ORIGINAL ARTICLE

The Effects of Water Consumption on Biometry in Myopic Young Adults

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ABSTRACT

Background: Myopia, characterized by excessive axial elongation and altered scleral biomechanics, is associated with an increased risk of ocular morbidity. Although axial length (AL) measurement is crucial for monitoring myopia progression, its stability under physiological stressors such as water ingestion remains uncertain. The water drinking test (WDT) transiently elevates intraocular pressure (IOP) and could potentially deform ocular structures, particularly in eyes with reduced scleral compliance. This study investigated the acute effects of water consumption on ocular biometry; AL, central corneal thickness (CCT), anterior chamber depth (ACD), and lens thickness (LT) in myopic and emmetropic young adults. **Methods:** Thirty-two healthy participants (15 emmetropes, 17 myopes; aged 18–25 years) underwent standardized WDT involving ingestion of 100 mL of water per 10 kg of body weight. Biometric parameters were measured at baseline and at 5, 15, 30, and 45 minutes post-ingestion using Lenstar optical biometry (Haag-Streit, Switzerland). Data were analyzed using appropriate parametric and non-parametric tests, with $p < 0.05$ considered statistically significant. **Results:** AL remained stable in myopes ($F(4,64)=1.678$, $p=0.166$) but showed a modest time effect in emmetropes ($\chi^2(4)=10.354$, $p=0.035$). Myopes exhibited consistently longer AL than emmetropes across all time points ($p<0.05$). LT showed a time effect in emmetropes ($p=0.004$) without significant pairwise changes. No significant alterations were observed for CCT or ACD in either group. **Conclusion:** Acute systemic hydration did not significantly affect ocular biometry in myopic young adults, supporting the reliability of single-timepoint measurements for clinical monitoring. The persistent AL disparity between groups highlights inherent structural differences in ocular biomechanics independent of short-term hydration.

INTRODUCTION

Myopia is an escalating global public health concern, projected to affect nearly half of the world's population by 2050 (Holden et al., 2016). The condition arises primarily from excessive elongation of the eyeball, resulting in light focusing anterior to the retina and subsequent visual blur. Beyond its refractive implications, myopia predisposes individuals to sight-threatening complications such as retinal detachment, myopic maculopathy, and choroidal neovascularization (Ohno-Matsui et al., 2021). The key structural determinant of myopia is axial length (AL), which reflects the degree of ocular elongation and serves as a critical metric for progression monitoring and intervention efficacy.

Biomechanically, myopic eyes undergo profound alterations within the scleral tissue. Chronic axial elongation triggers extracellular matrix remodeling, leading to thinning, collagen fiber disorganization, and reduced mechanical stiffness (McBrien et al., 2009; Yu & Zhou, 2022). These changes compromise the sclera's ability to resist deformation from intraocular pressure (IOP) or other transient forces, thereby influencing both ocular structure and function. Furthermore, reduced choroidal blood flow in myopia may disturb scleral hydration and further weaken its biomechanical stability (Zhou et al., 2021).

The water drinking test (WDT), originally developed as a provocative test for glaucoma, provides a controlled physiological challenge that transiently elevates IOP following rapid fluid ingestion (Read & Collins, 2010). This transient IOP elevation reflects a short-term imbalance in aqueous dynamics that may deform ocular structures,

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particularly in eyes with altered biomechanics. Recent local data by Yusof et al. (*in press*) demonstrated that systemic fluid ingestion significantly increases IOP in normal young Malaysian adults, confirming that the WDT effectively induces measurable intraocular stress under real-world conditions. This finding supports the use of WDT as a physiological model to probe the biomechanical resilience of the eye.

Prior studies have reported inconsistent outcomes regarding ocular biometry following WDT. Some observed transient axial shortening in myopic eyes, possibly due to pressure-induced compression of a thinner sclera or choroidal volume changes (Read & Collins, 2010), whereas others found axial elongation, implying heterogeneous scleral responses to fluid loading (Junghans et al., 2013). Given these contradictions, the influence of systemic hydration on ocular biometry remains unclear. Understanding whether hydration affects parameters such as AL, central corneal thickness (CCT), anterior chamber depth (ACD), and lens thickness (LT) is crucial, as such variability could confound biometry-based clinical monitoring in myopia management.

Therefore, this study aimed to investigate the short-term effects of water ingestion on ocular biometry in myopic and emmetropic young adults. By examining time-dependent changes following WDT, this study sought to determine whether myopic eyes exhibit distinct biomechanical responses to transient physiological stress, thereby assessing the reliability of biometric measurements in routine clinical and research settings.

MATERIALS AND METHODS

This cross-sectional study was conducted at the Optometry Clinic, Kulliyyah of Allied Health Sciences, International Islamic University Malaysia (IIUM) Kuantan. Ethical approval was obtained from the IIUM Research Ethics Committee (IREC) (Approval No. IREC 2024-KAHS/DOVS2). The study adhered to the principles of the Declaration of Helsinki for research involving human participants.

Participants

Healthy volunteers aged 18–25 years were recruited and categorized into two refractive groups: emmetropes (spherical equivalent +0.50 D to –0.25 D) and myopes (spherical equivalent < –0.50 D) (Morgan et al., 2010). Participants with ocular disease, prior ocular surgery, pregnancy, systemic illness, or media opacity were excluded. All participants were instructed to abstain from food and drink (including caffeine intake) for at least two hours before testing (Hamdan et al., 2024). Participants were tested at a relatively similar time to prevent diurnal effects on the IOP (Kim et al., 2016).

Sample Size Determination

The target sample size was determined a priori for a mixed (between–within) repeated-measures ANOVA with two groups (myopic vs emmetropic) and five time points (baseline, 5, 15, 30, 45 minutes). Assuming a small-to-medium effect size ($f = 0.25$), $\alpha = 0.05$, power $(1–\beta) = 0.80$, an estimated correlation among repeated measures $r = 0.60$, and nonsphericity correction $\varepsilon = 0.70$, the required total sample size was $N = 28$ (≈ 14 per group). Allowing for attrition, the target enrollment was 30–32 participants. The final sample comprised 32 participants (emmetropes $n = 15$; myopes $n = 17$), satisfying this requirement and providing 80% power to detect $f \geq 0.25$ effects on axial length. Sample size estimation was performed using GPower v3.1 (Faul et al., 2007).

Water Drinking Test Protocol

Following baseline measurements (T_0), each participant consumed 100 mL of water per 10 kg of body weight within five minutes, following the standard water drinking test (WDT) protocol (Raman & Clement, 2020; Yusof et al., 2024). Ocular biometry and systemic parameters were then recorded at 5, 15, 30, and 45 minutes post-ingestion (T_1–T_4).

Ocular and Systemic Measurements

Ocular biometry, including axial length (AL), central corneal thickness (CCT), anterior chamber depth (ACD), and lens thickness (LT), was measured using the Lenstar LS 900 optical biometer (Haag-Streit, Switzerland). Systemic parameters (systolic (SBP) and diastolic (DBP) blood pressure) were measured concurrently using an OMRON HEM-907 digital sphygmomanometer (Omron, Japan), and oxygen saturation (SpO_2) and perfusion index (PI) were recorded using a fingertip pulse oximeter.

Data Analysis

All data were analyzed using IBM SPSS Statistics version 20.0 (IBM Corp., Armonk, NY). The normality of data distribution was assessed using the Shapiro-Wilk test to determine the appropriate statistical approach. For normally distributed data, repeated-measures analysis of variance (ANOVA) was employed to evaluate within-group changes across time points, with Greenhouse-Geisser corrections applied whenever the assumption of sphericity was violated, as determined by Mauchly's test. Non-normally distributed repeated measures were analyzed using the Friedman test. Comparisons between the myopic and emmetropic groups at each time point were conducted using either the independent-samples t-test for normally distributed variables or the Mann-Whitney U test

for non-parametric data. To examine the combined effects of time and refractive group, a mixed (between-within) ANOVA model was applied. Statistical significance was set at $p < 0.05$ for all analyses, and relevant effect sizes were reported where appropriate.

RESULTS

Demographic and Baseline Characteristics

A total of 32 participants were included, 15 emmetropes (11 females, 4 males) and 17 myopes (all females). A significant age difference was observed between the groups (U = 77, z = –2.089, p = 0.037), with emmetropes (median = 23 years) being slightly older than myopes (median = 22 years). No significant differences were found in weight (U = 94.50, p = 0.210) or baseline pulse rate (t(30) = 0.124, p = 0.902). As expected, participants' refractive errors in spherical equivalent (SE) differed significantly between groups (U < 0.001, p < 0.001), with myopes showing higher refractive error (median = -6.00 D) compared to emmetropes (median = –0.25 D). Baseline axial length (AL) was also significantly longer in myopes (U = 27, p < 0.001). The demographic and baseline characteristics are summarized in Table 1.

Table 1: Demographic and baseline ocular characteristics of emmetropic and myopic participants. Data are presented as mean ± standard deviation (SD) for normally distributed variables and as median (interquartile range, IQR) for non-normal data (#). *P*-values represent between-group comparisons (emmetropic vs myopic), either using the t-test or the Mann-Whitney U test. Significant differences at $p < 0.05$ are indicated in bold.

Variable	Emmetropic (n=15, 11 females, 4 males)	Myopic (n=17, 17 females)	Test Statistic	p
Age (years)#	23 (1)	22 (2)	*U* = 77	**0.037**
Weight (kg)#	65 (30)	50 (25)	*U* = 94.50	0.210
Spherical Equivalent, SE (D)#	-0.25 (0.25)	-6.00 (3.75)	*U* < 0.001	**<0.001**
Pulse Rate (BPM)	76.97 ± 6.21	76.59 ± 10.45	t (30) = 0.124	0.902
Baseline AL (mm)#	23.86 (0.69)	25.91 (1.81)	*U* = 27	**<0.001**

Axial Length (AL)

For emmetropic eyes, AL data were non-normally distributed (Shapiro-Wilk $p < 0.05$). A Friedman test revealed a significant difference in AL across time points ($\chi^2(4) = 10.354$, $p = 0.035$). Post-hoc pairwise comparisons with a Bonferroni adjustment revealed a significant decrease in AL from T_1 to T_3 ($p = 0.032$). In contrast, AL data in myopic eyes were normally distributed ($p > 0.05$), and repeated-measures ANOVA showed no significant variation over time ($F(4,64) = 1.678$, $p = 0.166$). Between-group comparisons at each time point showed consistently greater AL in myopes than emmetropes ($p < 0.05$ at all intervals). Figure 1 illustrates AL trends across time points in both groups.

Central Corneal Thickness (CCT)

Mauchly's test indicated violation of sphericity in both emmetropic (W = 0.150, p = 0.006) and myopic groups

(W = 0.206, p = 0.007); therefore, Greenhouse-Geisser corrections were applied. Repeated-measures ANOVA revealed no significant temporal change in CCT for emmetropes ($F(2.105,29.475) = 0.463$, $p = 0.644$, partial $\eta^2 = 0.032$) or myopes ($F(2.211,35.370) = 1.094$, $p = 0.351$, partial $\eta^2 = 0.064$).

Anterior Chamber Depth (ACD)

ACD data were normally distributed except at one time point (T_2, $p = 0.023$). Using repeated-measures ANOVA with Greenhouse-Geisser correction (emmetropes: W = 0.037, p < 0.005; myopes: W = 0.223, p = 0.011), no significant effect of time was found for either group (emmetropes: $F(1.661,23.248) = 2.569$, $p = 0.106$, partial $\eta^2 = 0.155$; myopes: $F(2.345,37.523) = 0.819$, $p = 0.456$, partial $\eta^2 = 0.049$).

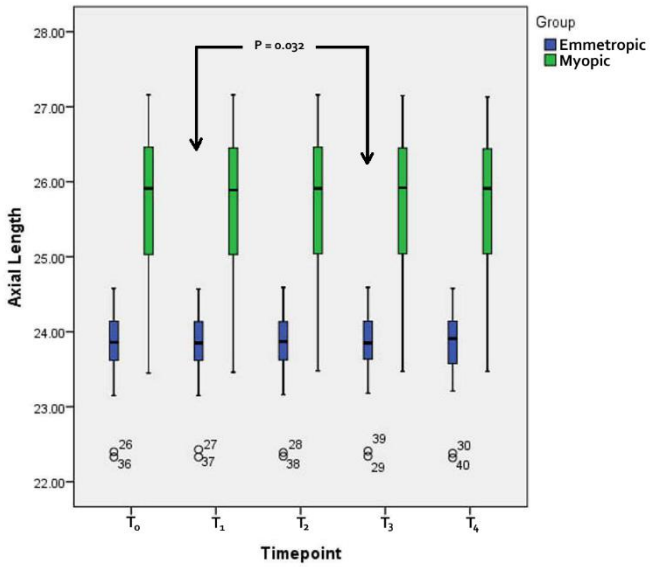

Figure 1: Distribution of axial length (AL) measurements in emmetropic and myopic eyes at baseline (T_0) and four subsequent timepoints (T_1–T_4) following water ingestion. Boxes represent the interquartile range (IQR), the horizontal line indicates the median, whiskers denote 1.5×IQR, and circles represent outliers. The Bonferroni post hoc test indicates a significantly greater AL at T_1 than at T_3.

Lens thickness (LT)

LT data met normality assumptions across all time points. In emmetropes, sphericity was violated (χ^2 (9) = 43.361, p < 0.001); after Greenhouse–Geisser correction, a significant time effect was observed (F (1.870,26.184) = 7.319, p = 0.004, partial η^2 = 0.343). Post-hoc pairwise comparisons with a Bonferroni adjustment revealed a significant decrease in LT from T_0 to T_2 (p = 0.004), from T_3 to T_2 (p = .001), and from T_4 to T_2 (p=0.014). In myopes, no significant temporal changes were detected (F (2.669,42.711) = 0.372, p = 0.751, partial η^2 = 0.023).

Systemic Parameters

Systolic Blood Pressure (SBP) showed a significant overall effect of time (emmetropes: F(4,56) = 3.248, p = 0.017, η^2 = 0.169; myopes: F(4,56) = 2.566, p = 0.048, η^2 = 0.115), but no significant time × group interaction (p = 0.088). Diastolic Blood Pressure (DBP) showed no significant changes over time (emmetropes: $\chi^2(4)$ = 3.891, p = 0.421; myopes: F(1.81,29.03) = 2.027, p = 0.153).

Oxygen Saturation (SpO_2) remained stable across all time points in both groups (emmetropes: $\chi^2(4)$ = 1.221, p = 0.875; myopes: $\chi^2(4)$ = 7.300, p = 0.121). Perfusion Index (PI) showed significant decreases across time in both groups (emmetropes: p = 0.003; myopes: p = 0.002–0.001), but no between-group difference (p > 0.05). Table 2 summarizes the biometric and systemic data across time intervals.

Table 2: Mean ± standard deviation (or median for non-normal data) of ocular and systemic parameters: axial length (AL), central corneal thickness (CCT), anterior chamber depth (ACD), lens thickness (LT), systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygen saturation (SPO_2), and perfusion index (PI), measured at five time intervals (T_0 = baseline; T_1 = 5 min; T_2 = 15 min; T_3 = 30 min; T_4 = 45 min) following water ingestion in emmetropic and myopic participants. *p* values represent within-group comparisons across time points. Data are expressed as mean ± standard deviation (SD) for normally distributed variables and as median (interquartile range, IQR) for non-normal data.

Group	Parameter	Time Interval					p*
		T_0	T_1	T_2	T_3	T_4	
Emmetropic (n = 15)	**AL (mm)‡**	23.86 (0.69)	23.85 (0.69)	23.87 (0.69)	23.81 (0.68)	23.91 (0.71)	**0.035†**
	CCT (mm)	555.13 ± 31.30	554.27 ± 32.88	555.33 ± 32.99	555.20 ± 33.05	555.13 ± 32.99	0.644
	ACD (mm)	3.20 ± 0.15	3.20 ± 0.15	3.21 ± 0.15	3.20 ± 0.16	3.19 ± 0.17	0.106
	LT (mm)	3.48 ± 0.18	3.47 ± 0.17	3.45 ± 0.19	3.48 ± 0.19	3.49 ± 0.19	**0.004†**
	SBP (mmHg)	112.2 ± 13.0	109.0 ± 11.0	107.1 ± 15.6	108.1 ± 15.0	109.33 ± 13.1	**0.017†**
	DBP (mmHg)‡	71.0(14)	71.0(12)	68.0(13)	74.0(13)	71.0(15)	0.421
	SPO2 (%)‡	98(2)	98(1)	98(0)	98(1)	98(0)	0.875
	PI (%)‡	3.4(2.7)	2.1(3.2)	3.2(3.7)	2.1(2.7)	2.3(1.4)	**0.021†**
Myopic (n = 17)	**AL**	25.64 ± 1.12	25.64 ± 1.12	25.65 ± 1.12	25.65 ± 1.12	25.64 ± 1.12	0.166
	CCT	549.35 ± 22.16	547.94 ± 21.13	548.82 ± 20.29	549.24 ± 20.52	549.24 ± 20.68	0.351
	ACD	3.16 ± 0.25	3.18 ± 0.24	3.17 ± 0.26	3.17 ± 0.27	3.17 ± 0.26	0.456
	LT	3.56 ± 0.14	3.56 ± 0.14	3.57 ± 0.15	3.56 ± 0.14	3.57 ± 0.14	0.751
	SBP (mmHg)	106.94 ± 10.49	107.76 ± 12.43	107.06 ± 14.99	101.47 ± 11.86	104.06 ± 13.53	**0.048†**
	DBP (mmHg)	72.82 ± 8.68	76.37 ± 12.80	78.82 ± 18.76	72.47 ± 13.90	72.71 ± 13.60	0.153
	SPO2 (%)‡	98(1)	98(1)	98(0)	98(2)	98(0)	0.121
	PI (%)#	3.7(3.2)	1.7(1.9)	2.6(2.4)	1.8(1.9)	1.5(2.2)	**0.005†**

‡ Data deemed as not normal

* p values represent within-group comparisons across time points

† significant p value within-group comparisons across time points

DISCUSSION

This study examined the acute influence of systemic hydration, induced through the water drinking test (WDT), on ocular biometry in myopic and emmetropic eyes. The principal finding was that axial length (AL) in myopic eyes remained stable following water ingestion, whereas emmetropic eyes demonstrated small but statistically significant fluctuations. These results suggest fundamental biomechanical differences between refractive groups, consistent with the adaptive remodeling of scleral tissue in myopia.

The observed AL stability among myopes contrasts with previous reports of transient axial shortening (Read & Collins, 2010) and elongation (Junghans et al., 2013) after WDT, differences that may reflect variation in methodology, sample characteristics, or myopia severity. In the present cohort, the absence of measurable AL change in myopes may reflect altered scleral biomechanics secondary to chronic tissue remodeling. Although progressive myopia is associated with collagen disorganization and reduced intrinsic stiffness (McBrien et al., 2009; Yu & Zhou, 2022), such remodeling also increases viscoelastic damping and reduces the sclera's ability to respond dynamically to short-term pressure fluctuations. Consequently, despite its long-term susceptibility to gradual axial elongation, the myopic sclera may exhibit limited immediate deformation during transient IOP elevations, such as those induced by the water drinking test.

Notably, Yusof et al. (*in press*) confirmed that fluid ingestion elicits a short-term IOP rise in young Malaysian adults. The present study complements that work by demonstrating that, despite the IOP increase expected under similar physiological stress, ocular biometry particularly AL remained unchanged in myopic participants. This implies that the myopic eye, though structurally elongated, behaves as a mechanically stable compartment under transient IOP load, reinforcing the concept of adaptive rather than purely weakened scleral remodeling.

In contrast, the modest AL variability observed in emmetropes may reflect preserved posterior ocular compliance, consistent with the choroid's capacity for rapid volume adjustment in response to hydration and perfusion changes (Zhou et al., 2021). While the fluctuation was not clinically significant, it suggests a more elastic posterior segment capable of dynamic compensation, which likely represents a protective biomechanical feature in non-myopic eyes.

No significant time-dependent effects were observed for CCT, ACD, or LT in either group, indicating that anterior segment structures are minimally influenced by short-term systemic hydration. This finding aligns with the concept of effective ocular autoregulation, wherein corneal and anterior chamber geometries remain stable despite systemic or IOP variations (Luo et al., 2015).

Systemic responses, including increases in systolic blood pressure (SBP) and perfusion index (PI), were consistent with the sympathetic reflex described in previous WDT studies (Jordan et al., 2000; Guidoboni et al., 2014). However, the lack of accompanying biometric change reinforces the eye's resistance to short-term hemodynamic perturbation (Flammer et al., 2013). Collectively, these findings suggest that the posterior segment, particularly in myopia, exhibits stable viscoelastic behavior even when transiently challenged by systemic fluid shifts.

Clinically, this stability is important for interpreting serial axial length data in myopia control. Since hydration-induced variability appears negligible, clinicians can be confident that routine biometry accurately reflects structural progression rather than short-term physiological noise. The consistent AL difference between refractive groups, independent of hydration, underscores the reliability of AL as a biomarker for myopia monitoring.

Future studies should expand sample diversity, incorporate varying myopia severities, and integrate optical coherence tomography (OCT) based choroidal imaging to elucidate the interplay between hydration, choroidal perfusion, and scleral biomechanics. Combining IOP tracking with real-time biometry, building on Yusof et al. (*in press*), may further clarify the dynamic relationship between intraocular pressure fluctuations and structural stability in myopia.

In summary, systemic hydration induced by the WDT produced no significant biometric changes in myopic eyes. Together with evidence from Yusof et al. (*in press*), these findings suggest that although IOP may transiently rise after fluid ingestion, the myopic globe maintains mechanical stability. The inherent rigidity of the remodeled sclera appears to buffer against short-term physiological stress, reaffirming the reliability of AL as a clinical parameter for myopia management.

CONCLUSION

Systemic hydration through the water-drinking test induced short-term systemic changes but did not measurably affect ocular biometry in myopic young adults.

In contrast, emmetropic eyes exhibited small yet statistically detectable axial-length fluctuations, reflecting greater posterior-segment compliance. Overall, these results suggest that the myopic eye maintains mechanical stability under transient physiological stress, consistent with adaptive scleral remodeling rather than structural fragility.

Clinically, this biomechanical stability supports the use of axial length as a reliable indicator of myopia progression, unaffected by short-term hydration or pressure fluctuations. Complementing the transient IOP elevations reported by Yusof et al. (*in press*), the present findings emphasize that functional pressure changes do not necessarily produce structural deformation. Future work integrating real-time biometry with choroidal imaging should further clarify the dynamic interplay among ocular biomechanics, hydration, and intraocular pressure in myopia.

AUTHOR DECLARATIONS

Competing Interests

The authors declare no conflict of interest related to the conduct or publication of this study.

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Authors' Contributions

All authors contributed substantially to the conception, design, data collection, analysis, and interpretation of results. A.I.A. and N.S.C.M.Z. conducted data collection, analysis, and initial manuscript drafting. M.A.S.A.R., M.M.S., and N.S.S. verified data analysis, critically revised the manuscript for intellectual content. F.Y. supervised the study, verified data analysis, critically revised the manuscript for intellectual content, and approved the final version for submission. All authors read and approved of the final manuscript.

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REFERENCES

Flammer, J., Konieczka, K., Bruno, R. M., Virdis, A., Flammer, A. J., & Taddei, S. (2013). The eye and the heart. *European Heart Journal*, 34(17), 1270–1278. https://doi.org/10.1093/eurheartj/eht023

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). *G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191. https://doi.org/10.3758/BF03193146

Guidoboni, G., Harris, A., Cassani, S., Arciero, J., Siesky, B., Amireskandari, A., Tobe, L., Egan, P., Januleviciene, I., & Park, J. (2014). Intraocular Pressure, Blood Pressure, and Retinal Blood Flow Autoregulation: A Mathematical Model to Clarify Their Relationship and Clinical Relevance. *Investigative Ophthalmology & Visual Science,* 55(7), 4105. https://doi.org/10.1167/iovs.13-13611

Hamdan, N., Sabere, A., Ruslan, A., Buari, N., Abdul Rahim, M., Che Azemin, M., & Yusof, F. (2024). The Short-term Effects of Coffee and Caffeine on Intraocular Pressure in Healthy Subjects. *Journal of Health Science and Medical Research, 42*(6), e20241108. http://dx.doi.org/10.31584/jhsmr.20241108

Holden, B. A., Fricke, T. R., Wilson, D. A., Jong, M., Naidoo, K. S., Sankaridurg, P., Wong, T. Y., Naduvilath, T. J., & Resnikoff, S. (2016). Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050. *Ophthalmology,* 123(5), 1036–1042. https://doi.org/10.1016/j.ophtha.2016.01.006

Jordan, J., Shannon, J. R., Black, B. K., Ali, Y., Farley, M., Costa, F., Diedrich, A., Robertson, R. M., Biaggioni, I., & Robertson, D. (2000). The pressor response to water drinking in humans: a sympathetic reflex? *Circulation,* 101(5), 504–509. https://doi.org/10.1161/01.cir.101.5.504

Junghans, B., Chang, C.-J., Siu, A., Soesanto, N., Tu, M., Murphy, M., & Crewther, S. (2013). Intraocular Pressure in Myopic Eyes during the Water Drinking Test. *Investigative Ophthalmology & Visual Science*, 54(15), 1912–1912. https://iovs.arvojournals.org/article.aspx?articleid=2146562

Kim SH, Lee EJ, Han JC, Sohn SW, Rhee T, Kee C. (2016) The Effect of Diurnal Fluctuation in Intraocular Pressure on the Evaluation of Risk Factors of Progression in Normal

Tension Glaucoma. *PLoS One*, 24;11(10):e0164876. https://doi.org/10.1371/journal.pone.0164876.

Luo, X., Shen, Y., Jiang, M., Lou, X., & Shen, Y. (2015). Ocular Blood Flow Autoregulation Mechanisms and Methods. *Journal of Ophthalmology*, 2015, 1–7. https://doi.org/10.1155/2015/864871

McBrien, N. A., Jobling, A. I., & Gentle, A. (2009). Biomechanics of the Sclera in Myopia: Extracellular and Cellular Factors. *Optometry and Vision Science,* 86(1), E23–E30. https://doi.org/10.1097/opx.0b013e3181940669

Morgan, I. G., Rose, K. A., & Ellwein, L. B. (2010). Is emmetropia the natural endpoint for human refractive development? An analysis of population-based data from the refractive error study in children (RESC). *Acta Ophthalmologica,* 88(8), 877–884. https://doi.org/10.1111/j.1755-3768.2009.01800.x

Ohno-Matsui, K., Wu, P.-C., Yamashiro, K., Vutipongsatorn, K., Fang, Y., Cheung, C. M. G., Lai, T. Y. Y., Ikuno, Y., Cohen, S. Y., Gaudric, A., & Jonas, J. B. (2021). IMI Pathologic Myopia. *Investigative Ophthalmology Visual Science*, 62(5), 5. https://doi.org/10.1167/iovs.62.5.5

Raman, P., & Clement, C. (2020). The water drinking: Practical Tips. *Malaysian Society of Ophthalmology Express*, (15), 6-8. https://mso.org.my

Read, S. A., & Collins, M. J. (2010). Water drinking influences eye length and IOP in young healthy subjects. *Experimental Eye Research*, 91(2), 180–185. https://doi.org/10.1016/j.exer.2010.04.015

Yu, Q., & Zhou, J. B. (2022). Scleral remodeling in myopia development. *International Journal of Ophthalmology*, 15(3), 510–514. https://doi.org/10.18240/ijo.2022.03.21

Yusof F. A., Mohammad N. A., Hilmi M. R. (in press). Effects of Fluid Ingestion on Intraocular Pressure in Normal Young Malaysian Adults, *Malaysian J Med Health Sci*, (In press)

Zhou, X., Ye, C., Wang, X., Zhou, W., Reinach, P., & Qu, J. (2021). Choroidal blood perfusion as a potential "rapid predictive index" for myopia development and progression. *Eye and Vision*, 8(1). https://doi.org/10.1186/s40662-020-00224-0