Immediate Effect of Yoga Exercises for Eyes on the Macular Thickness

Abstract

Background: Yoga exercises for eyes have been advocated as beneficial to eye health. In a previous study, we evaluated the effect of yoga exercises for eyes on the intraocular pressure (IOP). The other aspects of the effects of yoga exercises for eyes to ocular structure have not been investigated yet.

Aim: The aim of this study is to evaluate the effect of yoga exercises for eyes on the macular structure using the optical coherence tomography (OCT) and OCT angiography (OCTA) parameters.

Methods: Twenty-nine participants were included in this masked within participant comparison of healthy controls. Basic ophthalmic examination was performed, after which patients were evaluated for IOP, OCT, and OCTA before and after yoga exercises for eyes. OCT/A parameters that were evaluated were: average macular thickness (AMT) (µm), central macular thickness (µm), central choroidal thickness (µm) vessel density (%) in the superficial, deep vascular layers, and in the choriocapillaris.

Results: IOP was significantly reduced (postexercise IOP = 13.02 mmHg ± 2.82 mmHg) from the initial value (preexercise IOP = 13.86 mmHg ± 2.85 mmHg, P = 0.02). AMT significantly increased (postexercise AMT = 275.40 µm ± 10.85 µm) from the preexercise measurement (preexercise AMT = 274.41 µm ± 10.89 µm; P = 0.02). Conclusion: After yoga ocular exercises, IOP significantly decreased and AMT significantly increased in healthy controls, suggesting an effect of these exercises on the macular thickness.

Keywords: Exercise, macula, optical coherence tomography, yoga

Introduction

Physical activity was reported to have beneficial effects on some of the major causes of blindness, such as glaucoma,[1] age-related macular degeneration,[2] and diabetic retinopathy.[3] Exercise, such as jogging and cycling, was reported to affect both IOP[4] and ocular hemodynamic parameters.[5] Yoga, as a part of the traditional Indian system of medical practice, has also been reported to affect ocular physiology in several aspects. In previous reports, yoga postures (headstand) induced increased intraocular pressure (IOP) that may affect patients with glaucoma.[6] Eye fatigue score and IOP were reduced after yoga ocular exercises.[7,8]

Yoga is gaining increasing popularity, and it is of interest to study the effects of the exercises on both healthy eyes and those affected by pathology. This is especially important since some ophthalmic conditions, such as glaucoma or diabetic retinopathy have tendency to deteriorate despite the good control of the risk factors.

In this current report, we aim to study the effect of yoga exercises for eyes to the macular optical coherence tomography (OCT) and OCT angiography (OCTA) parameters. To the best of our knowledge, this is the first report that investigates the effect of local bulbomotoric exercise to the macular thickness and blood vessel density (VD).

Methods

The study protocol of this experimental within participant comparison of healthy controls was approved by the ethics committee of our hospital (Approval no. 31/30-1) and was in accordance with the tenets of the declaration of Helsinki. All participants signed informed consent before study enrollment. We recruited 31 participants. Participants with diabetes, uncontrolled hypertension, ametropia >6 D, ocular pathology except for cataracts and dry eye, intraocular surgery except remote LASIK and cataract, and those with IOP measurements >21 mmHg were excluded from the study. One eye was included in the study. One eye was included in the study.
study (the right eye, unless there was significant pathology or poor image quality).

Participants underwent the following ophthalmic examination – Best-corrected visual acuity (BCVA), autorefractometry (Shin-Nippon, K-900), slit-lamp examination, IOP, OCT, and OCTA of macula without using mydriatics. Blood pressure (BP) was also initially evaluated. After the initial examination, participants did the yoga exercises. One experienced yoga teacher guided the participants. The procedure lasted 10 min and consisted of a short relaxation technique, slow and continuous movements with stretching of the bulbar motor muscles in maximal horizontal, vertical, diagonal, right-side, and left-side circular movements of the eyeballs. After the exercises, participants did “palming” or warming one’s eyes by previously rubbing the palms without applying any pressure to eyeballs. Participants were instructed to breathe deeply and slowly during the initial relaxation and between the various ocular exercises. Following the exercise participants underwent IOP, BP, OCT, and OCTA measurements again.

IOP was measured in a sitting position using air puff tonometry (Keeler). BP was evaluated using a brachial automatic device (Omron). Systolic (SBP) and diastolic BP (DBP) were recorded and mean arterial pressure (MAP) was calculated using the following formula:

\[
(1) \text{MAP} = \frac{(\text{SBP} − \text{DBP})}{3} + \text{DBP}
\]

From the IOP and BP values, we calculated mean ocular perfusion pressure (MOPP) using the formula:

\[
(2) \text{MOPP} = \frac{2}{3}\text{XMAP} − \text{IOP}
\]

For the OCT and OCTA measurements, we applied swept-source OCT (Atlantis, Topcon, Tokyo, Japan). We used the automatic program of the device for the retinal thickness map (Early Treatment of Diabetic Retinopathy Study grid) of the macula including 12 radial sections of the macula and for the central choroidal thickness (CCT) measurement. All 12 radial sections were evaluated for any pathology. The full-retinal thickness boundaries were from the internal limiting membrane to the outer boundary of the retinal pigment epithelium. Parameters that were included in the study were – average macular thickness (AMT) (µm), central macular thickness (CMT) (µm), and CCT (µm). OCTA measurements were evaluated in a macular 3 × 3 area of retinal superficial and deep, and of choriocapillaris vasculature slabs. One experienced operator did all the OCT and OCTA measurements (GD). We used image J for image binarization to evaluate percentage of VD of the entire region. One experienced and masked investigator (JK) analyzed the OCTA images.

Image quality was secured by including the images with signal strength of at least 60. Quality of images was categorized considering the presence of artifacts such as vessel doubling, motion, blink, and other artifacts. Images were categorized into three groups: good (absence of artifacts), fair (cumulative presence of artifacts in <¼ of the image), and poor (cumulative presence of artifacts in more than ¼ of the image). Images categorized as poor were excluded from the study. The quality of images was determined by a masked reviewer (ST). Intraoperator reproducibility was checked by performing five consecutive OCT and OCTA measurements in five participants by the same investigator.

The Paired t-test was used to analyze the differences between the first and second measurements. \( P < 0.05 \) was considered as statistically significant.

Results
Initially, 31 participants were recruited. Two participants were excluded from the study owing to diabetes and high myopia. In the study group, six participants had well-controlled hypertension, one subject was post LASIK (preoperative spherical equivalence = −2.75 D) and two participants were pseudophakic. The mean age of the enrolled participants was 51 years (standard deviation [SD] = 14.20), there were 27 female and 2 male participants, the body mass index was 24.31 (SD = 4.11), mean BCVA was 0.99 decimal units (SD = 0.04), mean spherical equivalence was -0.51D (SD = 1.59D).

We were able to obtain IOP measurements pre- and post-exercise in all participants. OCT measurements were taken in all participants; however, in two participants, the measurements were excluded because of poor image quality and eccentric fixation. There were 10 OCTA images with good quality, 9 images with fair quality, and 10 images with poor quality. The 19 OCTA images with good and fair quality were included in the study. Mean coefficients of variation for the OCT and OCTA parameters were as follows: AMT = 0.33%, CMT = 1.10%, superficial vascular layer VD = 1.64%, deep vascular layer VD = 3.17%, and choroidal VD = 0.77%.

After yoga exercises for eyes, IOP was significantly reduced (postexercise IOP = 13.02 mmHg ± 2.82 mmHg) from the initial value (preexercise IOP = 13.86 mmHg ± 2.85 mmHg, \(P = 0.02\)) [Table 1]. AMT significantly increased (postexercise AMT = 275.40 µm ± 10.85 µm) from the preexercise measurement (preexercise AMT = 274.41 µm ± 10.89 µm; \(P = 0.02\). All the other clinical parameters pre- and post-exercise were not significantly different [Table 1].

Discussion
The results from this study indicate that IOP decreased, whereas average retinal thickness of the macula increased after yoga exercises for eyes. In this report, we confirm previous cross-sectional and longitudinal results showing that IOP is reduced after yoga exercises for eyes.\(^{[7,8]}\) The effect of the exercise on the reduction of IOP may be
multifactorial. The exercises that were practiced in this study involved slow deep breathing that was reported to increase oxygen saturation in blood.\[^10\] Hyperoxia, on the other hand, reduces IOP.\[^{11}\] Bulbomotor muscles were maximally and continuously stretched in all directions that may also act as a pump for a more efficient intraorbital venous outflow. At the end of the exercises, warming of eyes was applied, and heat was also reported to reduce IOP in healthy controls.\[^{12}\]

Average retinal thickness at the macula significantly increased after yoga exercises for eyes in this study [Figure 1]. Diurnal variations of full retinal thickness were previously reported to be nonsignificant.\[^{13}\] IOP reduction was correlated with increased macular thickness in patients after glaucoma filtering surgery suggesting that decreased IOP may be related to the AMT increase in our study.\[^{14}\] On the other hand, 10 min of moderate intensity exercise was also reported to decrease IOP and axial length.\[^{15}\] Axial length inversely correlated with retinal thickness measurements\[^{16}\] suggesting that a short-term decrease of axial length may have also influenced the measurement of macular thickness in our study.

Several reports analyzed the effect of exercises, diet, and vitamins on glaucoma.\[^{17,18}\] Moderate exercise and a balanced diet that involved moderate coffee consumption and intake of fruits and vegetables were considered beneficial for glaucoma patients. In a randomized and controlled study, patients with glaucoma who practiced 45 min meditation daily for 6 weeks achieved significant reduction of IOP and stress markers and improvement in brain oxygenation and quality of life.\[^{19}\] Impaired retinal oxygen extraction and a decline of retinal ganglion cells were associated with age,\[^{20}\] whereas aerobic exercise protected the retinal function and photoreceptor damage from light injury in mice.\[^{21}\] This suggests that treatments including changes in life style other than medication and invasive procedures may affect the course of ophthalmic diseases. The results from these studies suggest that yoga may also be investigated as a potential alternative care for patients with glaucoma and other age-related ophthalmic diseases.

Although moderate exercise is considered beneficial in patients with glaucoma, specific physical exercises such as headstand, weight lifting, squats, wearing of goggles during swimming, etc., were reported to transiently increase IOP.\[^{22}\] Therefore, it is important to define which exercises may be risky and which may be favorable for certain ophthalmic conditions.

Our study has several limitations. Because more women volunteered for the study, we were not able to obtain gender balance. We refrained using the Goldmann applanation tonometry method for measuring IOP to avoid using eye drops and to abbreviate measurement time. However, air puff tonometry that was used in this study is a reliable method that was significantly correlated to Goldmann tonometry.\[^{23}\] OCTA measurements in this study were undertaken without pupillary dilation because tropicamide 0.5% was suggested to affect retinal capillary blood flow.\[^{24}\] This may have been the reason for the poor quality of some of the images that were discarded from the evaluation and may have weakened the power to detect change in the OCTA parameters after yoga exercises. Furthermore, because yoga exercises for eyes are not only movements of the bulbomotor muscles, but also involve relaxation, slow deep breathing, and eye warming, we are not able to discern which one of these components of the exercise had the effect on the parameters that we evaluated.

Nevertheless, our study shows for the first time an impact of yoga exercises for eyes on macular thickness. Although we found a statistically significant effect of the yoga exercises to the macular thickness, the effect was small. Therefore, longitudinal studies would be beneficial to study the effects of the exercises when practiced on a regular basis. We believe that this study may be relevant for future
investigation of various exercises on ocular physiology and blood perfusion. It may also be relevant as a possible adjunct treatment of patients with glaucoma and other ocular vascular and degenerative pathology.

**Conclusion**

We report that IOP significantly decreased and average retinal thickness of the macula significantly increased after yoga exercises for eyes in healthy controls. Further prospective studies involving a larger study group are necessary to evaluate effectiveness and safety of the exercises.

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**Conflicts of interest**

There are no conflicts of interest.

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