International Journal of Community Medicine and Public Health
Srivastava N et al. Int J Community Med Public Health. 2023 Oct;10(10):3741-3746
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20233109

Original Research Article

The relationship between intraocular pressure and random blood glucose levels with open angle glaucoma

Namrata Srivastava[1], Y. S. Yadav[2]*, Prashant Kumar[3]

[1]Department of Optometry, Era University of Allied Health Science, Lucknow, Uttar Pradesh, India
[2]Department of Ophthalmology, GSVM Medical College, Kanpur, Uttar Pradesh, India
[3]Department of Optometry Himalayan University, Itanagar, Arunachal Pradesh, India

Received: 21 July 2023
Revised: 01 September 2023
Accepted: 08 September 2023

***Correspondence:**
Dr. Y. S. Yadav,
E-mail: optometry.cnb@gmail.com

ABSTRACT

Background: Primary open-angle glaucoma (POAG) is a multifactorial chronic optic neuropathy, characterized by progressive loss of retinal ganglion cells (RGC), leading to structural damage to the optic nerve head (ONH), retinal nerve fibre layer (RNFL), with visual field defects. This study was carried out at the department of optometry GSVM Medical College, Kanpur, UP from December 2015 to September 2017. Objectives were determination of the relationship between intraocular pressure and blood glucose levels in patients with primary open-angle glaucoma.
Methods: A total of 74 subjects, 28 males and 46 females were used for the study. The Accu-Chek glucometer was used to measure the random blood glucose level and the intraocular pressure was measured using the Perkins applanation tonometer.
Results: The mean intraocular pressure was 16.57±3.97 while the mean random blood glucose level was 168.43±108.48. Analysis of the SPSS version 23 data using the Pearson product-moment correlation coefficient at a significance level of 0.05 and a 95% confidence interval revealed no correlation between IOP and random blood glucose (p and gt; 0.05). People with primary open-angle glaucoma are advised to have their blood sugar levels monitored frequently.
Conclusions: This study showed that there was no significant correlation between intraocular pressure and random blood glucose levels in patients with primary open-angle glaucoma. This would suggest that diabetics should be monitored regularly for intraocular pressure to detect an early onset of glaucoma.

Keywords: Diabetes mellitus, Intraocular pressure, Multifactorial chronic optic neuropathy, Primary open angle glaucoma, Random blood glucose

INTRODUCTION

It is characterized by optic neuropathy, including glaucoma, chronic axonal damage and retinal nerve cell (RGC) damage.[1] It affects the eye and is associated with increased intraocular pressure (IOP), which is the only risk factor for glaucoma treatment.[2] If left untreated, patients may develop visual impairment and even blindness. It is the number one cause of blindness loss and the second cause of blindness worldwide.[3,4] Glaucoma involves cell loss of retinal ganglion cells (RGCs) and is characteristic of neural retinal organization in the optic nerve head (ONH), along with visual disturbances (VF).[5,6] This eye disease is the leading cause of blindness worldwide and has created a significant public health problem. Intraocular pressure (IOP) is determined by the balance between aqueous humour production and outflow, and IOP homeostasis is primarily maintained by changes in aqueous humour outflow resistance.[7] Epidemiological studies have suggested that IOP is affected by several factors, including non-modifiable risk factors, such as age, race, refraction, and

central corneal thickness (CCT), and modifiable risk factors, such as blood pressure (BP), physical activity, and obesity.[8] High intraocular pressure can lead to glaucomatous optic nerve damage and subsequent blindness.[9] Examination of the optic disc is indicative of glaucoma.[10] The optic disc is a small blind area of the retina formed by RGC axons that curve from the disc and exit the eye from the cribriform plate.[11] In primary open-hole glaucoma, the trabecular meshwork underwent morphological changes over time and caused significant fluid obstruction despite remaining anatomically open. Primary open-angle glaucoma (POAG) accounts for 74% of all glaucoma cases.[10] As a result of the increase in the height of the nerve, it is sent to the optic disc and eventually causes atrophy and nerve damage.[11] The main risk factors for POAG are high intraocular pressure, usually greater than 21 mmHg, strong genetic predisposition, and advanced age, mostly elderly and elderly people. It is chronic, usually bilateral, failure and poor onset.[6] POAG is generally asymmetrical, with a visual difference of more than 0.2, more severe in one eye than the other, and without side effects.[12] It is asymptomatic until blindness occurs. In POAG, the iris-corneal (filtering) angle is usually open or wide with no narrow bias and has a normal chamber depth Its main feature is glaucomatous optic neuropathy with thinning of the temporal disc margin. Because the disease progresses slowly, POAG is asymptomatic until the underlying cause is not identified. It does not cause headaches, eye pain or vision loss. This increases the challenges of diagnosing and treating open-angle glaucoma.[13] Diabetes is a chronic disease caused by the body's inability to produce insulin or absorb sugar.[14] In people with diabetes, the pancreas does not produce enough insulin or the cells do not respond properly to insulin. Hyperglycaemia, also known as high blood sugar or high blood sugar, is the result of uncontrolled blood sugar and over time can cause serious damage to many organs in the body, especially veins and arteries.[15] Diabetes mellitus (DM) is an important public health problem with increasing morbidity. An estimated 451 million people (18-99 years old) worldwide had diabetes in 2017, this number could rise to 693 million by 2045.[14] According to the World Health Organization, the number of people with diabetes increased from 108 million in 1980 to 422 million in 2014.[16,17] Diabetes was estimated at 476 million people worldwide in 2017 and is expected to increase to 571 million by 2025.[18] According to the International Diabetes Federation, the incidence of diabetes will be 9.9% and the number of people with diabetes will reach 9.9%. In 2030, the number of people with diabetes will reach 552 million.[18] The objective of this study was to investigate the correlation between intraocular pressure and random blood glucose levels in patients with primary open-angle glaucoma.

METHODS

This was an observational study conducted for about 10 month (December 2016 to September 2017) at the department of optometry GSVM Medical College, Kanpur, UP, India. All participants in this study obtained informed consent. This study was approved by the ethics committee of the faculty of health technologies and the department of optometry GSVM Medical College, Kanpur Uttar Pradesh state, India. Patients diagnosed with open-angle glaucoma were recruited to participate in this study.

Inclusion criteria

This study included patients of all genders and 20 years of age or older.

Exclusion criteria

Section excluded patients under 20 years of age with a family history of glaucoma, myopia, or pseudo exfoliation syndrome, section with a history of previous trauma/surgery and long-term steroid use.

74 patients who met the inclusion criteria were included in the study. Written informed consent was taken from the patients. Detailed history of patients regarding name, age, sex, occupation, address, drug history, presenting symptom, duration, associated conditions and past history was recorded. History of diabetes such as symptoms, duration, and type of treatment was enquired. Overall control was assessed by lab parameters.

Intraocular pressure was measured using the Perkins applanation tonometer while their blood glucose level was measured using the Accu-Chek glucometer. Before each measurement the tonometer was set to 10 mmHg and pressure was recorded. Gonioscopy and perimetry was planned if IOP>21 mmHg or optic disc changes suggestive of glaucoma were present. Dilated fundus examination was done by direct ophthalmoscopy and with +90D lens.

Statistical methods

The data obtained from the study was uploaded into the Statistical Package for Social Sciences (SPSS) version 23 software. The Pearson product moment correlation coefficient was used to test the correlation of intraocular pressure and blood glucose levels at 0.05 level of significance and 95% confidence interval.

RESULTS

A total of 74 patients diagnosed with open-angle glaucoma were included in this study.

Table 1 shows the age and gender distribution of the subjects. Of these, 28 were men and 46 were women. The prevalence of men aged 39 to 58 years (mean age) was 13.51%. Among people aged 79-98 years, the incidence was lowest in men and women, both at 2.7%. For people aged 20-38 years (adults), the rate for men and women was 10.81%.

Table 1: Age and gender distribution of subjects.

Age (years)	Male		Female		Total	
	N	%	N	%	N	%
20-38	8	10.81	8	10.81	16	21.62
39-58	10	13.51	24	32.43	34	45.95
59-78	8	10.81	12	16.22	20	27.03
79-98	2	2.70	2	2.70	4	5.41
Total	28	37.84	46	62.16	74	100.00

Table 2: Intra ocular pressure distribution of subjects.

IOP (mmHg)	n	Mean (mmHg)
5-10	3	9.67
11-15	26	13.19
16-20	29	17.76
21-25	11	22.45
26-30	09	26.00
Total	70	

Table 2 shows the frequency and mean IOP values in different variables. Tonometry was performed on 70 eyes of 37 patients, one (1) eye ranging from 26 to 30 mmHg; 3 eyes with an average of 9.67 mmHg in the 5-10 mmHg range. In 29 eyes, IOP was in the range of 16-20 mmHg, with a mean of 17.76 mmHg.

Table 3: Distribution of random blood glucose level of subjects.

Random BGL (mg/dl)	n	Mean (mg/dl)
1-100	3	74.33
101-200	14	132.57
201-300	1	242.00
301-400	1	353.00
401-500	2	431.50
Total	21	

Table 3 shows the frequency and average of patients' blood glucose levels. Of the 21 subjects whose RBG was measured, 3 had the lowest range of 1-100 mg/dl, and the mean random BGL was 74.33 mg/dl; 2 subjects ranged from 401 to 500 mg/dl, mean random BGL 431.50 mg/dl; The blood glucose level of 14 people was between 100-200 mg/dl and the average fasting BGL was 132.57 mg/dl.

Table 4: Descriptive statics for intraocular pressure and random blood glucose levels.

Variables	n	Range	Max	Min	Mean	SD
IOP (mmHg)	70	17	9	26	16.57	3.97
RBG (mg/dl)	21	416	42	458	168.43	108.48

n =Number, Max =Maximum, Min =Minimum, SD = Standard deviation.

Table 4 shows IOP and descriptive IOP statistics. The lowest IOP value was 9 mmHg; the maximum value was 26 mmHg, the range was 17 mmHg, the mean value was 16.57 mmHg, and the standard deviation was 3.97 mmHg.

Blood tests for anemia were performed on 21 patients. Minimum 42 mg/dl, maximum 458 mg/dl maximum 416 mm/dl. The mean was 168.43 mg/dl and the standard deviation was 108.4.

Table 5: SPSS data analysis.

Variables	Person correlation	P value
RBG-IOP	-0.076	0.745

Table 5 shows the SPSS data analysis using Pearson's product-moment correlation coefficient (significance 0.05, 95% confidence) to assess the relationship between RBG and IOP. It revealed a p value of 0.745 and a Pearson correlation of -0.076. There was no correlation between IOP level and RBG ($p>0.05$) among the subjects.

DISCUSSION

The results showed that there was no relationship between blood glucose and intraocular pressure ($p>0.05$). Mean IOP values of various age groups show that IOP gradually increases with age. High IOP is the main determinant of primary open-angle glaucoma. A study on diabetes and hypertension showed that the incidence of glaucoma increases with age.[20] However, the same study also found no association between age and IOP. The difference in IOP between male and female subjects in our study showed that female subjects with a mean IOP of 17.51 mmHg had higher IOP than men with a mean IOP of 14.88 mmHg. Although Khalaj et al showed an insignificant difference in mean IOP between genders both with diabetic and non-diabetic patients, Khachatryan, et al asserted that the male gender was significantly associated with the risk of primary open-angle glaucoma among African-Americans 35 years and older.[20,21] A study to predict fasting glucose provided evidence for the role of genetic determinants of fasting glucose in the development of high IOP.[22] A study to predict fasting glucose provided evidence for the role of genetic determinants of fasting glucose in the development of high IOP.[22] Intraocular pressure should be monitored in patients without diabetes mellitus and with high blood sugar. High IOP is an important indicator of primary open-hole glaucoma and increased eye pressure. Cui et al in a study on fasting blood glucose levels and risk in open-angle glaucoma patients, patients with the highest fasting blood glucose (≥160 mg/dl) were more likely to have the lowest (<80 mg/dl) blood glucose levels).[23] The hazard ratio (HR 2.189) and correlation ($p<0.001$) for open-angle glaucoma were higher in patients with and without type 2 diabetes compared with those with type 2 diabetes. This is in contrast to our study, perhaps because our subjects did not register high blood

sugar levels. In addition, body mass index (BMI), presence or absence of high blood pressure, smoking, alcohol consumption, exercise, etc. We excluded other factors such as from statistics, a negative Pearson correlation value (-0.076) emerges when testing hypothesis, which shows the relationship between IOP and blood glucose levels, and vice versa. However, a negative value close to zero indicates that the relationship is not significant. Intraocular pressure has been shown to be an independent risk factor for POAG and is currently the only modifiable risk factor. Many other risk factors are involved in the pathogenesis of glaucoma because IOP is not the only risk factor that puts a patient at risk of developing POAG. Other factors that have been shown to be associated with the development of POAG include cup-to-disc ratio, visual acuity, intervertebral disc haemorrhage, myopia, central corneal thickness (CCT), ocular perfusion pressure, intracranial pressure (ICP), and translaminar cribriform, pressure gradient, diabetic hypertension, blood flow to the eye, vascular status, genetic factors and age.[24-27] Gender and race are risk factors for POAG, but how these affect an individual's risk of POAG has not been determined. Several studies have shown that glaucoma development has a stronger vascular tone in diabetic glaucoma patients compared to non-diabetic POAG patients.[23,26] Specifically, diabetes affects structural and hemodynamic factors related to blood flow. In POAG patients with diabetes mellitus, changes in retinal blood flow have been associated with changes in ONH (e.g., volume, cup-to-disc area ratio, margin area, pit area, cup shape, linear c/d ratio) four years.[28] Additionally, changes in retinal blood flow in patients after four years were associated with changes in macular thickness. This suggests that POAG patients with diabetes may have a strong vascular contribution to their glaucomatous structural damage.

It is important to note that vascular changes are also associated with RNFL and macular deterioration in POAG patients with DM.[29] Amato et al used the DBA/2J mouse (D2) model of glaucoma to analyze the effect of early diabetes on glaucomatous RGC dysfunction before IOP rises, and found that intraocular pressure (IOP) did not affect duration or blood pressure.[30] In contrast, RGC activity in the D2 group gradually decreased independently of increased intraocular pressure (IOP) and peripheral retinal dysfunction. The result of our study is comparable with that of the study conducted by Neeetans et al in 1997.[31] The positive relationship between diabetes and increased intraocular pressure has been well documented in several other studies.[31-34]

A population-based study in the Netherlands found that newly diagnosed diabetes and hypertension were associated with weight gain.[35] Jian et al in 2000, it was reported that IOP increased in patients with diabetic retinopathy and hypertension.[36] Pimentel et al in 2015, there was a significant relationship between diabetes and eye pressure. This study also found that postprandial IOP was higher than random IOP.[37] Traisman and colleagues found that patients with blood glucose levels above × 200 mg/dl had higher IOP readings.[38]

CONCLUSION

This suggests that POAG patients with diabetes may have a strong vascular contribution to their glaucomatous structural damage. It is important to note that vascular changes are also associated with RNFL and macular deterioration in POAG patients with DM.[29] Amato et al used the DBA/2J mouse (D2) model of glaucoma to analyze the effect of early diabetes on glaucomatous RGC dysfunction before IOP rises and found that intraocular pressure (IOP) did not affect the duration or blood pressure.[30] In contrast, RGC activity in the D2 group gradually decreased independently of increased intraocular pressure (IOP) and peripheral retinal dysfunction.

ACKNOWLEDGEMENTS

We would like to thank the heads of the institution, the teachers, the staff and more so the students for having been very cooperative in the collection of the data. We thank our entire department faculty for being encouraging and supportive throughout this study.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Davis BM, Crawley L, Pahlitzsch M, Javaid F, Cordeiro MF. Glaucoma: the retina and beyond. Acta Neuropathol. 2016;132:807-26.
2. Vijaya L, Rashima A, Panday M, Choudhari NS, Ramesh SV, Lokapavani V, Boddupalli SD, Sunil GT, George R. Predictors for incidence of primary open-angle glaucoma in a South Indian population: the Chennai eye disease incidence study. Ophthalmology. 2014;121(7):1370-6.
3. Arthur S, Cantor LB. Update on the role of alpha-agonists in glaucoma management. Exp Eye Res. 2011;93(3):271-83.
4. Conlon R, Saheb H, Ahmed II. Glaucoma treatment trends: a review. Can J Ophthalmol. 2017;52(1):114-24.
5. Akaiwa K, Namekata K, Azuchi Y, Guo X, Kimura A, Harada C, et al. Edaravone suppresses retinal ganglion cell death in a mouse model of normal tension glaucoma. Cell Death Dis. 2017;8(7):e2934.
6. Shon K, Wollstein G, Schuman JS, Sung KR. Prediction of glaucomatous visual field progression: pointwise analysis. Curr Eye Res. 2014;39(7):705-10.
7. Crawley L, Zamir SM, Cordeiro MF, Guo L. Clinical options for the reduction of elevated

intraocular pressure. Ophthalmol Eye Dis. 2012;4:OED-S4909.
8. Perez CI, Singh K, Lin S. Relationship of lifestyle, exercise, and nutrition with glaucoma. Curr Opin Ophthalmol. 2019;30(2):82-8.
9. Quigley HA. Glaucoma. Lancet. 2011;377(9774):1367-77.
10. Bajwa MN, Malik MI, Siddiqui SA, Dengel A, Shafait F, Neumeier W, Ahmed S. Two-stage framework for optic disc localization and glaucoma classification in retinal fundus images using deep learning. BMC Med Inform Decision Making. 2019;19(1):1-6.
11. Salazar JJ, Ramírez AI, De Hoz R, Salobrar-Garcia E, Rojas P, Fernández-Albarral JA, et al. Anatomy of the human optic nerve: Structure and function. Opt Nerve. 2018;203:22-30.
12. Umezurike BC, Akhimien MO, Udeala O, Green UG, Okpechi-Agbo U, Ohaeri MU. Primary open angle glaucoma: the pathophysiolgy, mechanisms, future diagnostic and therapeutic directions. Ophthalmol Res. 2019;10(3):1-7.
13. Saade CE, Lari HB, Berezina TL, Fechtner RD, Khouri AS. Topical glaucoma therapy and ocular surface disease: a prospective, controlled cohort study. Can J Ophthalmol. 2015;50(2):132-6.
14. Cho NH, Shaw JE, Karuranga S, Huang Y, da Rocha Fernandes JD, Ohlrogge AW, et al. IDF Diabetes Atlas: Global estimates of diabetes prevalence for 2017 and projections for 2045. Diabetes Res Clin Pract. 2018;138:271-81.
15. World Health Organization. Global status report on noncommunicable diseases 2010. Available from: https://apps.who.int/iris/bitstream/handle/10665/44579/9789240686458_eng.pdf. Accessed on 12 November 2022.
16. World Health Organization. Diabetes. 2022. Available from: https://www.who.int/health-topics/diabetes#tab=tab_1. Accessed on 3 November 2022
17. Lin X, Xu Y, Pan X, Xu J, Ding Y, Sun X, et al. Global, regional, and national burden and trend of diabetes in 195 countries and territories: an analysis from 1990 to 2025. Sci Rep. 2020;10(1):14790.
18. Lin HC, Stein JD, Nan B, Childers D, Newman-Casey PA, Thompson DA, et al. Association of geroprotective effects of metformin and risk of open-angle glaucoma in persons with diabetes mellitus. JAMA Ophthalmol. 2015;133(8):915-23.
19. Whiting DR, Guariguata L, Weil C, Shaw J. IDF Diabetes atlas: global estimates of the prevalence of diabetes for 2011 and 2030. Diabetes Res Clin Pract. 2011;94(3):311-21.
20. Khalaj M, Fereydooni S, Barikani A. (2015). Relationship between diabetes and intraocular pressure. Acta Med Iran. 2015;53(6):363-8.
21. Khachatryan N, Pistilli M, Maguire MG, Salowe RJ, Fertig RM. Primary Open-Angle African American Glaucoma Genetics (POAAGG) study: gender and risk of POAG in African Americans. PloS One. 2019;14(8):18-24.
22. Tan X, Zhong Z, Wang Q, Su G, Cao Q, Kijlstra A, et al. Genetically predicted fasting blood glucose level plays a causal role in intraocular pressure: A Mendelian randomisation study. Clin Exp Ophthalmol. 2022;50(5):534-42.
23. Choi JA, Park YM, Han K, Lee J, Yun JS, Ko SH. Fasting plasma glucose level and the risk of open angle glaucoma: Nationwide population-based cohort study in Korea. PLoS One. 2020;15(9):e0239529.
24. Varma R, Lee PP, Goldberg I, Kotak S. An assessment of the health and economic burdens of glaucoma. Am J Ophthalmol. 2011;152(4):515-22.
25. Cherecheanu AP, Garhofer G, Schmidl D, Werkmeister R, Schmetterer L. Ocular perfusion pressure and ocular blood flow in glaucoma. Curr Opin Pharmacol. 2013;13(1):36-42.
26. Memarzadeh F, Ying-Lai M, Chung J, Azen SP, Varma R, Los Angeles Latino Eye Study Group. Blood pressure, perfusion pressure, and open-angle glaucoma: the Los Angeles Latino Eye Study. Investig Ophthalmol Vis Sci. 2010;51(6):2872-7.
27. Jonas JB, Wang N. Association between arterial blood pressure, cerebrospinal fluid pressure and intraocular pressure in the pathophysiology of optic nerve head diseases. Clin Exp Ophthalmol. 2012;40(4):233-4.
28. McIntyre N, Harris A, Amireskandari A, Eckert G, WuDunn D, Abrams J, et al. Changes in retinal capillary blood flow correlate with changes in macular thickness in glaucoma patients with diabetes. Investig Ophthalmol Vis Sci. 2014;55(13):2939.
29. Schaab T, Harris A, Amireskandari A, Eckert G, Wirostko B, Ling J, et al. Retrobulbar blood flow in glaucoma patients with and without diabetes. Investig Ophthalmol Vis Sci. 2014;55(13):2934.
30. Amato R, Lazzara F, Chou TH, Romano GL, Cammalleri M, Dal Monte M, et al. Diabetes exacerbates the intraocular pressure-independent retinal ganglion cells degeneration in the DBA/2J model of glaucoma. Investig Ophthalmol Vis Sci. 2021;62(9):9.
31. Neetens A, Badaniova D. Intraocular pressure and diabetic retinopathy. Bibl Anatom. 1977;16(2):437-41.
32. Wu SY, Leske MC. Associations with intraocular pressure in the Barbados Eye Study. Arch Ophthalmol. 1997;115(12):1572-6.
33. David RO, Zangwill LI, Stone DA, Yassur Y. Epidemiology of intraocular pressure in a population screened for glaucoma. Br J Ophthalmol. 1987;71(10):766-71.
34. Mitchell P, Smith W, Chey T, Healey PR. Open-angle glaucoma and diabetes: the Blue Mountains eye study, Australia. Ophthalmology. 1997;104(4):712-8.

35. Dielemans I, de Jong PT, Stolk R, Vingerling JR, Grobbee DE, Hofman A. Primary open-angle glaucoma, intraocular pressure, and diabetes mellitus in the general elderly population: the Rotterdam Study. Ophthalmology. 1996;103(8):1271-5.
36. Sakata K, Maia M, Matsumoto L, Oyamaguchi EK, Carvalho AC, Knoblauch N, et al. Analysis of the intraocular pressure in diabetics, hypertensive and normal patients (Glaucoma Project). Arq Brasil Oftalmol. 2000;63:219-22.
37. Pimentel LG, Gracitelli CP, da Silva LS, Souza AK, Prata TS. Association between glucose levels and intraocular pressure: Pre-and postprandial analysis in diabetic and nondiabetic patients. J Ophthalmol. 2015;2015.
38. Traisman HS, Alfano JE, Andrews J, Gatti R. Intraocular pressure in juvenile diabetics. Am J Ophthalmol. 1967;64(6):1149-51.

Cite this article as: Srivastava N, Yadav YS, Kumar P. The relationship between intraocular pressure and random blood glucose levels with open angle glaucoma. Int J Community Med Public Health 2023;10:3741-6.