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Comprehensive Evaluation of Dehydration Impact on Ocular Tissue During Ramadan Fasting

Javad Heravian[1,2], Mohsen Nematy[3], Negare Yazdani[2], Abbas Azimi[1,2], Hadi Ostadimoghaddam[1,2], Abbasali Yekta[1,2], Seyed Hosein Hoseini-Yazdi[4]

1. Refractive Errors Research Center, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
2. Department of Optometry, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran
3. Biochemistry and Nutrition, Endoscopic & Minimally Invasive Surgery, and Cancer Research Centers, Department of Nutrition, School of Medicines, Mashhad University of Medical Sciences, Mashhad, Iran
4. Contact Lens and Visual Optics Laboratory, School of Optometry and Vision Science, Queensland University of Technology, Brisbane, Australia

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ABSTRACT

Purpose: The present study aimed to review the effect of dehydration during Ramadan fasting on the health and ocular parameters leading to changes in eye function.
Methods: Articles included in the study were taken from PubMed, Ovid, Web of Science and Google Scholar up to 2014. Related articles were also obtained from scientific journals on fasting and vision system.
Results: Dehydration and nutrition changes in Ramadan cause an increase in tear osmolarity, ocular aberration, anterior chamber depth, IOL measurement, central corneal thickness, retinal and choroidal thickness, and also a decrease in IOP, tear secretion, and vitreous thickness.
Conclusion: Much research related to the effect of dehydration on ocular parameters during Ramadan fasting exists. The findings reveal association with significant changes on ocular parameters. Thus, it seems requisite to have a comprehensive study on "fasting and ocular parameters", which will be helpful in making decisions and giving plan to the patients.

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Introduction

Ramadan is the holiest month in the Islamic calendar. Since it is a lunar-based calendar, a month's duration varies between 29 and 30 days. Muslims fast every day from dawn to sunset and refrain from drinking and eating in this period; however, there are no restrictions on food or fluid intake between sunset and dawn. The period of fast may vary depending on the geographical location of the country and the season of the year (1). Modification of meal frequency and eating patterns during Ramadan may affect different aspects of human health (2). Water loading due to changed eating habits and periods may affect IOP, tear secretion, and maybe, corneal and anterior chamber parameters (3). It is known that oral water loading transiently elevates intraocular pressure (IOP) through mechanisms that remain unexplained (4). Accordingly, Kayikcioglu and Guler, and Indriss, Anas and Hicham found no significant effects on IOP (5,6). Dadeya and colleagues (7) found significantly lower IOP values during fasting at all four times of day studied, whereas Kerimoglu et al (3) showed that during Ramadan fasting, the IOP increase in the early morning period and decrease before sunset compared to non-fasting. They also found no significant difference in central corneal thickness (CCT) between fasting and non-fasting periods. As shown in several studies, fasting influences a variety of physiological parameters that can impact the ocular system, triggering a fall in insulin secretion and a rise in glucagon and sympathetic activity, which can lead to free fatty acid release and elevated norepinephrine and cortisol concentration (8,9). With respect to the

* *Corresponding author:* Mohsen Nematy, Department of Nutrition, School of Medicine, Biochemistry and Nutrition, Endoscopic & Minimally Invasive Surgery, and Cancer Research Centers, Mashhad University of Medical Sciences, Paradise Daneshgah, Azadi Square, Post code 91779-48564, Po BOX: 91775-379, Mashhad, Iran. Tel: +98(51)38002103 (direct), 38002107 & 38827033 (Secretary); Fax: +98 (51) 38002421; Mobile: +989153218798; E-mail: NematyM@mums.ac.ir

suggested role of these hormones in retinal hyperperfusion and increased intraocular pressure (IOP), one may anticipate a hypothetical distortion of ocular parameters during Ramadan (10,11). Fasting can affect lipid profile, melatonin, cortisol and electrolytes, which are also demonstrated to have a remarkable impact on ocular function. Weight loss and dehydration are among the physiological characteristics that undoubtedly affect fasting individuals; water deprivation in those who observe the fast has been functionally demonstrated to have a significant influence on the serum levels of sodium, chloride, bicarbonate, potassium, hematocrit, albumin, creatinine, urea and urinary osmolality (7, 12-15). It is well known that serum electrolytes affect ocular blood flow and IOP. Sodium and bicarbonate modulating systems, renin-angiotensin system and carbonic anhydrase are among the pathways modified to control IOP and glaucoma (16,17). Total fluid intake during the weeks of fasting was lower when compared with the prefasting level or to the fluid intake at the end of Ramadan. This was in spite of the significantly higher fluid intake at night ($P < 0.001$) during Ramadan, when compared to the intake at the end of fasting. Fluid intake during the night before fasting was higher than the intake at the end of Ramadan and indicated that the subjects voluntarily increased their fluid intake in anticipation of fasting the next morning (18). It can be seen that the maximum fluid deficit occurred at the beginning of the 3rd week and was 2.75 L, equivalent to a mean loss of total body-weight of 2.7±0.6% (18). However, the total fluid intake during Ramadan remained lower than normal and together with the diuresis at night a negative fluid balance developed in all subjects (18). After 1 month of fasting, body weight, body mass index (BMI) and the waist circumference (WC) decreased significantly compared to before Ramadan. This weight loss was reflected in the body composition, by a reduced fat mass (FM), total body water (TBW) and muscle mass (MM) (19). Total body water content was altered significantly during the first week of fasting as compared with values observed before the beginning of fasting (2). AL-Hourani and Atoum findings indicated Ramadan fasting affected body weight, BMI, body water percentage and body fat percentage (2).

Material and methods

The following steps were taken to find all studies regarding dehydration impact on ocular parameters during Ramadan fasting. Two review authors independently assessed the titles and abstracts of all reports, and pertinent articles were identified through a multistage systematic approach. At first a computerized search of databases: PubMed, Sciencedirect, Ovid and also Google Scholar were performed to identify all articles concerning "fasting and eye changes" up to 2014. There were no date or language restrictions. The terms "fasting", "ocular", "eye", "dehydration" and "Ramadan" were used for a comprehensive search. Second, the abstracts of all articles were carefully scanned to determine which was pertaining to the topic. Finally all the papers were reviewed to identify which ones noted the effect of fasting on ocular tissue. Dehydration and altered nutrition were considered as causes for any changes in ocular parameters.

Results

The electronic searches retrieved 18 records. After removing the duplicates, titles and abstracts underwent initial screening and 13 appeared to be relevant, which were published in 11 Journals: Journal of research in medical science (1), Eye (2), Eye and contact lens (1), Sudanese Journal of Ophthalmology (1), Clinical and Experimental Optometry (1), Experimental Eye Research (1), Acta Ophthalmologica Scandinavica (1), Acta Medica (1), Singapore Med J (2), Diabetes Metabolic Syndrome and Obesity (1) and Br J Nutr (1). The results are presented in the discussion section.

Discussion

Tear layer: The eye is covered by a thin, fluid film that serves several functions. Tear film has fundamental roles in the optical system, provides lubrication, nutrients and growth factors for epithelium, and serves as a barrier to the outside environment (20,21). Stability and functionality of tear film plays an important role in ocular surface diseases. Tear osmolarity was suggested as the key driver for normal homeostasis in tear film dynamics, and increased level of osmolarity was found a reliable indicator of dry eye syndrome (22). As dehydration is expected to happen during the fasting period, tear osmolarity may be an alternative method for the assessment of tear film functions and dynamics during Ramadan (23). Tear osmolarity significantly increased during the fasting period compared with the non-fasting period (P=0.02), whereas Schirmer I values decreased (P, 0.001) (23). The correlation of the water intake with tear osmolarity during non-fasting and fasting periods was also assessed. Pearson correlation coefficient was found as 20.371 (P=0.05) during non-fasting and interpreted as moderately negatively correlated, whereas this correlation was low during fasting (Pearson correlation coefficient=0.076, P=0.678). The correlation of water intake during fasting and the amount of osmolarity difference between 2 time periods was also low (Pearson correlation coefficient=0.086) (23). Comparison of measurements between fasting and non-fasting periods at 0800 hours revealed significantly higher values for reflex tear secretion (RTS) (P=0.006), and basal tear secretion (BTS) (P=0.014) during fasting, conversely at 1600 hours, no statistically significant difference was noted for RTS and BTS (3). H Kerimoglu (3) highlighted an important aspect of Ramadan fasting and suggested that fluid loading at the pre-dawn meal might increase the tear secretion in the early morning period. Kayikcioglu et al, found that religious fasting in the winter season did not affect BTS in healthy individuals (24). They found only a 0.2 mm decrease in BTS between 0800 and 1700 hours during the fasting period and significantly higher RTS and BTS values at 0800 hour measurement during fasting compared with non-fasting period, and the values decreased remarkably with a mean of 2.71±8.55 and 3.06±6.37mm, respectively, at 1600 hours in the fasting group. Higher values of RTS and BTS in the morning in fasting group compared with non-fasting group may also be explained with water loading at the pre-dawn meal a few hours before (24). According to electrophoresis results, most of individual proteins slightly decreased in fasting compared to non-fasting samples (25). Quantity of the enzyme decreased in fasting samples (25). HPLC analysis of tear samples indicated that the most of proteins have decreased in fasting state (25). Fasting has been shown to have a profound effect on sympathetic nervous system, best characterized by an increase in adrenergic stimulation and reduced tissue sensitivity tocatecholamines (26-29). Secretion of protein in lacrimal gland is based on nervous regulations. Thus, when the sympathetic nervous system is more active in fasting state, protein secretion is decreased. The results of another study indicated that predawn fluid loading increases tear secretion in the early morning, whereas dehydration due to fasting for a 12 h period causes a decrease (4). Sariri *et al.* have reported a decrease in the level of some proteins as well as a decrease in the activity of lysozyme, lactoferrin and alpha amylase in tear during fasting (30). Rabbanikhah *et al.* described a decrease in tear break time (1.8 s) and (BTS, 2.1 ml) at 5:00 p.m. in the 3rd week of Ramadan compared to 8:00 a.m. 1 week before Ramadan (P<0.0001) (30,31). Data collection appears in Table 1.

Ocular aberrations: Optical aberrations of the human eye degrade the quality of the retinal image and may, therefore, represent a major limit of visual acuity**.** Ocular aberrations were reported to be negatively correlated with ocular tear film stability in previous studies (32,33). Patients with dry eyes have larger optical aberrations than normal eyes do, which was based on the surface irregularity of the cornea in dry eye patients (33). In Bengu Ekinci Koktekir study, there was a slight increase in ocular aberrations after 13 hr of fasting; however, the differences were statistically insignificant (23).

Table 1. Tear changes during fasting and non-fasting periods

	Non-fasting	Fasting	P-value
Osmolarity(mOsm/L)	285.6±8.2	293.3±16	0.02
Schirmer I test(mm)	14.8±6.0	10.6±5.3	<0.001
RTS(mm/5min)	-2.51±8.38	2.71±8.55	0.06
	0.38±6.18 (25)	3.06±6.37	0.04
BTS(mm/5min)	19.9 ± 10.9 (26)	19.7 ± 11.5	0.9
	15.9±7.0 (33)	14.7±6.9	<0.001
	8.0±1.9 (24)	7.2±2.1	0.08
Tear break-up time(sn)	20.05 ± 9.33 (26)	23.6 ± 14.9	0.19
	16.7±6.3 (33)	14.5±5.0	<0.001

Table 2. Evaluation of IOP during fasting and non-fasting periods

	Non-fasting	Fasting	P-value
IOP	13.6±3.0 (24)	12.0±2.3	0.001
	-1.10±3.28 (25)	2.45±2.67	<0.001

Intraocular pressure: Intraocular pressure is the fluid pressure inside the eye determined by tonometry. IOP is an important aspect in the evaluation of patients at risk from glaucoma. IOP of 10-20 mm Hg is currently defined normal by ophthalmologists and optometrists. Intraocular pressure measurements during non-fasting and fasting periods were found as 13.663.0 mm Hg (9–21 mm Hg) and 12.062.3 mm Hg (6–16 mm Hg), respectively, which was statistically significant (P=0.001) (23). Kerimoglu et al. reported that there is a double response in IOP, including a rise in the morning because of predawn meal and more fluid intake and a decrease in the afternoon because of dehydration (4). Depletion of lipid stores during fasting may diminish prostaglandin secretion, thereby resulting in a decrease in IOP (34). Melatonin has a proposed role in the diurnal rhythm of IOP (35). Comparison of measurements between fasting and non-fasting periods at 0800 hours revealed significantly higher values for IOP (P¼=0.005) (3). There is evidence from earlier studies that drinking 1 L of water increases the IOP, with a mean maximum increase of 4.4 mmHg for more than 2 h in healthy eyes (36). Kerimoglu highlighted an important aspect of Ramadan fasting and suggested that fluid loading at the pre-dawn meal might increase the IOP in the early morning period (3). IOP was uniformly reduced for each time of the day during the fasting period compared to the mean after the fasting period. The probable reason for the alteration of intra-ocular pressure might be that reduced water intake causes reduced aqueous formation and thereby a decrease in intra-ocular pressure. Secondly, fatty stores, which are depleted during fasting, cause decreased secretion of prostaglandin thereby causing decreased intra-ocular pressure (34). Scott A. revealed that water-drinking was found to lead to significant changes in IOP. Repeated measures ANOVA revealed a highly significant effect of time on IOP (p <0.0001), indicating a significant increase in IOP following water loading (37). Changes in electrolytes, carbonic anhydrase activity and renin-angiotensin system can alter IOP (38,39). In fasting, individuals drink much water and other fluids before dawn and after dusk. This leads to a reduced plasma osmolality and increase in IOP in healthy persons (<8 mmHg) (3). Mean IOP change is reported in Table 2.

Refractive status: The dioptric power of ametropia of the eye is called refractive error. There were no significant differences in spherical equivalent and corneal astigmatism; the spherical equivalent mean (SEM) was -0.006 _ 0.30 D(range, -2.75 to 3.75 D), 0.13 _ 0.32 D(range, -2.25 to 4.25 D) and 0.15 _0.31 D (range, -2.75 to 4.00 D) before Ramadan, while fasting and after Ramadan, respectively (40).In principle, dehydration during the fasting month might lead to refractive changes in the crystalline lens through either change in the refractive index, lens thickness, radii of curvature or combination. These changes in combination with possible changes in the refractive index of the dehydrated vitreous could offset the refractive consequences of a change in axial length resulting in little or no change in refraction (40).

Keratometry indexes: Nowroozzadeh noted that there were no significant differences in mean keratometry, flatter and steeper corneal radii of curvature[40]as Alameen also found that K-readings showed no differences in the measurements between the fasting and the fed state (41). Data is collected in Table 3.

Anterior chamber depth (ACD): ACD average length is 3.1 mm with normal range of 2.96-3.06 (42). ACD measurements were significantly increased during Ramadan fasting compared with baseline measurements and returned to baseline one month after Ramadan (40). The ACD measurements were significantly larger at 8:00 am during fasting compared with 4:00 pm (p = 0.01) (40). ACD might be influenced by daily fluctuations of water intake and hydration status of the body (40). In the case of anterior chamber depth, the difference

Table 3. Keratometry changes during fasting and non-fasting periods

	Non-fasting	Fasting	P-value
K1 reading(D) (44)	42.42±0.97	42.47±0.98	0.8
K2 reading(D) (44)	43.03±1.09	43.36±1.12	0.7
Mean keratometry(D) (43)	44.03±0.29	44.01±0.29	0.899
R1(mm) (43)	7.69±0.05	7.70±0.05	0.863
R2(mm)[43]	7.52±0.09	7.59±0.05	0.414

Table 4. Comparison of ACD between fasting and non-fasting periods

	Non-fasting	Fasting	P-value
ACD	2.93±0.31(44)	2.77±0.39	0.02
	3.22±0.07(43)	3.72±0.15	<0.001

Table 5. Comparison of AL between fasting non-fasting periods

	Non-fasting	Fasting	P-value
Axial length(mm)	23.35±0.87(44)	23.10±0.97	0.08
	23.09±0.14(43)	22.83±0.17	<0.001

between the fasting state and the fed state was 0.165 mm, and it is longer in the fed state than in the fasting state (40). Anterior chamber depth exhibited a small increase on average from baseline levels (mean baseline ACD 3.18 _ 0.08) following water drinking, however the changes were not statistically significant (p >0.05) (37). Data collection is displayed in Table 4.

Axial length (AL): Hashemi et al reported the normal range of AL as 22.93-23.33 with mean of 23.13 (42). Axial length was significantly decreased during Ramadan fasting compared with baseline measurements and returned to baseline one month after Ramadan (40). Axial length significantly decreased during Ramadan fasting. Theoretically, the dehydration occurring during fasting periods can shrink the vitreous humor and subsequently decrease the axial length.[5] In addition; vitreous dehydration might result in changes in its acoustic properties leading to inaccurate axial length measurement with ultrasonic instruments, which assume a predetermined average value for sound speed in the vitreous. A 0.251 mm difference was recorded in axial length between the fasting state and the fed state. The axial length was longer in the fed state (41). In our population of young healthy adult subjects, water-drinking was found to lead to significant changes in axial length.[37]The changes we have observed in axial length following water loading could potentially be due to changes in choroidal thickness (37). Data collection appears in Table 5.

Intraocular lens (IOL): Three important parameters in calculating the IOL power are the corneal power, axial length, and anterior chamber depth (43). IOL power calculation measurements were significantly increased during Ramadan fasting compared with baseline measurements and returned to baseline one month after Ramadan (40). Decrease in axial length was significantly correlated with increase in ACD and IOL power calculations (Pearson correlation coefficient: -0.64 [for ACD] and-0.80 [for either formula])(40). The increase in ACD was significantly correlated with the increase in IOL power calculation (Pearson correlation coefficient: -0.64 and-0.67, for SRK-2 and SRK-T formulae, respectively)(40). There were significant correlations between changes in axial length or ACD after fasting (8.00 am) and the resultant changes in SRK-2 or SRK-T formulae (40). Ramadan fasting can confound the IOL power calculation and might lead to post-operative refractive errors (40). Intraocular lens power calculation, while the volunteers were in the fasting state, resulted in a lens power that is 1.06 D higher than the IOL power in the fed state. This change is statistically significant (P=0.030) (41). Mean changes are gathered in Table 6.

Visual acuity: Assadi et al reported that visual acuity in 1st week (0.0483 ± 0.0173 [left] and 0.0345±0.0087 [right]) was not statistically different from those of 3rd week (0.0517 ± 0.0173 [left] and 0.0310 ± 0.0078 [right]). They did not observe a significant difference between visual acuity of two measurements in a single day, either (44).

Corneal parameters: Kerimoglu et al observed a slight increase in the CCT in 0800 hour measurement in fasting period (540.8±33.02 mm) compared with the afternoon measurement (535.03±35.75 mm), which might also be as result of fluid loading at the pre-dawn meal, but the difference was not statistically significant (4). The normal range of CCT was reported as 546.59-552.07 with mean of 549.33 (42). Central corneal thickness (CCT) was the only variable to show a significant change after water drinking. The mean CCT at baseline was 530.9 _ 6.3 mm, which showed a small but significant reduction following water-drinking. The mean decrease in CCT was less than 2 mm at all measurements following water-drinking (37).

Table 6. Evaluating IOL measurement during fasting and non-fasting periods

	Non-fasting	Fasting	P-value
IOL	20.66±3.11(44)	21.73±2.50	0.03
With SRK-2	21.15±0.21(43)	21.92±0.32	<0.001
With SRK-T	21.46±0.27(43)	22.32±0.37	<0.001

Crystalline lens: The crystalline lens was 0.177 mm thicker in the fasting state (41). Lens thickness exhibited a small decrease from baseline levels (mean baseline LT 3.52 _ 0.05) following water drinking, however the changes were not statistically significant (P>0.05) (37). Hashemi et al reported 3.58 as normal mean of LT with rang of 3.55-3.61 (42).

Vitreous: Vitreous thickness decreased by 0.239 mm in the fasting state (41).

Central retinal vein occlusion: The retinal venous circulation is characterized by low flow in the presence of high vascular resistance. This combination should make the central retinal vein particularly susceptible to thrombosis in hyperviscosity states and indeed conditions such as polycythemia and multiple myeloma have been associated with CRVO (45). Dehydration is a risk factor for CRVO in healthy individuals (46,47). Additionally increased incidence of central retinal vein occlusion during religious fasting has been reported.

Retina: The mean retinal thickness at baseline was 199.5±4.2 μm. A small, but statistically significant increase in retinal thickness was observed following water-drinking (P=0.01) (37).

Choroid: A small increase in choroidal thickness was observed at the 10 and 15 min measurements following water-drinking, however the changes in choroidal thickness did not reach statistical significance (p >0.05) (37).

Conclusion

This review literature provided an up-to-date summary of best available evidence for doctors, patients and other decision makers about positive and negative effects of Ramadan fasting on ocular parameters. Current research suggests that Ramadan dehydration causes an increase in tear osmolarity, ACD, IOL power, and retinal thickness versus decrease in IOP, AXL, CCT, and lens thickness. Although many studies have been conducted pertaining to the fasting and changes in ocular parameters in healthy population, there is only limited research on fasting and ocular diseases. Therefore, further studies could be helpful in deciding whether fasting has any uncompensated effects on ocular health.

References

1. Shariatpanahi ZV, Shariatpanahi MV, Shahbazi S, Hossaini A, Abadi A. Effect of Ramadan fasting on some indices of insulin resistance and components of the metabolic syndrome in healthy male adults. Br J Nutr. 2008; 100(1):147–51.
2. Al-Hourani HM, Atoum MF. Body composition, nutrient intake and physical activity patterns in young women during Ramadan. Singapore Med J. 2007; 48(10):906-10.
3. Kerimoglu H, Ozturk B, Gunduz K, Bozkurt B, Kamis U, Okka M. Effect of altered eating habits and periods during Ramadan fasting on intraocular pressure, tear secretion ,corneal and anterior Chamber parameters. Eye(Lond). 2010; 24(1):97–100.
4. Brucculeri M, Hammel T, Harris A, Malinovsky V, Martin B. Regulation of intraocular pressure after water drinking. J Glaucoma.1999;8:111–6.
5. Kayikcioglu O, Guler C. Religious fasting and intraocular pressure. J Glaucoma.2000;9:413-4.
6. Indriss BA, Anas BM, Hicham T. Influence of fasting during Ramadan on intra-ocular pressure. Ann Saudi Med. 2008; 28(1):61.
7. Dadeya S, Kamlesh, Shibal F, Khurana C, Khanna A. Effect of religious fasting on intra-ocular pressure. Eye (Lond). 2002; 16:463–5.
8. Cahill GF Jr. Starvation in man. N Engl J Med. 1970; 282(12):668-75.
9. Azizi F. Research in Islamic fasting and health. Ann Saudi Med. 2002; 22(3-4):186-91.
10. Bayerle-Eder M, Polska E, Kopf A, Roden M, Waldhäusl W, Pleiner H, *et al.* Free fatty acids exert a greater effect on ocular and skin blood flow than triglycerides in healthy subjects. Eur J Clin Invest. 2004; 34(8):519-26.
11. Liu JH, Dacus AC. Endogenous hormonal changes and circadian elevation of intraocular pressure. Invest Ophthalmol Vis Sci. 1991; 32(3):496-500.
12. Bogdan A, Bouchareb B, Touitou Y. Ramadan fasting alters endocrine and neuroendocrine circadian patterns. Meal-time as a synchronizer in humans? Life Sci. 2001; 68(14): 1607-15.
13. al-Hadramy MS, Zawawi TH, Abdelwahab SM. Altered cortisol levels in relation to Ramadan. Eur J Clin Nutr. 1988; 42(4):359-62.
14. Sarraf-Zadegan N, Atashi M, Naderi GA, Baghai AM, Asgary S, Fatehifar MR, *et al.* The effect of fasting in Ramadan on the values and interrelations between biochemical, coagulation and hematological factors. Ann Saudi Med. 2000; 20(5-6):377-81.
15. Leiper JB, Molla AM, Molla AM. Effects on health of fluid restriction during fasting in Ramadan. Eur J Clin Nutr. 2003; 57 suppl 2:S30-8.
16. Campbell DA, Renner NE, Tonks E. Effect of diamox on plasma bicarbonate and on the electrolyte balance in relation to intra-ocular pressure in man. Br J Ophthalmol. 1958; 42:732-8.

17. Vaajanen A, Luhtala S, Oksala O, Vapaatalo H. Does the renin-angiotensin system also regulate intra-ocular pressure? Ann Med. 2008; 40(6):418-27.
18. Mustafa KY, Mahmoud NA, Gumaat KA, Gader AM. The effects of fasting in Ramadan.2.Fluid and electrolyte balance. Br J Nutr. 1978; 40(3):583-9.
19. Sadiya A, Ahmed S, Siddieg HH, Babas IJ, Carlsson M. Effect of Ramadan fasting on metabolic markers, body composition, and dietary intake in Emiratisof Ajman (UAE) with metabolic syndrome. Diabetes Metab Syndr Obes. 2011; 4:409–16.
20. Dilly PN. Structure and function of the tear film. Adv Exp Med Biol. 1994; 350:239–47.
21. Fleiszig SM, McNamara NA, Evans DJ. The tear film and defense against infection. Adv Exp Med Biol. 2002; 506(pt A):523–30.
22. Srinivasan S, Nichols KK. Collecting tear osmolarity measurements in the diagnosis of dry eye. Exp Rev Ophthalmol. 2014; 4:451–3.
23. Koktekir BE, Bozkurt B, Gonul S, Gedik S, Okudan S, Effect of Religious fasting on Tear Osmolarity and Ocular Surface. Eye Contact Lens. 2014; 40(4):239–42.
24. Kayikcioglu O, Erkin EF, Erakgun T. The influence ofreligious fasting on basal tear secretion and tear break up time. Int Ophthalmol 1998; 22(2):67–9.
25. Sariri R, Varasteh A, Sajedi RH. Effect of Ramadan fasting on tear Proteins. Acta Medica (Hradec Kralove). 2010; 53(3):147–51.
26. Landsberg L, Young JB. Fasting, feeding and regulation of the sympathetic nervous system. N Engl J Med. 1978; 298(23):1295–301.
27. Leiter LA, Grose M, Yale JF, Marliss EB. Catecholamine responses to hypocaloricdiets and fasting in obese human subjects. Am J Physiol. 1984; 247(2 Pt 1):E190–7.
28. Schaefer S, Wang LF, Vliet der Vliet A, Hristova M, Vulliet PR, Fan SD. Fasting Limits Norepinephrine Release with Myocardial Ischemia and Reperfusion. Cardiovasc Drugs Ther. 1999; 13(5):399–405.
29. Young JB, Landsberg L. Suppression of sympathetic nervous system during fasting. Obes Res. 1997; 5(6):646-9.
30. Rabbanikhah Z, Javadi MA, Karimian F, Rouhani MR, Zamani M, Banaee T, *et al.* Effect of religious fasting on basal tear secretion, tear break up time and intraocular pressure. BINA. 2007; 12(4):485-91.
31. Rabbanikhah Z, Rafati N, Javadi MA, Sanago M. Effect of religious fasting on intraocular pressure in healthy individuals. Bina. 2005; 10(4):489-92.
32. Koh S, Tung C, Aquavella J, Yadav R, Zavislan J, Yoon G. Simultaneous measurement of tear film dynamics using wavefront sensor and optical coherence tomography. Invest Ophthalmol Vis Sci. 2010; 51(7):3441–8.
33. Montés-Micó R. Role of the tear film in the optical quality of the eye. J Cataract Refract Surg. 2007; 33(9):1631–5.
34. Dadeya S, Kamlesh, Shibal F, Khurana C, Khanna A. Effect of religious fasting on intra-ocular pressure. Eye (Lond). 2002; 16:463-5.
35. Rohde BH, McLaughlin MA, Chiou LY. Existence and role of endogenous ocular melatonin. J Ocul Pharmacol. 1985; 1:235-43.
36. Buckingham T, Young R. The rise and fall of intra-ocularpressure: the influence of physiological factors. Ophthalmic Physiol Opt. 1986; 6(1):95–9.
37. Read SA, Collins MJ. Water drinking influences eye length and IOP in young healthy subjects. Exp Eye Res. 2010; 91(2):180-5.
38. Campbell DA, Renner NE, Tonks E. Effect of diamox on plasma bicarbonate and on the electrolyte balance in relation to intra-ocular pressure in man. Br J Ophthalmol. 1958; 42(12):732-8.
39. Vaajanen A, Luhtala S, Oksala O, Vapaatalo H. Does the renin-angiotensin system also regulate intra-ocular pressure? Ann Med. 2008; 40(6):418-27.
40. Nowroozzadeh MH, Mirhosseini AH, Meshkibaf MH, Roshannejad J. Effect of Ramadan fasting in tropical summer months on ocularrefractive and biometric characteristics. Clin Exp Optom. 2012; 95(2): 173–6.
41. Alameen SM, Albagi AA. The effect of fasting on intra ocular parameters. Sudanese J Ophthalmol. 2014; 6(2):62-5.
42. Hashemi H, Jafarzadehpur E, Ghaderi S, Yekta A, Ostadimoghaddam H, Norouzirad R, *et al.* Ocular components during the ages of ocular development. Acta Ophthalmol. 2015;93:74-81.
43. Nema HV, Nema N. Recent Advances in Ophthalmology. 1th ed. New Delhi: Jaypee Highlights Medical Publisher; 2011.
44. Assadi M, Akrami A, Beikzadeh F, Seyedabadi M, Nabipour I, Larijani B, *et al.* Impact of Ramadan fasting on intraocular pressure, visual acuity and refractive errors. Singapore Med J. 2011; 52(4):263-6.
45. Fong A. Schatz H. Central retinal vein in young adults. Surv Ophthalmol. 1993; 37: 393–417.
46. Alghadyan A. Retinal vein occlusion in Saudi Arabia: possible role of dehydration. Ann Ophthalmol. 1993, 25(10):394–8.
47. Hoseini-Yazdi SH. Evaluation of ocular accommodation, convergence and fusional vergence changes during Ramadan. J fast Health. 2013; 1(1):13-8.