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Role of body mass index and blood pressure on intraocular pressure in elderly population

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ABSTRACT

Aims: To identify the role of body mass index (BMI) and Blood pressure (BP) on Intraocular pressure (IOP) in elder population.**Materials and Methods:** Totally 50 elderly individuals without any systemic diseases were included and IOP was measured by tonometer. Total subjects divided into 3 groups based on BMI as: Group1 with BMI \geq 25 and Group 2 with BMI \leq 30. Mean and standard deviation of IOP, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were statistically analysed.**Results:** Out of a total of 50 Subjects, 23 (46%) subjects had normal weight, 15(30%) subjects were overweight and 10 (20%) subjects were obese. Mean age of 56.5 \pm 9.5 and 56.2 \pm 9.4 years in male and females (p=145). Mean BMI of 25.8 \pm 3.9 and 26.4 \pm 4.2 kg/m² in male and females. SBP of 135.8 \pm 20.4 and 128.4 \pm 21.5 mmHg in male and female (p=0.02). Mean DBP of 78.5 \pm 10.5 and 81.4 \pm 10.5 mmHg in male and female (p=0.04). Mean CCT of right eye was 515.5 \pm 31.2 and 510.2 \pm 28.8 μ m in male and females respectively (p=0.03). Mean IOP of right eye was 15.6 \pm 2.2 and 14.9 \pm 2 mm Hg in male and females respectively (p=0.25). Mean CCT of left eye was 520.4 \pm 27.5 and 515.2 \pm 28.5 μ m in male and females respectively (p=0.03). Mean IOP of left eye was 15.1 \pm 2.2 and 14.9 \pm 2.1 mm Hg in male and females respectively (p=0.12). The mean IOP of right eye is highest in the overweight and obese age groups. The mean SBP is highest in the overweight and obese age groups. The mean DBP is highest in the overweight and obese age group. Hence, increase in BMI results in non-significant increase in IOP and BP as age increases in normal BMI subjects. For obese Subjects, there was positive correlation between the BMI, age, IOP, SBP and DBP. Increase in BMI resulted in increase in IOP, increase in systolic and diastolic blood pressure respectively with increase in age.**Conclusion:** Results showed positive correlation relationship between BMI and intra-ocular pressure, BMI and blood pressure and BMI and age in obese population. It indicate that subjects with higher BMI have lower ocular blood flow. Results suggest that IOP increases with increasing age and increasing BMI. Periodic checking of IOP in elderly and overweight individuals can play an important role in reducing the morbidity due to glaucoma.© This is an open access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1. Introduction

Overweight and obesity increase the risk of elevated blood pressure, an increase in BMI is significantly associated with increased systolic blood pressure (SBP) and diastolic blood pressure (DBP) therefore as BMI increases, there is an increased risk of hypertension. Obesity increases

blood viscosity and episcleral venous pressure, and damage aqueous outflow facility. Cataract, glaucoma, diabetic retinopathy, and macular degeneration eye disorders have relation to obesity.¹⁻⁵ Besides the increased IOP, there are several other factors associated with glaucoma progression such as neurotoxicity, reduced ocular blood flow, ocular vascular dysregulation and changes in systemic blood pressure.⁶⁻¹⁰

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Various studies examined the relationship of IOP or ocular hypertension to BMI. In the Beaver Dam Eye Study, higher IOP was associated with higher BMI.¹¹ Some literature concluded that while evidence exists regarding the association between higher IOP and higher BMI, findings regarding the relationship between glaucomatous optic neuropathy and obesity are conflicting.¹² Tina et al.¹³ study on the relationship of intraocular pressure with age, systolic blood pressure, and central corneal thickness and found that IOP increased with age and systolic BP had a positive association with IOP.

IOP has been found to be associated with systemic blood pressure levels in various population based studies. Klein et al.¹⁴ showed that there were significant direct correlations between changes in systemic blood pressures and changes in intraocular pressure.

It is unclear whether higher BMI may increase or decrease the likelihood of having glaucoma and what confounding factors play a role. Hence the purpose of this study is to investigate the role of body mass index (BMI) and Blood pressure on intraocular pressure (IOP) in elderly population aged more than 50 years.

2. Materials and Methods

This study was an observational, cross-sectional study conducted in the Department of Ophthalmology, Narayana Medical College and Hospital, Nellore, Andhra Pradesh, India. Patient on medication of any form were also not included in the study. The subjects were divided into 2 categories according to gender i.e. male and female.

Exclusion criteria included history of Severe myopia (>6D), diseases of the cornea, presence of renal, neurological, mental or metabolic disorders and genetic syndromes.

The subjects were divided into 2 categories according to gender i.e. male and female.

2.1. Measurement of blood pressure and body mass index

Height and weight were measured with subjects wearing light clothes without shoes in the standing position using an automatic height and weight tester. Height measured to closest 0.5 cm and weight was measured to 0.5 kg. BMI of each Subject was categorized using World Health Organization's categorization which is the same for all ages and for both men and women. (Normal weight BMI: 18.5-24.9 kg/m²; Overweight BMI: 25.0-29.9 kg/m²; and Obese BMI: \geq 30.0 kg/m²).

Blood pressure of each Subject was measured after a 5-minute rest and recorded by the mean value of three successive readings taken at 60-second intervals, with sphygmomanometer and Sprague stethoscope between 9 and 11 a.m.

2.2. Measurement of intraocular pressure and CCT

Slit lamp mounted Goldmann applanation tonometer-Haag-Streit model used to measure the IOP recording by sitting position. IOP was measured in both eyes by non-contact tonometer prior to pupil dilation. The data was measured as the mean of 3 continuous measurements. Topical 0.5% paracaine used for anaesthesia of ocular surface.

Central corneal thickness measured with a specular-type CCT apparatus and the median of three measurements was used; CCT measurements were performed prior to any other eye examinations. After confirming fixation, CCT was measured in the right eye first and in the left eye immediately afterwards. The time interval between the two measurements was <15 seconds.

Statistical analysis done using SPSS version 18.0. Student t-test used to compare the groups according to the gender and WHR. ANOVA test used to compare the IOP in the groups according to age. Linear regression test was used to determine change in IOP per unit change in age and Waist-hip ratio. The p-value of <0.05 was considered significant in all the tests.

3. Results

3.1. Demographics

Mean age of 56.5 \pm 9.5 and 56.2 \pm 9.4 years in male and females respectively were observed (chi-square, p=145). Mean BMI was 25.8 \pm 3.9 kg/m² and 26.4 \pm 4.2 kg/m² in male and females respectively. Mean systolic BP was 135.8 \pm 20.4 mmHg and 128.4 \pm 21.5 mmHg in male and female respectively (p=0.02). Mean diastolic BP was 78.5 \pm 10.5 mmHg and 81.4 \pm 10.5 mmHg in male and female respectively (p=0.04). Mean CCT of right eye was 515.5 \pm 31.2 and 510.2 \pm 28.8 μ m in male and females respectively (p=0.03). Mean IOP of right eye was 15.6 \pm 2.2 and 14.9 \pm 2 mm Hg in male and females respectively (p=0.25). Mean CCT of left eye was 520.4 \pm 27.5 and 515.2 \pm 28.5 μ m in male and females respectively (p=0.03). Mean IOP of left eye was 15.1 \pm 2.2 and 14.9 \pm 2.1 mm Hg in male and females respectively (p=0.12) (Table 1).

Out of a total of 50 Subjects, 23 (46%) subjects had normal weight, 15(30%) subjects were overweight and 10 (20%) subjects were obese.

The mean IOP of right eye is higher in overweight and obese subjects (Table 2). The mean IOP of right eye is higher in the overweight and obese groups (Table 3). The mean SBP is higher in the overweight and obese subjects (Table 4). The mean DBP is higher in overweight and obese groups (Table 5).

3.2. Correlation analysis

Correlation coefficients between IOP and age, BMI, systolic BP, refraction, corneal radius and CCT in of right and

Table 1: Demographic characteristics (mean \pm SD)

	Male	Female	p-value
No. of subjects	28	22	
Age (year)	56.5 \pm 9.5	56.2 \pm 9.4	0.145
Body mass index (kg/m ²)	25.8 \pm 3.9	26.4 \pm 4.2	0.04
Systolic blood pressure (mmHg)	135.8 \pm 20.4	128.4 \pm 21.5	0.02
Diastolic blood pressure (mmHg)	78.5 \pm 10.5	81.4 \pm 10.5	0.04
Right eye			
Central corneal thickness (μ m)	515.5 \pm 31.2	510.2 \pm 28.8	0.03
Intraocular pressure (mmHg)	15.6 \pm 2.2	14.9 \pm 2.0	0.25
Left eye			
Central corneal thickness (μ m)	520.4 \pm 27.5	515.2 \pm 28.5	0.03
Intraocular pressure (mmHg)	15.1 \pm 2.2	14.9 \pm 2.1	0.12

Table 2: Mean IOP for categories of BMI according to their age groups. The mean IOP of right eye is highest in the overweight and obese age groups

	Mean intraocular pressure of right eye \pm SD (mmHg)		
	50-60 YR	60-70 YR	>70 YR
Normal Weight (BMI 18.5-24.9)	14.65 \pm 2.72	17.07 \pm 2.3	17.93 \pm 1.20
Overweight (BMI 25.0-29.9)	15.58 \pm 2.93	17.21 \pm 3.09	18.80 \pm 1.19
Obese (BMI>30.)	15.59 \pm 2.77	18.74 \pm 1.63	19.91 \pm 0.36

Table 3: Mean IOP for categories of BMI according to their age groups. The mean IOP of right eye is highest in the overweight and obese age groups

	Mean intraocular pressure of LEFT eye \pm SD (mmHg)		
	50-60 YR	60-70 YR	>70 YR
Normal Weight (BMI 18.5-24.9)	14.58 \pm 2.4	17.77 \pm 1.52	18.01 \pm 1.27
Overweight (BMI 25.0-29.9)	15.83 \pm 2.58	18.19 \pm 1.75	18.75 \pm 1.19
Obese (BMI>30.)	15.89 \pm 2.63	18.93 \pm 2.26	19.44 \pm 0.85

Table 4: Mean SBP for the categories of BMI according to their age groups. The mean SBP is highest in the overweight and obese age groups

	Mean SYSTOLIC blood pressure \pm SD (mmHg)		
	50-60 YR	60-70 YR	>70 YR
Normal Weight (BMI 18.5-24.9)	116.9 \pm 10.	119.3 \pm 13.5	121.4 \pm 13.8
Overweight (BMI 25.0-29.9)	118.8 \pm 19.9	122.1 \pm 18.5	126.0 \pm 25.2
Obese (BMI>30.)	120.7 \pm 14.2	129.5 \pm 14.3	134.5 \pm 20.5

Table 5: Mean DBP for the categories of BMI according to their age groups. The mean DBP is highest in the overweight and obese age group

	Mean diastolic blood pressure \pm SD (mmHg)		
	50-60 Yr	60-70 Yr	>70 Yr
Normal Weight (BMI 18.5-24.9)	74.9 \pm 11.0	75.3 \pm 9.6	76.7 \pm 11.4
Overweight (BMI 25.0-29.9)	77.5 \pm 6.9	79.3 \pm 10.7	81.5 \pm 11.3
Obese (BMI>30)	78.5 \pm 8.3	81.8 \pm 8.3	82.4 \pm 13.1

Table 6: Pearson correlation of the relationship between BMI, age, IOP, SBP and DBP of normal, overweight, and obese subjects

		BMI	Age	Right Eye IOP	Left Eye IOP	SBP	DBP
Normal Weight	Pearson Correlation	1	0.050	0.0120	0.0330	0.1080	0.076
	Sig. (2-tailed)		0.578	0.890	0.709	0.226	0.391
Over weight	Pearson Correlation	1	0.266**	0.214**	0.223**	0.229**	0.236**
	Sig. (2-tailed)		0.010	0.000	0.000	0.005	0.003
Obese	Pearson Correlation	1	0.342**	0.268**	0.289**	0.245**	0.256**
	Sig. (2-tailed)		0.000	0.000	0.000	0.000	0.000

** . Correlation is significant at the 0.01 level (2-tailed)

left eyes were analysed (Table 6). IOP shows positive correlations with BMI, BP and CCT, age and refraction.

For normal weight subjects (BMI 18.5-24.9), there was weak positive correlation between the BMI and age, IOP, SBP and DBP without statistically significant. Therefore an increase in BMI resulted in a non-significant increase in IOP and blood pressure as age increases in the normal BMI subjects.

For overweight subjects (BMI 25.0-29.9), there was positive correlation between body mass index, age, IOP, SBP and DBP. Increase in BMI resulted in increase in IOP, increase in systolic and diastolic blood pressure respectively, with increase in age.

For the obese Subjects (BMI>30), there was positive correlation between the body mass index, age, IOP, SBP and DBP. Increase in BMI resulted in increase in IOP, increase in systolic and diastolic blood pressure respectively with increase in age.

4. Discussion

This study showed that there are significant positive correlations between BMI, age, IOP and BP in the overweight and obese population. Results suggest that IOP increases when age progress and higher BMI. In this study, there was no significant difference in IOP gender wise. The mean IOP of males was higher, the difference was statistically non-significant. Some reports show that higher IOP among females while others report higher IOP in males. Difference in gender wise IOP may be due to hormonal factors, environmental conditions.¹⁵ A study in Central Indian population reported no statistical difference between the IOP levels in males and females.¹⁶ Study by Shiose et al., reported a higher mean IOP of 12.0 mm of Hg in males as compared to 11.5 mm of Hg in females by non-contact tonometry without statistical significant.¹⁷ The results of our study conclude that the gender has no significant correlation with IOP, while increasing age is a risk factor for raised IOP which leads to glaucoma.

Blood pressure has been found to increase with age in most populations, and intraocular pressure (IOP) has been found to be associated with systemic blood pressure levels

in population based studies.¹⁷⁻²¹

BMI increased with increasing age, the mean diastolic and systolic blood pressure increased, and these became statistically significant in the overweight and obese subjects.

A study on South Indian population results that the prevalence of glaucoma increased with age.⁶ In our study, we noted higher SBP, DBP, BMI and CCT and IOP in subjects with increasing age. The increasing trend of IOP with age could be because of age related changes in the trabecular meshwork or could be indirectly attributed to change in systemic health parameters like high systemic arterial blood pressure and BMI.¹⁸⁻²⁰ With increasing age, there occurs accumulation of wide spacing collagen which decreases the aqueous outflow facility. With ageing, the crystalline lens increases in thickness and density in turn leads to compression of the schlemm's canal and as a result obstruction of aqueous outflow. Rise in systemic blood pressure can be attributed to the rise in IOP with age.²¹⁻²³

In our study, increase in BMI in both the sexes is associated with increase in IOP i.e., a positive correlation of IOP is seen with BMI. Previous reports examined the effect of BMI on IOP and found a positive correlation between the two. Positive correlation between BMI and IOP has been recorded in Central and South Indian population.^{18,20,23}

Systemic blood pressure in this study was also significantly associated with high IOP in the right eye. Increase in SBP can be considered as an indicator of high IOP. Increase in systemic blood pressure probably can affect changes in IOP by sympathetic tone, atherosclerotic changes and high level of renin-angiotensin, indirectly. All these factors can affect the pressure of epi-scleral venous which regulate the watery humor through the Schlemm's canal. Then it leads to effects on intraocular pressure. Increased blood pressure has been thought to elevate IOP by not only elevating ciliary artery pressure and consequently inducing an increase in production of aqueous humor, but also increased serum corticoids and sympathetic tone.

The physiological basis for the correlation between raised IOP and obesity may be due to accumulation of fat in the periorbital space leading to raised episcleral venous pressure.^{23,24} Higher incidence of hypertension in obese

subjects could also be indirectly linked to higher IOP in them.

Findings from this study indicated that systolic blood pressure and systemic blood pressure effectively and positively, can be associated with high intraocular pressure. Changes were not affected by age.

In conclusion, overweight and obesity are independent risk factors for increase in blood pressure and intraocular pressure which may result in systemic hypertension and glaucoma in the aging population.

5. Conclusion

Study demonstrates that systolic blood pressure effectively associated with high intraocular pressure. IOP increases with increasing age and increasing BMI. Periodic checking of IOP in elderly and overweight individuals can play an important role in reducing the morbidity due to glaucoma. Life style modification like exercise and dietary alteration can be an important preventive measure.

6. Conflict of interest

The authors declare that there is no conflict of interest.

7. Sources of Funding

None.

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