

ORIGINAL ARTICLE

Effects of Fluid Ingestion on Intraocular Pressure in Normal Young Malaysian Adults

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ABSTRACT

Introduction: Intraocular pressure (IOP) is an important parameter in diagnosing and monitoring glaucoma. IOP is dynamic and its measurement and monitoring is challenging. Water Drinking Test (WDT) is a test to evaluate the fluctuation of IOP due to fluid ingestion. This study aimed to investigate the effect of WDT on IOP in normal young healthy adults. **Materials and Methods:** Eighty participants were recruited in this prospective study. Comprehensive optometric examination were done including Goldmann application tonometry and visual field (VF) testing. Refractive error were objectively measured using Shin Nippon SLM-500 auto-refractometer. VF testing was done using automated perimetry. All procedures were performed between 08:00 to 12:00 PM, and every 5 minutes for 30 minutes after 1000mls of water. All data were analysed using repeated measures analysis of variance (RM-ANOVA). **Results:** Immediately after the WDT, the IOP increase to its peak at 10 minute and reducing trend was observed from the peak to the 30 minutes timeline. RM-ANOVA analysis revealed significant changes in IOP measurements between baseline and 30 minutes observation period ($P < 0.001$). Post hoc comparisons using the Tukey HSD test indicated the changes in IOP between right after drinking to at 10 minutes (mean = 17.8, SD = 2.3) was significant compared to other time intervals ($P < 0.001$). No significance difference ($P = 0.09$) in IOP between baseline and 30 minutes. **Conclusion:** WDT is a meaningful, quicker alternative test in attempting to uncover diurnal IOP characteristics in clinic, thus reducing both time requirements and associated costs.

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Keywords: Water drinking test (WDT), Diurnal variation, Intraocular pressure, Fluid ingestion, Healthy young adult

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INTRODUCTION

Glaucoma is a group of diseases characterized by optic neuropathy progression due to loss of the optic nerve fibre layer which resulting in visual field reduction. Intraocular pressure (IOP) is an important parameter in early detection and monitoring glaucoma. Despite knowing that lowering IOP is crucial in monitoring glaucoma progression, the approach in monitoring remains inadequate (1-4). Commonly, studies related to IOP monitoring are done during working hours,

however, recent report suggested an approximation of 75% of cases has been reported that maximum IOP occurs mostly outside these times (5,6). It is a fact that IOP fluctuations may occur due to several factors including ingestion certain amount of water (7,8), different postural position (2,9), physical activities (10,11), time (12) and even changes in accommodation (13,14). This indirectly indicates inaccuracy of IOP measurement could be multifactorial.

Several approaches has been suggested to determine the maximum IOP. Mottet et al. (15) had utilised continuous contact lens sensor for 24-hour diurnal monitoring. However, this approach was both time and resource-consuming. Not to mention this approach could also lead to inaccuracy of IOP measurement as it is exposed

to other external factors such as corneal curvature, thickness and hysteresis. Alternatively, water drinking test (WDT) has been proposed to detect IOP peaks and evaluate variations of IOP. The IOP measurement can be done in various time intervals; from 15-minute to 2-hours interval throughout the day. Recent works (16,17) has reported that the WDT are correlated with maximum diurnal IOP. With its potential of time and resource savings, the WDT could be the alternative to estimate maximum IOP for 24-hour monitoring. To the best of our literature search, there is no report on IOP changes using WDT test from Malaysian population. Thus, this study aimed to investigate the effect of WDT on IOP and maximum response time on IOP changes in young adults.

MATERIALS AND METHODS

Eighty young adults were recruited in this prospective study via convenience sampling. The study protocols were approved by the International Islamic University Malaysia (IUM) Research Ethics Committee (IREC2019-125) and conform with the tenets of the Declaration of Helsinki. Written consent was obtained from each participant prior to data acquisition. Inclusion criteria includes aged 20 - 50 years old with no history or pending diagnosis of primary open angle glaucoma (POAG) or normal tension glaucoma (NTG) in either eye. Retinal evaluation with emphasis on glaucomatous optic disc and visual field loss were evaluated by a senior consultant glaucoma specialist. Patients with a history of ocular trauma, evidence of active ocular infection in either eye, or significant underlying ocular pathology affecting the anterior eye including ocular surface lesion/trauma, cornea lesion, anterior chamber and lens abnormalities were excluded (18-20). For posterior segment, ophthalmic retinal and neurological were also excluded (21-24). In addition, participants with history of renal disease or organ failure due to risk of excessive fluid intake or those with swallowing difficulties were also excluded (1).

Comprehensive optometric examination including visual acuity, slit-lamp biomicroscopy, Goldmann applanation tonometry (GAT) and pupil examination were done prior to recruitment (25,26). All assessment were done on both eyes, however, only data recorded from one eye were used for analysis. Refractive error was measured using Shin Nippon SLM-500 autorefractometer (Shin Nippon, Tokyo, Japan), with five (5) readings were automatically acquired, and the average were recorded. Central corneal thickness (CCT) was measured using Oculus

PARK1 (OCULUS Inc, Arlington, WA, USA) with five (5) readings were automatically acquired, and the average were recorded. IOP was measured by Goldmann applanation tonometer (GAT) (GAT, Haag-Streit, Koeniz, Switzerland) with average of three (3) reading were recorded. Visual field (VF) testing was performed on each eye separately using Humphrey Visual Field Analyser 3 (Carl Zeiss Meditec, Jena, Germany) using a 24-2 testing modality. To limit the influence of diurnal variations in IOP, all measurements were carried out between 08:00 to 12:00 PM, with all examination were done by a group of qualified optometrists. All participants were reminded not to ingest any food or liquid three (3) hours before the baseline measurements of IOP. After baseline measurements, participants drank 1000 mL of water in 10 minutes. IOP measurements were repeated at 5, 10, 15, 20, 25 and 30 minutes into the WDT.

All data were analysed using the IBM SPSS (Predictive analytics software) (Version 25, SPSS Inc., Chicago, IL, USA). Shapiro-Wilk test was used to check normality of data. All data were recorded in mean and standard deviation (mean $\pm$ SD). Repeated measures analysis of variance (RM-ANOVA) with Tukey Honest Significant Difference (HSD) post-hoc test for multiple comparisons was carried out to investigate the changes in each of measured parameter after water ingestion with each time interval. P-value was set at 0.05 as level of significance.

RESULTS

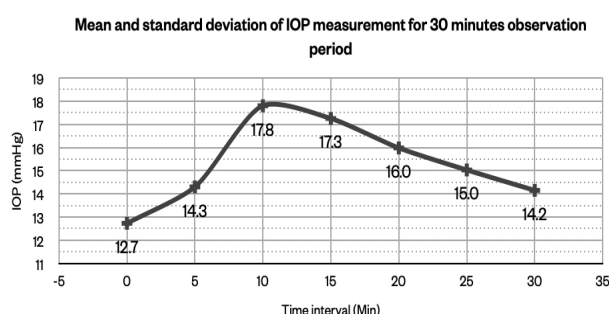
Data from eighty eyes of 80 healthy young adults were analysed in this study. Shapiro-Wilk test revealed all parameters were normally distributed. The baseline IOP were 12.7 ± 1.4 mmHg. While refractive error and CCT were -3.23 ± 0.45 DS and 523 ± 34 μ m. This study found that immediately after drinking 1000 ml of fluid, the IOP increase to its peak at 10 minute and reducing trend was observed from the peak to the 30 minutes timeline. The mean and standard deviation for IOP measured in every time interval are summarised in Table 1. RM-ANOVA analysis revealed statistically significant changes in IOP measurements between baseline and 30 minutes observation period. Post hoc comparisons using the Tukey HSD test indicated that the mean IOP between right after drinking to at 10 minutes (mean = 17.8, SD = 2.3) was significantly different than the other time intervals ($P < 0.001$) (Fig. 1). However, no significant difference were found in IOP measurement made between baseline and at 30 minutes interval ($P = 0.09$). The dynamic changes in IOP during 30-minutes observation period are shown in Fig. 1.

Table 1: The mean and SD of IOP for 30 minutes observation period (n=80)

Time interval	IOP (mmHg) (mean $\pm$ SD)	P-value ^a
Baseline	12.7 $\pm$ 1.4	-
5 minutes	14.3 $\pm$ 1.8	< 0.001 ^a
10 minutes	17.8 $\pm$ 2.3 ^b	< 0.001 ^a
15 minutes	17.3 $\pm$ 1.6	< 0.001 ^a
20 minutes	16.0 $\pm$ 1.5	< 0.001 ^a
25 minutes	15.0 $\pm$ 1.9	< 0.001 ^a
30 minutes	14.2 $\pm$ 1.2	0.09

^aP-value analysed using RM-ANOVA (Baseline vs. 5 minutes, Baseline vs. 10 minutes, Baseline vs. 15 minutes, Baseline vs. 20 minutes, Baseline vs. 25 minutes and Baseline vs. 30 minutes)

^bTukey HSD test

**Fig 1 : The dynamic changes in IOP measurement for 30 minutes observation period (n=80)**

DISCUSSION

The WDT indicates the efficiency of the fluid outflow system of the eye. The exact mechanism of IOP increase is not clear and still debatable (1,27). There are several hypotheses been proposed to elucidate this process. Few studies (28,29) had commented that the WDT could lead to increase in IOP by inducing changes in episcleral venous pressure by causing reduction in aqueous outflow which in turn lead to increase in IOP. Recent works (27,30,31) also suggested that increase in aqueous production somehow interrupt the balance of circadian rhythm of IOP following to water drinking could also lead to increase in IOP. Many researchers had hypothesised that choroidal expansion or changes in choroidal thickness during WDT causing the increase in IOP, however the findings were still debatable with several reports in agreement with theory (32-34), while group of studies disagree (35-38).

This study findings showed subsequent to the WDT, there was an immediate increase in IOP and recedes steadily within 30 minutes. Our findings in agreement with previous studies that reports variation in fluid volume intake and duration of drinking time taken would give different values of IOP changes (39,40). It is challenging to compare our results with other studies

as there are no standardisation in conducting the test. Recent work (41) reported an increment of 6.6 ± 2.9 mmHg after ingestion of 800 mL of water within 5 minutes. Previous work (42,43) reported an increment of 5.00 ± 1.00 mmHg 2.24 ± 0.31 mmHg respectively after 1 liter of fluid ingestions. While another study (39) reported increment of 4.70 ± 0.90 mmHg after taking fluid at 14 mL/kg body weight within 5 minutes. Thus, the amount of fluid ingested are varies between studies. In addition, different duration of drinking time and the time interval for IOP measurement also varies between one study to another. Several studies measured the IOP within the first 5 minutes (39,43) after the WDT, while other group of studies at 10 minutes (44), 15 minutes (1,16,35,45), and even in ranges between 5 - 15 minutes (47)

Increment of IOP were also noted slightly different with other studies. This study found that the maximum IOP was at 10 minutes after the WDT. This is in agreement with a previous work (43,44). However, several studies reported the maximum IOP was observed at 5 minutes (39), or even at 15 minutes (41). This result suggest that the time required could be related different ethnicity with studies from countries near the equator (43) showed faster increment compared to farther countries like Japan (41). Study from Indian and East Indian population (43). Nonetheless, we postulated that this study findings could be due to our sample, in which most of them are young and healthy adults. It is assumed that the ocular drainage system are well-function and still intact. Recent study had commented that increased age is one of factors that leads to notable increase in IOP compared to younger individuals (48). And the time difference in reaching the maximum IOP changes could be due to variations of hydration levels within the ocular dimension (46).

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CONCLUSION

Water Drinking Test (WDT) is a meaningful, quicker alternative test in attempting to uncover diurnal IOP characteristics in clinic, thus reducing both time requirements and associated costs.

REFERENCES

1. Yap TE, Gao Y, Ahmad H, Susanna F, Susanna R, Normando EM, Bloom PA, Cordeiro MF. Comparison of intraocular pressure profiles during the water drinking test and the modified diurnal tension curve. *Eye (Lond)*. 2024;38(8):1567-1574. doi: 10.1038/s41433-024-02954-0.
2. De Bernardo M, Cione F, De Pascale I, Pagliarulo S, Rosa N. Intraocular Pressure Measurements in

- Standing, Sitting, Prone, and Supine Positions. *J Pers Med*. 2024;14(8):826. doi: 10.3390/jpm14080826.
3. Olatunji OP, Olawoye O, Ajayi B. Correlation and Agreement Between Water Drinking Test and Modified Diurnal Tension Curve in Untreated Glaucoma Patients in Nigeria. *J Glaucoma*. 2020;29(6):498-503. doi: 10.1097/IJG.0000000000001493.
4. Firat PG, Dikci S, Firat İT, Demirel S, Firat M, Öztürk E, Guk ZE. Correlation between intraocular pressure obtained with water drinking test versus modified diurnal tension curve measurement in pseudoexfoliation glaucoma. *Int Ophthalmol*. 2021;41(8):2879-2886. doi: 10.1007/s10792-021-01847-5.
5. Grippo TM, Liu JH, Zebardast N, Arnold TB, Moore GH, Weinreb RN. Twenty-four-hour pattern of intraocular pressure in untreated patients with ocular hypertension. *Invest Ophthalmol Vis Sci*. 2013;54(1):512-7. doi: 10.1167/iovs.12-10709.
6. Mansouri K, Tanna AP, De Moraes CG, Camp AS, Weinreb RN. Review of the measurement and management of 24-hour intraocular pressure in patients with glaucoma. *Surv Ophthalmol*. 2020;65(2):171-186. doi: 10.1016/j.survophthal.2019.09.004.
7. Jin E, Goh CXY, Betzler BK, Heng CP, Ang BCH. Assessing the value of the water drinking test in glaucoma-a systematic review and meta-analysis. *Eye (Lond)*. 2024 May 7. doi: 10.1038/s41433-024-03107-z.
8. Germano RA, Hatanaka M, Susanna R Junior. Choroidal thickness variation in highly myopic eyes during the water drinking test. *Arq Bras Oftalmol*. 2016;79(4):214-7. doi: 10.5935/0004-2749.20160062.
9. Løke JN, Enders P, Handel A, Gietzelt C, Dietlein J, Schuneberger V, Lappa A, Widder R, Dietlein TS. Posture-related fluctuations of intraocular pressure in healthy children with suspicion of glaucoma. *Graefes Arch Clin Exp Ophthalmol*. 2024;262(1):171-177. doi: 10.1007/s00417-023-06212-z.
10. González-Devesa D, Suárez-Iglesias D, Diz JC, Esmerode-Iglesias A, Ayón C. Systematic review on the impact of exercise on intraocular pressure in glaucoma patients. *Int Ophthalmol*. 2024;44(1):351. doi: 10.1007/s10792-024-03216-4.
11. Krobot Cutura N, Mrak M, Cutura DM, Petric Vickovic I, Ruzic L. Evaluating Intraocular Pressure Alterations during Large Muscle Group Isometric Exercises with Varying Head and Body Positions. *Int J Environ Res Public Health*. 2024;21(4):476. doi: 10.3390/ijerph21040476.
12. McMonnies CW. The importance of and potential for continuous monitoring of intraocular pressure. *Clin Exp Optom*. 2017;100(3):203-207. doi: 10.1111/cxo.12497.
13. Priluck AZ, Hoie AB, High RR, Gulati V, Ghatge DA. Effect of Near Work on Intraocular Pressure in Emmetropes. *J Ophthalmol*. 2020 Jan 28;2020:1352434. doi: 10.1155/2020/1352434.
14. Stokkermans TJ, Reitingen JC, Tye G, Kao CY, Ragupathy S, Wang HA, Toris CB. Accommodative Exercises to Lower Intraocular Pressure. *J Ophthalmol*. 2020 Dec 18;2020:6613066. doi: 10.1155/2020/6613066.
15. Mottet B, Aptel F, Romanet JP, Hubanova R, Păpin JL, Chiquet C. 24-hour intraocular pressure rhythm in young healthy subjects evaluated with continuous monitoring using a contact lens sensor. *JAMA Ophthalmol*. 2013;131(12):1507-16. doi: 10.1001/jamaophthalmol.2013.5297.
16. Susanna CN, Susanna BN, Susanna FN, Susanna R Jr, De Moraes CG. Peak Intraocular Pressure Time during Water Drinking Test and Its Relationship with Glaucoma Severity. *J Ophthalmic Vis Res*. 2022;17(1):27-32. doi: 10.18502/jovr.v17i1.10167.
17. Razeghinejad R, Tajbakhsh Z, Masoumpour MB, Nowroozzadeh MH. Intraocular Pressure Changes after Water Drinking Test in Surgically Treated Primary Congenital Glaucoma. *J Ophthalmic Vis Res*. 2020;15(3):318-325. doi: 10.18502/jovr.v15i3.7450.
18. Jais FN, Che Azemin MZ, Hilmi MR, Mohd Tamrin MI, Kamal KM. Postsurgery Classification of Best-Corrected Visual Acuity Changes Based on Pterygium Characteristics Using the Machine Learning Technique. *Scientific World Journal*. 2021 Nov 15;2021:6211006. doi: 10.1155/2021/6211006.
19. Md Mustafa MMS, Abdul Mutalib H, Ab. Halim N, Hilmi MR. Accuracy of contact lens method by spherical and aspheric rigid gas permeable lenses on corneal power determination in normal eyes. *Sains Malaysiana*. 2020;49(6): 1431-1437.
20. Abdul-Kadir MA, Hilmi MR, Mohd Kamal K. Safety and efficacy of "hydro-fluorescein" technique in removing Tenon in pterygium surgery: a 1-year follow-up study. *Eye (Lond)*. 2025 Apr;39(6):1081-1085. doi: 10.1038/s41433-024-03539-7.
21. Che Arif FA, Hilmi MR, Kamal MK, Ithnin MH (2021). Comparison of Immediate Effects on Usage of Dual Polymer Artificial Tears on Changes in Tear Film Characteristics, *Malaysian J Med Health Sci (MJMHS)*,17(3): 252-258.
22. Hilmi MR, Khairidzan MK, Ariffin AE. Norazmar NA, Maruziki NN, Musa NH, Nasir MS, Azemin MZC, Azami MH, Abdul Rahim MAS. Effects of Different Types of Primary Pterygium on Changes in Oculovisual Function. *Sains Malaysiana*. 2020;49(2):383-388.
23. Hilmi MR, Azemin MZC, Khairidzan MK, Ariffin AE, Abdul Rahim MAS, Mohd Tamrin MI. Reliability of Pterygium Redness Grading Software

- (PRGS) in describing different types of primary pterygia based on appearance. *Sains Malaysiana*. 2020;49(5): 1015-1020.
24. Hilmi MR, Khairidzan MK, Azemin MZC, Azami MH, Ariffin AE. Corneo-ptyerygium Total Area Measurements Utilizing Image Analysis Method, *J Optom*, 2019;12(4): 272 - 277.
 25. Che Azemin MZ, Hilmi MR, Mohd Tamrin MI, Mohd Kamal K. Fibrovascular redness grading using Gaussian process regression with radial basis function kernel. In *Biomedical Engineering and Sciences (IECBES)*, 2014 IEEE Conference on 2014 Dec 8 (pp. 113–116). IEEE.
 26. Che Azemin MZ, Mohd Tamrin MI, Hilmi MR, Mohd Kamal K. Inter-grader reliability of a supervised pterygium redness grading system. *Adv Sci Lett* 2016;22(10):2885-2888.
 27. Ikegami K, Shigeyoshi Y, Masubuchi S. Circadian Regulation of IOP Rhythm by Dual Pathways of Glucocorticoids and the Sympathetic Nervous System. *Invest Ophthalmol Vis Sci*. 2020;61(3):26. doi: 10.1167/iops.61.3.26.
 28. Qin VL, Nguyen BJ, Tripp P, Lehman A, Addis VM, Cui QN. Elevated IOP following a bladder filling protocol: A case report. *Am J Ophthalmol Case Rep*. 2022;29:101786. doi: 10.1016/j.ajoc.2022.101786.
 29. Chen ZQ, Chen W, Deng CH, Guo JM, Zhang H, Wang JM. In vivo quantification of human aqueous veins by enhanced depth imaging optical coherence tomography and optical coherence tomography angiography images. *Int J Ophthalmol*. 2023;16(9):1482-1488. doi: 10.18240/ijo.2023.09.15.
 30. Ikegami K. Circadian rhythm of intraocular pressure. *J Physiol Sci*. 2024;74(1):14. doi: 10.1186/s12576-024-00905-8.
 31. Xu D, Wu F, Yu Y, Lou X, Ye M, Zhang H, et al. Sympathetic activation leads to Schlemm's canal expansion via increasing vasoactive intestinal polypeptide secretion from trabecular meshwork. *Exp Eye Res*. 2022;224:109235. doi: 10.1016/j.exer.2022.109235.
 32. Nongpiur ME, Foo VH, de Leon JM, Baskaran M, Tun TA, Husain R, et al. Evaluation of Choroidal Thickness, Intraocular Pressure, and Serum Osmolality After the Water Drinking Test in Eyes With Primary Angle Closure. *Invest Ophthalmol Vis Sci*. 2015;56(4):2135-43. doi: 10.1167/iops.14-15280.
 33. Nagasato D, Mitamura Y, Egawa M, Kameoka M, Nagasawa T, Tabuchi H, et al. Changes of choroidal structure and circulation after water drinking test in normal eyes. *Graefes Arch Clin Exp Ophthalmol*. 2019;257(11):2391-2399. doi: 10.1007/s00417-019-04427-7.
 34. Kocabeyoglu S, Uzun S, Kadayifcilar S, Mocan MC, Irkeç M. The Relationship Between Choroidal Expansion and Intraocular Pressure Rise During the Water Drinking Test in Healthy Subjects and Patients With Exfoliation Syndrome. *J Glaucoma*. 2016;25(4):e324-8. doi: 10.1097/IJG.0000000000000283.
 35. Kandarakis SA, Katsimpris A, Kourti P, Psinakis F, Karmiris E, Papakonstantinou E, et al. The Effect of the Water Drinking Test on Ocular Parameters and Choroidal Thickness in Glaucoma Suspects. *Medicina (Kaunas)*. 2023;59(2):381. doi: 10.3390/medicina59020381.
 36. Bhatti MS, Tang TB, Laude A. Effects of water drinking test on ocular blood flow waveform parameters: A laser speckle flowgraphy study. *PLoS One*. 2017;12:e0181512.
 37. Song YJ, Kim YK, Jeoung JW, Park KH. Assessment of Open-Angle Glaucoma Peripapillary and Macular Choroidal Thickness Using Swept-Source Optical Coherence Tomography (SS-OCT). *PLoS One*. 2016;11(6):e0157333. doi: 10.1371/journal.pone.0157333.
 38. Park Y, Kim HK, Cho KJ. Comparison of peripapillary and macular choroidal thickness and ganglion cell complex thickness in glaucomatous and healthy eyes. *Int J Ophthalmol*. 2019;12(4):603-606. doi: 10.18240/ijo.2019.04.13.
 39. Sakata R, Aihara M, Murata H, Saito H, Iwase A, Yasuda N. Intraocular pressure change over a habitual 24-hour period after changing posture or drinking water and related factors in normal tension glaucoma. *Invest Ophthalmol Vis Sci* 2013; 54:5313-20.
 40. Hatanaka M, Sakata LM, Susanna R Jr, Nascimento LT, Vessani RM. Comparison of the Intraocular Pressure Variation Provoked by Postural Change and by the Water Drinking Test in Primary Open-angle Glaucoma and Normal Patients. *J Glaucoma*. 2016;25(11):914-918. doi: 10.1097/IJG.0000000000000519.
 41. Olatunji OP, Olawoye O, Ajayi B. Correlation and Agreement Between Water Drinking Test and Modified Diurnal Tension Curve in Untreated Glaucoma Patients in Nigeria. *J Glaucoma*. 2020;29(6):498-503. doi: 10.1097/IJG.0000000000001493.
 42. Vasconcelos-Moraes CG, Susanna R Jr. Correlation between the water drinking test and modified diurnal tension curve in untreated glaucomatous eyes. *Clinics (Sao Paulo)*. 2008;63(4):433-6. doi: 10.1590/s1807-59322008000400004.
 43. Read SA, Collins MJ. Water drinking influences eye length and IOP in young healthy subjects. *Exp Eye Res*. 2010;91(2):180-185. doi:10.1016/j.exer.2010.04.015.
 44. Józwiak A, Przeździecka-Dołyk J, Wątek E, Czerniak M, Asejczyk M. Corneal Behavior during Tonometer Measurement during the Water Drinking Test in Eyes with XEN GelStent in Comparison to Non-Implanted Eyes. *J Clin Med*. 2022;11(11):2962. doi: 10.3390/jcm11112962.

45. Mucoz CR, Macias JH, Hartleben C. Reproducibility of the water drinking test. *Arch Soc Esp Oftalmol*. 2015;90(11):517-21. doi: 10.1016/j.oftal.2015.03.011.
46. Chen A, Virk A, Harris Z, Abazari A, Honkanen R, Arbab MH. Non-contact terahertz spectroscopic measurement of the intraocular pressure through corneal hydration mapping. *Biomed Opt Express*. 2021;12(6):3438-3449. doi: 10.1364/BOE.423741.
47. Kadambi SV, Balekudaru S, Lingam V, George R. Comparison of intraocular pressure variability detected by day diurnal variation to that evoked by water drinking. *Indian J Ophthalmol*. 2021;69(6):1414-1417. doi:10.4103/ijo.IJO_1149_20
48. Marquez-Trochez, J., Vanegas-Ramírez, C. M., Castaco-Alzate, C. F., Mucoz-Gómez, M., & Donado-Gómez, J. H. (2023). Intraocular pressure values during the water drinking test in a Colombian population. *Revista de La Sociedad Colombiana de Oftalmología*, 56(2). <https://doi.org/10.24875/rsco.23000003>