veins and resulting in higher intra ocular pressure in obese subjects.

**Study setting:** Department of Ophthalmology, Government Medical College, Thrissur, Kerala, India.

**Study Design:** Cross sectional study

**Study population:** 160 patients attending the Ophthalmology Outpatient department who satisfied the inclusion criteria were considered for the study.

### Inclusion Criteria

1. Age group 20-70 years.
2. Sex – males and females.
3. IOP ≤ 30 mmHg
4. Subjects with the written informed consent

### Exclusion Criteria

Patients having:

1. Any chronic systemic or ocular diseases.
2. Any chronic systemic or ocular medication.
3. Any past ocular surgery.
4. Any past ocular trauma history.
5. Any congenital ocular diseases.

### Sample size calculation

$$n = \left[ \frac{Z_{1-\alpha/2}}{FZ(\rho_1) - FZ(\rho_0)} \right]^2 + Z_{1-\beta} + 3$$

Where,  $FZ(\rho_1) = \frac{1}{2} \ln \left( \frac{1 + \rho_1}{1 - \rho_1} \right)$

$$FZ(\rho_0) = \frac{1}{2} \ln \left( \frac{1 + \rho_0}{1 - \rho_0} \right)$$

$\rho_0$  = Population Correlation Coefficient was taken as 0.5

$\rho_1$  = Sample Correlation Coefficient got as 0.31 (Calculated from the study titled Comparison of body mass index and intraocular pressure done by Kumar A, Sharma N, Rathee. A, Pradhan N).<sup>[2]</sup>  $\alpha$  error taken as 5%  $1 - \beta$  power is 80% And so n = 153; will be taken as 160.

### Study Variables:

1. Dependent variable:
  - Body Mass Index
2. Independent variables:
  - Intraocular Pressure

**Data Collection:** The study was conducted only after the approval of the ethical Committee (B6-155/2019/MCTCR (6)). After obtaining informed consent the necessary history and clinical examination of subjects were done and the details were recorded in the Proforma.

### Clinical examination

#### 1. Estimation of Body Mass Index

In this study, anthropometric measurements of 160 subjects were recorded using standardized procedures.

#### Weight:

Body weight was measured using standardized weighing machine. Subjects were clothed in regular casual attire and barefooted.

#### Height:

Height of the subjects were measured using a wall-mounted tape with the subjects being barefooted and were made to stand erect, looking straight on a level ground with heels placed together and toes apart. Height was read to the nearest centimeters from the wall mount measuring tape.

#### Body mass index:

Body mass index of the subjects was calculated using the Quetelet's index ie. Weight (in Kg)/Height (in m).<sup>[2]</sup> Cut off points were chosen based on the World Health Organization (WHO) criteria for overweight and obesity. According to WHO, a BMI over 25 is considered overweight and over 30 is obese.

#### 2. Estimation of Intra Ocular Pressure:

##### Procedure

##### A. Setting up of Slit Lamp:

- Place the probe in the probe holder.
- Set the dial to the 15mmHg mark
- Place the tonometer on the guide plate. The guide plate should be placed with the tapered end towards the patient.
- Clean the chin rest and forehead bar in front of subject.
- Set the magnification to 10x.
- Adjust illumination to maximum.

- Flip to cobalt blue filter.
- Set illumination system to 45°, put on our left side for the patient's right eye.

### B. Subject set up:

- Explained procedure to the patient.
- Checked for any allergies.
- Made sure that the subject doesn't have any tight clothing around the neck.
- Adjusted patient's chair and slit lamp height.
- Instilled a drop of local anesthetic and fluorescein combination into the subject's eye.
- Asked the subject to place their chin on the chin rest; forehead against the bar.

### C. Goldmann procedure

- Asked the subject to fixate a distant object.
- Held the upper lid against the patient's eyebrow.
- Came close to the eye and briefly touch the cornea as soon as the mires appears, stopped nudging the tonometer forward.
- Adjusted the dial on the side of the tonometer to position the mires so that the inner edges of the mires are touching. Read off the number on the dial and multiplied by 10 to get the reading in mmHg.
- Noted the IOP measurement and the time measured.
- The mean of the 3 successive reading was taken for study.

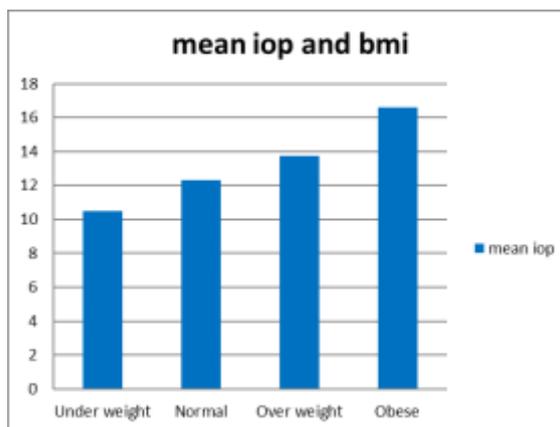
**Statistical Analysis:** Data collected were entered into Microsoft excel sheet and was analyzed using the latest version of SPSS software and the correlation between the two parameters were assessed using the Pearson's Correlation coefficient. p value less than 0.05 was considered significant.

## RESULTS

Total 160 patients (64 males and 96 females) were included in the study. The participants were divided into five categories according to age i.e. 20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-69 years. In the age group of 20-29 years there were 18 females and 3 males. In the age group of 30-39 years there were 26 females and 18 males. In the age group of 40-49 years there were 23 females and 19 males. In the age group of 50-59 years there were 25 females and 19 males. In the age group of 60-69 years there were 4 females and 5 males. [Table 1]

### Mean IOP according to age groups

The mean IOP of age group 19-29 year was 11.4 ± 1.6mm of Hg. The mean IOP for age group 30-39 years was 12.8 ± 2.4mm of Hg. The mean IOP of the age group 40-49 years was 14.29 ± 2.9mm of Hg. The mean IOP for the age group 50-59 years was 15.7 ± 2.8mm of Hg. The mean IOP for the age group 60-69 years was 17.1 ± 3.3 mm of Hg. [Table 2] The mean IOP of males was 14.20 ± 1.8mm of Hg and the mean IOP of females was 14.34 ± 2.2 mm of Hg.



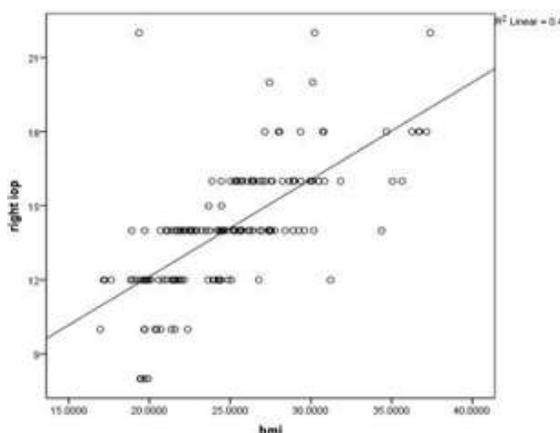
**Figure 1: Statistical comparison of IOP in groups according to BMI**

### Relationship of IOP with BMI

According to BMI the participants were divided into four groups. Underweight with BMI <18.5kg/m<sup>2</sup>, Normal weight with BMI 18.5 to 22.9kg/m<sup>2</sup>, overweight with BMI 23 to 24.9kg/m<sup>2</sup>, and obese with BMI >25 kg/m<sup>2</sup>.

The mean IOP of underweight group was 10.50 ± 2.4mm of Hg. The mean IOP of normal weight group was 12.32 ± 2.1mm of Hg. The mean IOP of overweight group was 13.73 ± 2.2mm of Hg. The mean IOP of obese group was 16.61 ± 2.6mm of Hg. [Figure 1]

The IOP increased with BMI among the four groups i.e. IOP was positively correlated with BMI. The Right IOP, left IOP and Mean IOP was compared with BMI with scatterplot (Figure 2, Figure 3, Figure 4) suggests a strong correlation. The correlation between right eye IOP, left eye IOP, and Mean IOP with BMI was calculated using Pearson's correlation coefficient [Figure 2,3,4]. A positive correlation was found which was statistically significant p < 0.001 on comparing right IOP with BMI, left IOP with BMI and mean IOP with BMI.



**Figure 2: Statistical comparison using scatter plot for IOP of Right eye versus BMI, p value < 0.01).**

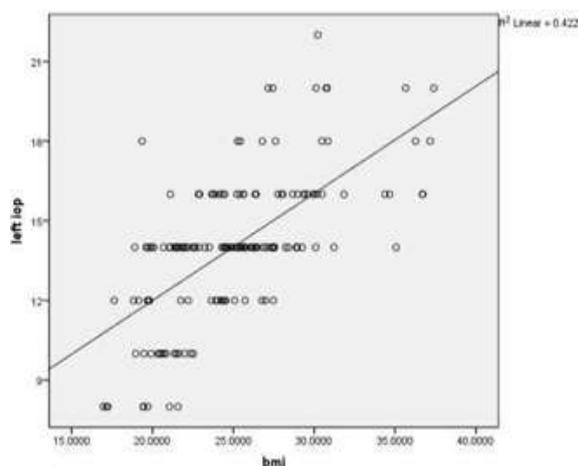


Figure 3: Statistical comparison using scatter plot for IOP of Left eye versus BMI, p value <0.01.

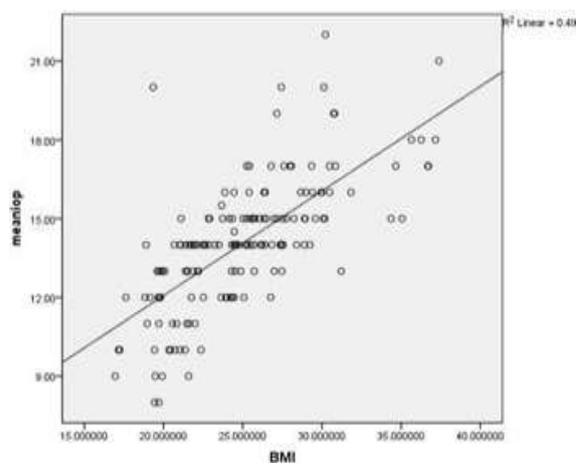


Figure 4: Statistical comparison using scatter plot for mean IOP and BMI

### Descriptive statistics

Mean age of study for female is 41.4 years and male is 45.41 years with standard deviation 11.493 for male and 10.493 for female. Mean height is 1.583 for female and 1.7 for male with standard deviation of .07 and .05. Mean weight of 63 for female and 71 for male with standard deviation of 11.89 and 11.707 respectively. Mean BMI of 25 for female and 24.6 for male with standard deviation of 4.68 and 3.93 respectively. Mean IOP of 13.73 for female and 14.54 for male with standard deviation of 2.7, 2.443 respectively. [Table 3]

Table 1: Distribution of study population based on age group

Age group	Male	Female
20 - 29	3	18
30-39	18	26
40-49	19	23
50-59	19	25
60-70	5	4

Table 2: IOP according to the age groups

Age Group	Mean IOP ± SD (mmHg)	Minimum IOP (mmHg)	Maximum IOP (mmHg)
20-29	11.4+1.6	08	16
30-39	12.8+2.4	10	22
40-49	14.29+2.9	10	20
50-59	15.7+2.8	12	22
60-69	17.1+3.3	10	22

(IOP: Intra Ocular Pressure, SD: Standard Deviation, mm Hg: millimeters of mercury)

Table 3: Descriptive statistics

Sex		N	Minimum	Maximum	Mean	Std. Deviation
F	Age	96	21	65	41.44	11.493
	Height	96	1.44	1.79	1.5843	.07074
	Weight	96	42	94	63.22	11.899
	BMI	96	16.9550	37.3932	25.216735	4.6885238
	Right IOP	96	8	22	13.83	2.574
	Left IOP	96	8	22	13.63	2.833
	SBP	96	104	148	132.65	10.059
	DBP	96	62	96	79.13	7.818
	Valid N (listwise)	96				
M	Age	64	26	65	45.41	10.463
	Height	64	1.56	1.81	1.7002	.05644
	Weight	64	51	99	71.25	11.707
	BMI	64	17.2390	34.6627	24.651365	3.9310496
	Right IOP	64	8	20	14.50	2.410
	Left IOP	64	8	20	14.59	2.486

	SBP	64	122	148	137.22	6.879
	DBP	64	62	94	80.12	7.188
	Valid N (listwise)	64				

(F: Female, M: Male, BMI: Body Mass Index, IOP: Intraocular Pressure, std: Standard)

## DISCUSSION

In the present study, a total of 160 subjects (64 males and 96 females) within the specified age group of 20-70 years were included through random selection from the ophthalmology OPD of the medical college hospital. The participants were divided into five categories according to age ie.20-29 years, 30-39 years, 40-49 years, 50-59 years, 60-70 years. In the age group of 20-29 years there were 18 females and 3 males. In the age group of 30-39 years there were 26 females and 18 males. In the age group of 40-49 years there were 23 females and 19 males. In the age group of 50-59 years there were 25 females and 19males. In the age group of 60-69 years there were 4 females and 5 males. [Table 1]

Mean of IOP measured using Goldmann Applanation Tonometer, are shown in [Table 2]. The Mean IOP of males was 14.20 mm of Hg and the mean IOP of females was 14.32 mm of Hg. The normal value of IOP varies between 10 and 21 mm of Hg (mean 16+/-2.5).

BMI measured using the formula  $BMI = \text{weight in kg} / \text{height in m}^2$ . The normal value of BMI is 18.5 to 24.9 kg/m<sup>2</sup>. Pearson's correlation coefficient was done to find out whether there is a correlation between IOP and BMI.

The mean IOP of Underweight group was 10.50 mm of Hg, mean IOP of normal weight group was 12.32 mm of Hg, mean IOP of overweight group was 13.73 mm of Hg, mean IOP of obese group was 16.61 mm of Hg. The results show that IOP is directly correlated with raised BMI [Figure 4]. Similar results were seen in a study by Cohen et al,<sup>[8]</sup> wherein the authors found a significant gradual increase in IOP for increase in BMI category.

The possible cause of elevated BMI resulting in raised IOP has been elucidated by several possible pathophysiological mechanisms. One prominent theory is that obesity induces changes in plasma levels of leptin, which is secreted by adipose tissue, and ghrelin, both of which play an important role in the pathophysiological mechanisms linking obesity with glaucoma.<sup>[9-11]</sup> The results of the present study are in concordance with this theory.

In further support of this theory, studies have found that many individuals with obesity have hyperleptinemia.<sup>[9]</sup> In accordance with this finding, recent research has found that oxidative stress in obese individuals may increase as a result of hyperleptinemia, which may trigger pathological changes leading to elevated IOP.<sup>[12,13]</sup>

A second theory proposes that vascular and mechanical factors associated with the etiology of glaucoma may both be rooted in obesity related changes.<sup>[14,15]</sup> An increase in intra orbital adipose tissue decrease the episcleral aqueous outflow, thus

leading to an increase in IOP.<sup>[15]</sup> This is an added factor to the present findings.

A third theory, that obesity has a significant effect on the human microcirculation, proposes the existence of a relationship between BMI and nitric oxide (NO), an endothelium-derived vasodilator molecule. As NO acts as an important mediator regulating ocular blood flow, it could positively affect IOP regulation as well. There are several studies suggesting the hereditary nature of BMI. Eleven monogenic forms of obesity are now recognized. These include disruptions in leptin and melanocortin-4 receptor gene, which are vital in energy homeostasis by Heymsfield et.al.<sup>[16]</sup> However, in the present study genetic analysis has not been done. Hence this requires further evaluation with large population using genetic screening tools. Since IOP is probably one of the most important risk factors for glaucoma in general population, screening and monitoring of blood pressure along with BMI to assess obesity status could help in assessing the potential risk of developing glaucoma in the population. The above findings are also suggestive of the need for extensive screening and risk assessment based on wider population studies.

In the NATIONAL PROGRAMME FOR CONTROL OF BLINDNESS AND VISUAL IMPAIRMENT OF GOVT OF INDIA, the following parameters are included for early detection and prevention of glaucoma:

- It provides establishment of Multipurpose District Mobile Ophthalmic Units at the District Hospitals of States/UTs in order to extend eye-care services to every nook and corner of the nation.
- Ensures that state-level hospitals and medical colleges across the nation establish Super specialty clinics for all important eye illnesses, such as diabetic retinopathy, glaucoma, retinopathy of prematurity, etc.
- Linking tele-ophthalmology centers at PHC / Vision centers with super specialty eye hospitals will ensure that eye disorders are diagnosed and treated as effectively as possible, especially in challenging locations like steep terrain.

This being a national programme of wide reach, and imbuing the spirit of the programme it is suggested the screening for raised IOP and BMI may also be incorporated into this. The AASHA workers (who have direct interactions with the common people at village level) may be trained for the screening process. How ever this requires policy decisions at national level.

It may be noted that glaucoma can occur in individuals with normal IOP. It may not develop in some individuals with increased IOP. Gasser et al,<sup>[17]</sup> evaluated the direct effect of BMI on glaucoma and could not show such association. In a study by

Flammer et al,<sup>[18]</sup> it was emphasized that the element of vascular dysregulation rather than vascular atherosclerosis, in which BMI is a cofactor, was the major risk factor for glaucoma. Vascular dysregulation may lead to local vasospasms and disturbed autoregulation of blood flow. This pathophysiologic pathway can explain why even though BMI could increase the risk of raised IOP, it does not necessarily increase the risk of glaucoma. This finding correlates well with the findings of the present study.

#### Limitations

1. CCT (central corneal thickness) is one of the most important factor affecting IOP measurements and correlation between CCT and IOP is well established. CCT is also associated with BMI, high BMI will have high CCT values. Thicker CCT will show falsely higher IOP reading with applanation tonometry. So adults with high BMI may show falsely higher IOP readings. Considering the role of corneal biomechanics in measurement of IOP, assessment of correlation of BMI with CCT may be clinically more useful to study the exact relationship between IOP and BMI.
2. A small sample size is definitely another limitation of this study. Including a large sample size may help to generalize our study results.

#### Strength

1. Multiple contributory factors like Diabetes Mellitus, Hypertension, Dyslipidemia etc. for increasing IOP were excluded.
2. To our knowledge no studies have been conducted in our population that focused on IOP and BMI.
3. IOP is the only modifiable risk factor for control of glaucoma. BMI due to its correlation to IOP may be considered as yet another modifiable risk factor during workup of glaucoma patients.
4. Control of obesity seems to be very useful for control of IOP. So we can advise patients to engage in healthy exercises to keep one's body weight under check for better control of IOP in addition to medical therapy. Have used Gold Standard instrument (Goldmann Applanation Tonometer) for measuring IOP.

## CONCLUSION

#### In the present study

- Intraocular pressure is found to be increased along with body mass index in the study population.
- This was found to be increased across different age groups
- Obesity is possibly an independent risk factor for increasing IOP in both men and women of age group 20 to 70 years with no comorbidities.

- Increase in BMI is positively correlated with increase in IOP
- Raised IOP is one of the risk factors for glaucoma
- Hence measures for prevention of abnormally elevated BMI could be useful in prevention of development of raised intraocular pressure.
- Elevated BMI is said to have strong genetic correlates, which necessitate further genetic studies.
- Hence, it is suggested in the light of the above observations that, it will be worthwhile to screen for elevated BMI and co existing raised intraocular pressure which is the major risk factor in high IOP glaucoma.

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