

The effects of Ramadan fasting on the health and function of the eye

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Background: Ramadan fasting may alter a variety of physiological parameters which by themselves influence ocular system. Here, we review the effects of Ramadan fasting on the health and function of the eye. **Materials and Methods:** Literature records in PubMed/MEDLINE, Web of Science, EMBASE, Google Scholar, and Iran Medex databases as well as proceedings of related meetings from January 1986 to March 2014 were systematically reviewed. The search key words was based on the terms “Ramadan Fasting,” “Ramadan,” “Islamic Fasting,” “Fasting in Ramadan” accompanied with one of the eye, tear drop, myopia, intraocular pressure (IOP), tear break up time, basal tear secretion, refractive error, and visual acuity. **Results:** Predawn water loading and dehydration in the evening are shown to increase and decrease IOP and tear secretion, respectively. Ocular blood flow is changed in Ramadan fasting, and patients with ocular vein occlusion may experience more frequent attacks. There are no or minimal fluctuations in visual acuity and refractive errors, but most of them are decompensated after Ramadan. **Conclusion:** Although the influence of fasting in different eye parameters is evaluated in several studies, there are no or only limited studies conducted on patients suffering from glaucoma, damage to ophthalmic vasculature, tear dysfunction, and minimal visual acuity. Such studies are required to make a definite decision before fasting is declared harmless to these patients.

Key words: Eye, fasting, intraocular pressure, Ramadan, refractive errors, visual acuity

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INTRODUCTION

Ramadan is the 9th month of the Lunar (354 days) calendar; therefore, it takes place 11 days earlier every year, and may happen in any of the four seasons.^[1] In Ramadan, Muslims refrain from eating and drinking for 12-17 h each day from dawn to dusk for 1 month.^[2] Ramadan fasting is a distinct from experimental fasting by the fact that the individuals avoid both food and drink. Therefore, the physiological changes during an experimental fasting may not necessarily simulate those arising from Ramadan fasting.^[3,4]

There are several studies highlighting the physiological or psychological benefits of fasting.^[5-7] However, because of lack of a clear guideline to determine those incapable of fasting, some individuals may oblige themselves for a harmful fasting.^[8] It is not recommended, even forbidden in Islam, when fasting is proven to be deteriorative to the body. These situations include diabetes, kidney disease, cardiovascular disorders, gastrointestinal disorders, and malfunction in other systems.^[2,9-13] Changes in physiological function may also involve ocular system.

Fasting alters a variety of physiological parameters leading to changes in eye function. A decrease in insulin as well as an increase in glucagon, norepinephrine and cortisol levels and changes in lipid profile, melatonin, and electrolytes is well-documented.^[2,14-18] Even though studies have been conducted in this area, there are still questions to be answered regarding the effects of fasting on the visual system. Here, we review the literature regarding the effects of Ramadan fasting on eye. A comparison with the impacts developed by experimental fasting is implemented whenever possible.

MATERIALS AND METHODS

The attempt was made to identify all investigations regarding pertaining to the eye and Ramadan Fasting was performed through the following stages:

Eligibility criteria

All indexed articles including original and review articles, short communications, case reports and scientific letters by selected bibliographic databases pertaining to the eye and Ramadan Fasting in any country were eligible in this study.

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Data sources

Literature records in PubMed/MEDLINE, Web of Science, EMBASE, Google Scholar, and Iran Medex databases as well as proceedings of related meetings from January 1986 to March 2014 were systematically reviewed.

Search strategy

The search strategy was based on the terms “Ramadan Fasting,” “Ramadan,” “Islamic Fasting,” “Fasting in Ramadan” accompanied with one of the eye, tear drop, myopia, intraocular pressure (IOP), tear break up time (BUT), basal tear secretion (BTS), refractive error, and visual acuity.

Data extraction

First, two researchers acquired data from eligible studies separately and discussed discrepancies, and when agreement was not attained, a third researcher helped to resolve the difference. For each study, several items were recorded such as authors’ names, publication year, number of eligible patients, inclusion and exclusion criteria, study design (prospective, retrospective, or unclear) and demographic characteristics of patients.

RESULTS

A total of 42 papers were determined by searching sources. After screening the documents, 19 irrelevant studies were

excluded, and 23 papers were contemplated for full text assessment. The characteristics of such investigations are observed in Table 1.

DISCUSSION

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 mmHg is currently defined normal by ophthalmologists and optometrists. The average value of IOP is 15.5 mmHg with fluctuations of about 2.75 mmHg. IOP is high in the morning and low in the evening and is shown to be related to serum cortisol levels.^[19,39] Changes in electrolytes, carbonic anhydrase activity and renin-angiotensin system can alter IOP.^[40-42] 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) and in patients with open-angled glaucoma (>8 mmHg).^[19] Furthermore, because of changes in sleep pattern there might be changes in melatonin, cortisol and epinephrine levels which are demonstrated to influence IOP.^[43]

Soleymani *et al.* in their study they found a notable difference between IOP of fasting and nonfasting (control) individuals

Table 1: Characteristics of participants in included the studies

Study	Number of patient	Mean age; range (year)	Men/women	Reported condition (s)
Rabbanikhah <i>et al.</i> ^[14]	156	<40		BTS, TBT, and IOP
Dadeya <i>et al.</i> ^[17]	38	29		IOP
Kerimoglu <i>et al.</i> ^[19]	31			IOP and tear secretion
Soleymani <i>et al.</i> ^[20]	35			IOP
Rabbanikhah <i>et al.</i> ^[21]	14	31.9±4.4		IOP
Assadi <i>et al.</i> ^[1]	58	40.7±0.7	58/0	IOP, refractive error or visual acuity values
Kayikçioğlu and Güler ^[22]	38	22.4±2.7		IOP
Inan <i>et al.</i> ^[23]	14			Ocular blood flow
Salehi <i>et al.</i> ^[24]	25	65.16±10.31	-	IOP
Sariri <i>et al.</i> ^[25]	60	23–27	35/25	Tear
Kayikçioğlu <i>et al.</i> ^[26]	38	22.3±2.9		BTS and BUT
Khalaj and Ghasemi ^[27]	383	16–70	152/231	Eye problems
Alghadyan ^[28]	90			RVO
Nowroozzadeh <i>et al.</i> ^[29]	90	60.55±12.20	68/22	Anterior chamber depth, refractive errors after cataract surgery
Edwards ^[30]	92	7–10		Myopia
Salehi <i>et al.</i> ^[31]	61	22–50		Myopia
Boroumand <i>et al.</i> ^[32]	100	21–40		Myopia
Samavati and Bazazi ^[33]	30	23.9		Myopia
Hoseini-Yazdi <i>et al.</i> ^[34]	190			Ocular accommodation, convergence and fusional vergence
Kumar <i>et al.</i> ^[35]	100			Eye drop
Kumar and Jivan ^[36]	117			Eye drop
Ahmed <i>et al.</i> ^[37]				Eye drop
Mahmoud <i>et al.</i> ^[38]				Ophthalmological care

IOP = Intraocular pressure; BTS = Basal tear secretion; TBT = Tear breakup time; RVO = Retinal vein occlusion; BUT = Breakup time

in the morning ($P = 0.015$). Moreover, they reported a reduction comparing IOP in the morning (14.4 mmHg) and afternoon (13.6 mmHg) of fasting individuals ($P = 0.013$). However, they did not find a significant difference between IOP of afternoon (13.6 mmHg) and that after breaking fast (13.4 mmHg).^[20] The results of another study indicated that predawn fluid loading increases IOP and tear secretion in the early morning, whereas dehydration due to fasting for a 12 h period cause a decrease in both of the variables.^[19]

Rabbanikhah *et al.* have reported 1.1 mmHg (at 9 a.m.) and 1.5 mmHg (at 1 p.m.) decrease in IOP comparing the results of the 4th and 2nd week of Ramadan in healthy individuals. In addition, they described an increase of mean IOP between the last week of fasting and that measured 1 month later (1.4 and 2.1 mmHg for 9 a.m. and 1 p.m., respectively). In contrast, mean IOP at 5 p.m. shows an increase 1 month after Ramadan compared to that of 2nd (mean difference: 1.6 mmHg) and 4th (mean difference: 1.8 mmHg) week of Ramadan. In addition, mean IOP decreases after breaking the fast at 7 p.m. by 0.5 mmHg (in 2nd week) and 0.6 mmHg (in 4th week) comparing to 5 p.m. (before breaking fast).^[21] They have also demonstrated 0.5 mmHg decrease in IOP comparing the results of the 3rd week (at 5 p.m.) of Ramadan to that of 1 week before Ramadan (at 8:00 a.m.).^[4] Dadeya *et al.* have reported a significant decrease in IOP of healthy fasting individuals compared with that of nonfasting individuals (right eye: 10.3 ± 1.2 vs. 14.2 ± 0.8 at 9 a.m., 10.4 ± 1.3 vs. 14.6 ± 0.9 at 12 a.m., 10.6 ± 1.3 vs. 14.8 ± 1.6 at 3 p.m., 10.9 ± 2.1 vs. 16.2 ± 1.6 at 6 p.m.; left eye: 10.8 ± 1.1 vs. 13.6 ± 0.9 at 9 a.m., 10.4 ± 1.6 vs. 13.8 ± 1.0 at 12 a.m., 10.9 ± 1.6 vs. 14.2 ± 1.4 at 3 p.m., 10.6 ± 2.2 vs. 15.8 ± 1.4 at 6 p.m.).^[17] In our previous study, we did not find a significant alteration of IOP between the 1st (right: 14.52 ± 3.63 and left: 13.83 ± 3.60) and 3rd (right: 15.34 ± 4.70 and left: 13.97 ± 3.18) week of Ramadan, nor we found a difference between two measurements in the 1st day to study the diurnal variations.^[1] Similarly, Kayikçioğlu and Güler reported no significant difference in IOP of healthy male volunteers in fasting and nonfasting periods in different times of the day.^[22] Inan *et al.* have also reported no significant difference in IOP of fasting (12.71 ± 2.25 mmHg) and nonfasting (13.14 ± 2.62 mmHg) conditions in healthy individuals.^[23]

All of the above-mentioned studies were conducted on healthy individuals, whereas changes in IOP in glaucoma patients are more critical to be evaluated. There is only one such a study in which Salehi *et al.* have reported a decrease in IOP because of fasting in open-angle glaucoma patients.^[24] This study is limited because they only evaluated IOP once, and a more elaborated study design with multiple measurements in different times of the day is required to

rule out the harm for these patients, if they desire to oblige themselves for fasting.

Tear

The tear film covering the ocular surface presents a mechanical and antimicrobial barrier and endures an optical refractive surface.^[25] Tear contains water, mucin, lipids, lysozyme, lactoferrin, lipocalin, lacritin, immunoglobulins, glucose, urea, sodium, and potassium. Some of the substances in lacrimal fluid (such as lysozyme) shows antibacterial properties by dissolving the peptidoglycan in the outer membrane.^[44,45] It is a typical body fluid with a salt content similar to blood plasma.^[46,47]

Sufficient dietary protein, potassium, zinc, vitamins A, B6 and C are necessary for normal tear function.^[46] Excesses of dietary salt, fats, cholesterol, protein, sucrose, and alcohol have been associated with or suggested as causes of tear dysfunction.^[48] Thus, changes in the diet during Ramadan may also lead to changes in tear secretion.^[2,49-51]

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. In addition, they described a change in protein electrophoresis pattern between fasting and 1 month before Ramadan.^[25] fluid loading at the predawn meal and dehydration because of a 12 h fasting are shown to increase or decrease tear secretion, respectively.^[19] 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 ($P < 0.0001$).^[4,21] On the other hand, there are studies indicating no change in tear BTS and BUT in healthy individuals.^[22,26,27]

All of the above-mentioned studies have been conducted on healthy individuals. And there is no study evaluating tear parameters in patients with tear dysfunction. Moreover, environmental changes in different seasons may affect tear parameters. Therefore, an elaborate study is required to evaluate tear parameters in patients with tear dysfunction in different seasons, if one aims to definitively verdict no harm.

Ocular blood flow

The level of free fatty acid (FFA) and triglycerides (TG) are shown to influence retinal blood flow. In a randomized double-blind placebo-control trial, Bayerle-Eder *et al.* have reported a concentration-dependent increment in ocular and skin blood flow by FFA independently of elevated serum TG levels. They described that a sevenfold rise of serum FFA (by Intralipid®/heparin infusion) increased retinal, choroidal, and skin blood flow by $26\% \pm 5\%$, $17\% \pm 4\%$ ($P < 0.001$), and $47\% \pm 19\%$ ($P < 0.05$) from baseline, respectively without alteration of systemic hemodynamics. On the other hand,

three-fold increase of FFA (by Intralipid® infusion only) did not influence the mentioned variables; although, there has been an increase in serum TG levels (250-700 mg/dL).^[52]

Inan *et al.* studied the effects of dehydration and fasting on the blood velocity recordings from the orbital vasculature by color-Doppler ultrasound imaging. They described that peak systolic velocity in the ophthalmic artery (48.90 ± 14.66 vs. 58.28 ± 14.65 cm/s), central retinal artery (16.88 ± 4.30 vs. 24.24 ± 6.45 cm/s), and temporal short posterior ciliary artery (23.42 ± 6.19 vs. 26.68 ± 7.52 cm/s) was higher in nonfasting individuals compared to fasting-healthy volunteers. In addition, peak diastolic velocity of central retinal artery has also been higher in nonfasting individuals (6.69 ± 2.15 vs. 9.32 ± 3.08 cm/s). In addition, resistive index of the ophthalmic artery was higher in nonfasting individuals (0.7 ± 0.04 vs. 0.7 ± 0.04 cm/s).^[23]

Alghadyan conducted a study in 90 patients to study the frequency of retinal vein occlusion (RVO) in Ramadan. They included 50 patients with central RVO, 35 patients with branch RVO, and 5 patients with hemiretinal occlusion. These patients were suffering from arterial hypertension (43 patients), diabetes mellitus (28 patients) and preexisting glaucoma (26 patients). They recorded 18 attacks during Ramadan, which was significantly higher than that of other months.^[28]

Taken together, ocular blood flow is affected by a verity of factors including dehydration and systemic diseases such as diabetes, hypertension, coagulopathy, and pathologic vasculature conditions. There have been well-developed studies in healthy subjects. However, an elaborated study is required to investigate the potentials changes in blood flow of orbital vasculature during fasting in patients with such conditions.

Ocular refractive, accommodation, and biometric characteristics

Ramadan fasting is associated with notable modifications in the anterior chamber depth and axial length, leading to clinically significant changes in intraocular lens power calculations. Therefore, relying on measurements taken during this month might lead to refractive errors after cataract surgery.^[29] Myopia, a refractive error commonly known as being short/near sighted, is described by focus of light in front of the retina. Therefore, objects close to the eye appear clearly, but those distant from the eye appear blurry.^[53,54] This defect is common at the age of 12-13 years and gradually, increases until 18-20 ages.^[55]

One of the reasons for myopia is an imbalance in nutrients.^[30] However, studies conducted so far, indicate that fasting has no effect on raising the levels of myopia.^[31-33,56] In our

previous study, we included 65 male healthy volunteers and evaluated refractive errors and visual acuity in 1st and 3rd week of Ramadan. Refractive errors for the 1st day (0.310 ± 0.238 [left] and 0.168 ± 0.234 diopter [right]) were not significantly different from those of the 3rd week (0.302 ± 0.250 diopter [left] and 0.198 ± 0.242 diopter [right]); nor there was a notable difference in refractive errors in two measurements in a single day. In addition, visual acuity in 1st week (0.0483 ± 0.0173 [left] and 0.0345 ± 0.0087 [right]) was not statistically different from those of those of 3rd week (0.0517 ± 0.0173 [left] and 0.0310 ± 0.0078 [right]). We did not also observe a significant difference between visual acuity of two measurements in a single day.^[1] Nowroozzadeh *et al.* did not also find a significant alteration of refractive errors in Ramadan fasting healthy individuals.^[29]

Hoseini-Yazdi *et al.* detected a significant change in amplitude of accommodation (AA) and near point of convergence (NPC) during Ramadan. However, there has been no significant difference before and after Ramadan. Negative fusional vergences (NFV) blur break and recovery points at far were significantly lower in Ramadan compared to the values before it; in addition, these reductions were compensated after Ramadan. Moreover, they did not find any correlation between changes in diet pattern and AA, NPC and distant NFV.^[34]

Taken together, visual problems reported at far, and near visual tasks during Ramadan are temporary and are resolved after Ramadan. However, one must take care, or these visual errors to avoid serious problems, especially when their visual task performance is minimal. Thus, vision therapy and improvements in nutrients are recommended.

Eye drops

Ramadan could be an important reason for noncompliance with prescribed ophthalmic treatment. Investigating Muslims' views regarding the use of eye drops during Ramadan showed extensive misuse of prescribed drops.^[35,36] Kumar and Jivan have reported that 63.7% of people believe that application of eye drops breaks fasting, and they must avoid using them during fasting; although their answer was dependent in eye condition (whether the disease is painful or visual tasks are affected).^[36] Moreover, no significant association was found comparing responses based on gender, education, occupation, residential place (rural or urban), socioeconomic condition, and number of fasting days.^[36,37] Similarly, fasting Nigerian Muslims prefer minimizing their eye medications to twice a day to avoid taking them during fasting. In addition, they would rather re-schedule their routine ophthalmological care to outside Ramadan whenever possible.^[38] Patients with advanced glaucoma that must take oral acetazolamide because of failure to respond to topical eye medications, are recommended not to fast as they should take the pill every 6 h.^[40]

Taken together, health care provider must be aware of potential incompliance to use eye medications during Ramadan, and should minimize their use to twice daily whenever possible. Frequent eye examinations are recommended if potential eye damage is suspected.

CONCLUSIONS

Although the influence of fasting in different eye parameters is evaluated in several studies, there are no or only limited studies conducted on patients suffering from glaucoma, damage to ophthalmic vasculature, tear dysfunction, and minimal visual acuity. Such studies are required to make a definite decision before fasting is declared harmless to these patients.

As perhaps hundreds of million people may observe Ramadan fasting each year, additional scientific research on the eye issue during Ramadan fasting is needed. Medical practitioners who working in Muslim countries and those looking after for Muslims in different corners of the world should be aware of the physiological changes during Ramadan, the influence of Ramadan fasting on different eye issues and medications. It is also advisable for physicians to communicate with their local scholars before Ramadan begins to remind Muslims that certain people are exempt from fasting, and those who plan to fast should consult their medical practitioners before doing so.

AUTHORS' CONTRIBUTIONS

MAJ, MA contributed in the conception of the work, revising the draft, approval of the final version of the manuscript, and agreed for all aspects of the work. BE, HMR, MA contributed in the conception of the work, approval of the final version of the manuscript, and agreed for all aspects of the work. MA contributed in the conception of the work, conducting the study, revising the draft, approval of the final version of the manuscript, and agreed for all aspects of the work.

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