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A Comparison of Two Groups with and Without Glaucoma in Terms of the Effect of Yoga Positions on Intraocular Pressure: Intervention Research

Yoga Pozisyonlarının Göz İçi Basıncı Üzerine Etkisi Açısından Glokom Olan ve Olmayan İki Grubun Karşılaştırılması: Müdahale Araştırması

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ABSTRACT Objective: This study delves into the impact of three yoga poses, namely Adho Mukha Svanasana, Uttanasana, and Viparita Karani, on intraocular pressure (IOP) in 16 patients diagnosed with open-angle glaucoma and a control group of 16 healthy individuals. **Material and Methods:** The study design required all participants to perform the mentioned yoga poses sequentially. IOP measurements were collected four times during the execution of each pose: at the onset of the pose, after maintaining the pose for two minutes, immediately after ending the pose, and following a ten-minute rest period. **Results:** The data showed a statistically significant increase in IOP from baseline values after two minutes of performing each yoga pose in both patient and control groups. The most substantial increase was witnessed during the first yoga pose (Adho Mukha Svanasana), which showed a rise in IOP from 16.44±3.22 mmHg to 28.63±5.09 mmHg in glaucoma patients and 11.63±2.33 mmHg to 22.31±2.38 mmHg in the control group. Interestingly, there was no significant difference between the two groups concerning the magnitude of IOP increase across all the yoga poses. **Conclusion:** The findings suggest that certain yoga poses, especially those requiring the head to be downward-facing, lead to significant increases in IOP. However, these elevated IOP levels return to baseline as soon as the pose ends. More comprehensive, long-term follow-up studies are necessary to understand the potential consequences of these temporary IOP elevations in glaucoma patients. As a precautionary measure, glaucoma patients who practice or intend to start practicing yoga should disclose this information to their ophthalmologists.

Keywords: Glaucoma; head-down tilt; intraocular pressure; yoga

ÖZET Amaç: Bu çalışma, Adho Mukha Svanasana, Uttanasana ve Viparita Karani isimli üç yoga pozu üzerindeki intraoküler basınç (IOP) üzerindeki etkisini, açık açılı glokom tanısı konmuş 16 hasta ve 16 sağlıklı birey olmak üzere bir kontrol grubunda incelemektedir. **Gereç ve Yöntemler:** Çalışma tasarımı, tüm katılımcıların belirtilen yoga pozlarını sırasıyla gerçekleştirmesini gerektiriyordu. Her poz sırasında IOP ölçümleri dört kez toplandı: poz başlangıcında, pozun iki dakika sürdürülmesinin ardından, pozun hemen sona ermesinin ardından ve on dakikalık bir dinlenme süresinin ardından. **Bulgular:** Veriler, hem hasta hem de kontrol gruplarında her yoga pozunun iki dakika boyunca gerçekleştirilmesinden sonra, IOP'deki baz değerlerden istatistiksel olarak anlamlı bir artış gösterdi. En belirgin artış, glokom hastalarında IOP'un 16.44±3.22 mmHg'dan 28.63±5.09 mmHg'ya ve kontrol grubunda 11.63±2.33 mmHg'dan 22.31±2.38 mmHg'ya çıktığı ilk yoga pozu olan Adho Mukha Svanasana sırasında gözlendi. İlginç bir şekilde, iki grup arasında tüm yoga pozları boyunca IOP artışının büyüklüğü açısından anlamlı bir fark bulunmadı. **Sonuç:** Bulgular, başın aşağıda olmasını gerektiren belirli yoga pozlarının, IOP'de önemli artışlara yol açtığını öne sürmektedir. Ancak, bu yükseltilmiş IOP seviyeleri, poz sona erer ermez başlangıç değerlerine geri dönmektedir. Bu geçici IOP yükselmelerinin glokom hastalarında potansiyel sonuçlarını anlamak için daha kapsamlı, uzun dönemli takip çalışmaları gereklidir. Önlem olarak, yoga pratiği yapan veya yoga pratiği başlamayı planlayan glokom hastalarının, bu bilgiyi göz doktorlarına bildirmeleri önerilir.

Anahtar Kelimeler: Glokom; baş aşağıda yatırmak; intraoküler basınç; yoga

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Glaucoma is the most leading cause of irreversible blindness in the world. The most common subtype of glaucoma is primary open-angle glaucoma (POAG), which usually causes severe visual field loss without symptoms. High intraocular pressure (IOP) is associated with POAG and is the only parameter that can be modified in glaucoma treatment. Previous data in the literature has shown that the extent of damage to the optic nerve depends on the degree of IOP elevation. Previous researchs report that IOP values tends to fluctuate throughout the day.[1-4]

Body position can play an important role in IOP fluctuation. In the supine position, IOP is measured higher than in the sitting position, and postural increase in IOP has been shown to be more pronounced in older individuals than in younger individuals.[5-7]

Some prospective studies have proved that the significant elevation in IOP value in the supine position was associated with the severity of glaucoma.[8-11]

Yoga, which is an old non-religious Indian mind-body approach, consists of a certain posture (Asana), regulated breathing (Pranayama) and meditation. Practicing yoga allows for the improvement of health and well-being by integrating the physical, mental and spiritual components of the individual. Yoga became increasingly popular in the western world, making it a practice that an estimated 31 million American adults had performed at least once by 2012.[12]

Several previous studies have reported that practicing yoga in the head-down position (Sirsasana) causes twofold elevation of IOP in both POAG patients and healthy individuals.[13,14]

In this study, our purpose was to examine the effects of three yoga poses that are frequently used in daily yoga practice, not advanced yoga poses such as Sirsasana, on IOP.

MATERIAL AND METHODS

This study was designed as an intervention study in a prospective design with a cohort of 32 patients. It was conducted in İzmir Kâtip Çelebi University Atatürk Teaching and Research Hospital Ophthalmology Department between April to September 2021. The study was approved by the Clinical Research Ethics Committee of İzmir Kâtip Çelebi University (date: April 1, 2021, no: 0184). Informed consent was obtained from each participant and the study was conducted in accordance with the Declaration of Helsinki principles. Sixteen patients who were followed up with the diagnosis of POAG division and 16 control cases have been enrolled. Only glaucoma patients who received medical treatment and had no surgery or laser treatment were enrolled in this study. The glaucoma cases were selected from among individuals who had no accompanying systemic diseases. Neither patients nor the controls were regular yoga practitioners. Body mass indexes (BMI) were calculated by measuring the height and weight of all subjects.

First of all, 3 best-known yoga poses (The first, second and third poses are Adho Mukha Svanasana, Uttanasana, and Viparita Karani, respectively) were explained to all individuals participating in the research using visuals by the authors (Figure 1). Then, each individual was asked to practice these yoga poses in turn. Individuals' IOPs were measured 4 times for each pose using Tonopen device. The initial measurement was taken while sitting before starting the pose (baseline measurement), while the second measurement was taken during the pose at the second minute after starting the pose (positional measurement). Immediately after the second measurement was taken, the patient was placed in a sitting position and the third measurement was taken (post-position measurement). The last measurement was taken at the tenth minute in a sitting position (10-minute measurement).

Statistical analyzes were performed in IBM SPSS Statistics for Windows, Version 25.0 (Released 2017, Armonk, NY: IBM Corp.) package program.

The "Shapiro-Wilk" test was applied separately in 2 groups (glaucoma/control) whether the numerical changes showed a normal distribution or not. Single-measure variables were compared between the 2 groups using the "Independent two-group t-test". The effects of yoga pose-measurement time and group factors on IOP were evaluated with the "Repeated Measures ANOVA" method. Afterwards, the "Bon-

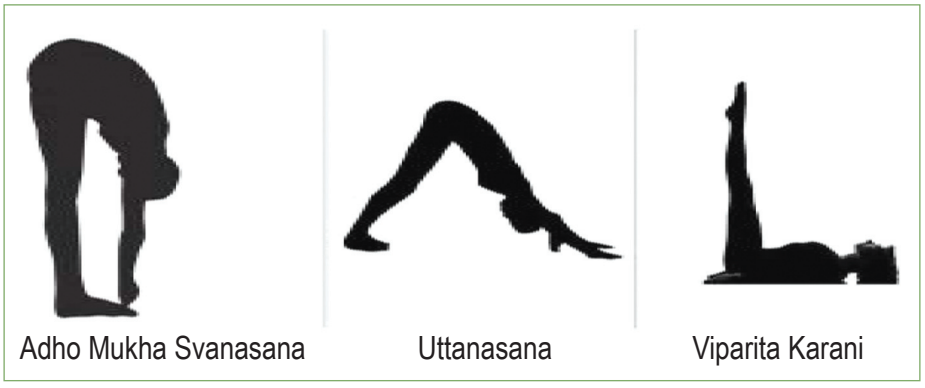

FIGURE 1: Scheme illustrating the yoga positions (Written permission for this figure was obtained from PLOS ONE journal).

ferroni" test was used as the post hoc method for pairwise comparisons. The existence of linear relationship between variables was evaluated by "Pearson Correlation Analysis". All statistical hypothesis checks were performed at the 0.05 significance level.

RESULTS

Thirty-two individuals participated in the study. Of these, 16 had POAG (5 males, 11 females; mean age: 52.63±10.39 years) and 16 were control (11 females, 5 males; mean age 44.35±5.92 years). The age difference between the two groups was found to be statistically significant (p=0.011). BMIs were similar between control (24.66±3.10 kg/m^2) and glaucoma (26.13±4.52 kg/m^2) groups (p=0.295). In both groups, IOP values showed a significant increase from the baseline measurement to the following measurements during all yoga poses (Table 1, Figure 2, Figure 3, Figure 4). In the first pose, IOP increased from 16.44±3.22 mmHg to 28.63±5.09 mmHg in glaucoma patients, and increased from 11.63±2.33 mmHg to 22.31±2.38 mmHg in the control group. In the Uttanasana pose, IOP increased from 16.38±2.89 mmHg to 25.06±4.31 mmHg in glaucoma patients, and increased from 11.06±2.20 mmHg to 19.38±2.06 mmHg in the control group. In the final pose (Viparita Karani), IOP increased from 16.13±3.28 mmHg to 22.50±5.52 mmHg in glaucoma patients and from 11.13±1.62 mmHg to 15.31±2.84 mmHg in the control group. However, in terms of the amount of increase in any of the yoga poses, there was no difference between the two groups (Figure 5). The 10-minute measurement in all yoga poses returned IOP to baseline levels, and this finding was similar between groups.

DISCUSSION

The most important finding of the study presented here is that IOP is significantly increased in three common head-down yoga poses. There are few studies and case reports in the literature reporting up to double IOP in the inverted yoga posture known as Sirsasana.[13,15-18] This posture is normally recommended not to be practiced by beginners or people with inappropriate health conditions, and can be considered an advanced posture. However, in this study, we examined the effects of 3 yoga poses that are frequently used in basic yoga classes on IOP. We found that IOP measured at 2 minutes performing the pose increased significantly in all three yoga poses. The highest increase was found in the first yoga pose (Adho Mukha Svanasana), while the least increase was detected in the third yoga pose (Viparita Karani). Another very important finding is that IOP returned to its normal values as soon as the subject finished the position and returned to a seated. Jasien et al. also conducted a similar study with 10 glaucoma patients and 10 controls with four yoga poses that are frequently used in yoga classes.[14] They found similar results to the present study, and reported that the head-down yoga position was related with a rapid increase in IOP, and pressure returned to baseline values within 2 minutes of end of the pose.

TABLE 1: Four measurements of IOP values during three yoga poses in both groups.

Adho Mukha Svanasana						
		Baseline	Positional measurement	Post-position measurement	10-minute measurement	Maximal difference in IOP between baseline and positional measurement
Controls	X̄±SD	11.63±2.33	22.31±2.38	11.75±2.67	10.75±2.01	10.68±1.70
Glaucoma	X̄±SD	16.44±3.22	28.63±5.09	17.13±4.08	17.00±4.44	12.18±3.76
p value		<0.001	<0.001	<0.001	<0.001	0.516
Uttanasana						
		Baseline	Positional measurement	Post-position measurement	10-minute measurement	Maximal difference in IOP between baseline and positional measurement
Controls	X̄±SD	11.06±2.20	19.38±2.06	11.06±2.11	10.94±1.61	8.31±1.85
Glaucoma	X̄±SD	16.38±2.89	25.06±4.31	17.06±3.67	16.06±3.39	8.68±3.70
p value		<0.001	<0.001	<0.001	<0.001	0.517
Viparita Karani						
		Baseline	Positional measurement	Post-position measurement	10-minute measurement	Maximal difference in IOP between baseline and positional measurement
Controls	X̄±SD	11.13±1.62	15.31±2.84	10.94±2.81	10.56±2.27	4.18±2.25
Glaucoma	X̄±SD	16.13±3.28	22.50±5.52	16.06±3.47	16.25±3.89	6.37±3.81
p value		<0.001	<0.001	<0.001	<0.001	0.554

IOP: Intraocular pressure; SD: Standard deviation.

Numerous studies in the literature aimed to investigate the effect of body posture on IOP. IOP values measured in the supine position are higher than those measured in the sitting position, with the difference in IOP between the two positions being 1.4 to 8.6 mmHg.[6,8,11,19] The IOP of the dependent eye in the lateral decubitus position rises even higher when shifted from the supine position.[20-23] There are studies reporting that head position also affects the IOP value. It has been reported that IOP decreases in the sleeping position with the head elevated 30 degrees, while increases in the posture with the head 30 degrees below the thoracic vertebra.[24,25] It is known that sports such as walking, jogging and cycling have a lowering effect on IOP.[26,27] However, it should not be forgotten that such dynamic exercises may increase IOP in pigment dispersion syndrome.[28] During isometric exercises such as weight lifting, IOP may increase temporarily in relation to the Valsalva maneuver.[29]

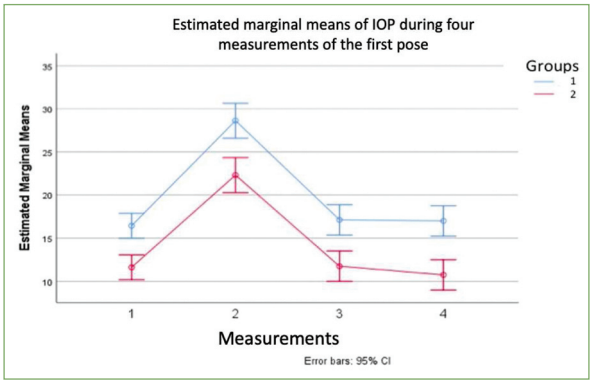

FIGURE 2: IOP changes in the first pose in both groups (Groups: 1=glaucoma, 2=controls). In the measurements, 1 indicates baseline measurements, 2 positional, 3 post position and 4 the ten minute measurements.
IOP: Intraocular pressure; CI: Confidence interval.

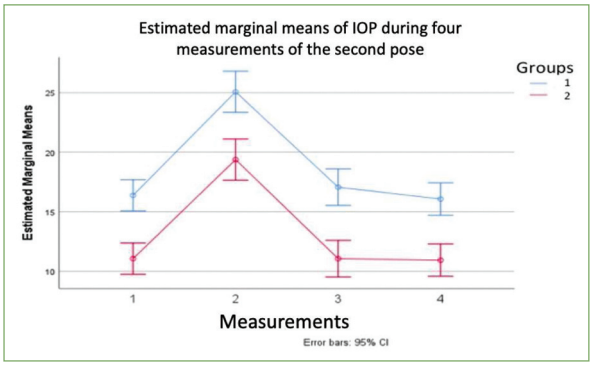

FIGURE 3: IOP changes in the second pose in both groups (Groups: 1=glaucoma, 2=controls). In the measurements, 1 indicates baseline measurements, 2 positional, 3 post position and 4 the ten minute measurements.
IOP: Intraocular pressure; CI: Confidence interval.

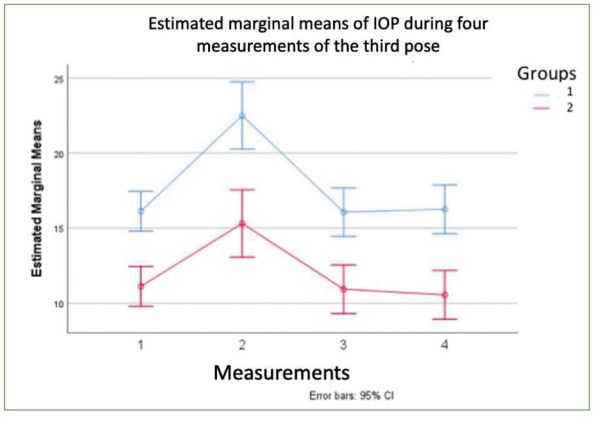

FIGURE 4: IOP changes in the third pose in both groups (Groups: 1=glaucoma, 2=controls). In the measurements, 1 indicates baseline measurements, 2 positional, 3 post position and 4 the ten minute measurements.
IOP: Intraocular pressure; CI: Confidence interval.

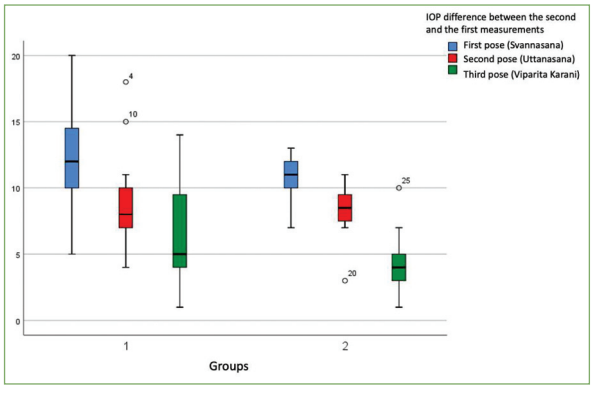

FIGURE 5: IOP differences between the second (positional) and the first (baseline) measurements in all three yoga poses among patients and controls.
IOP: Intraocular pressure.

Kim and Caprioli categorized IOP fluctuation under four headings according to the duration of IOP monitoring: instantaneous IOP fluctuation, diurnal-nocturnal IOP fluctuation, short-term IOP fluctuation, and long-term IOP fluctuation.[30] IOP variation occurring in a very short period of time (seconds) and caused by saccades, blinking, eye rubbing is defined as instantaneous IOP fluctuation. Diurnal-nocturnal IOP fluctuation refers to IOP fluctuations that occur throughout the day as a result of many conditions, such as changes in body posture.[31] Short-term IOP fluctuation is defined as IOP fluctuation that occurs over days or weeks, while fluctuations that occur over months or years are defined as long-term IOP fluctuations. IOP fluctation caused by yoga poses can be considered as instantaneous or diurnal-nocturnal fluctation depending on the duration of the pose. There is no clear evidence that instantaneous fluctuations causes glaucoma progression. Based on animal studies, it is estimated that short-term, transient and very high IOP peaks may affect susceptible eyes.[32] There have been several published researches on the effect of diurnal-nocturnal fluctuations on glaucoma progression.[4,33] Bertschinger et al. reported that in their 46-year-old patient with a diagnosis of juvenile glaucoma, there was a significant progression in the visual field test one year after starting yoga, and visual field loss improved significantly after stopping yoga.[16] Interestingly, de Barros et al. reported a patient with congenital glaucoma who had a progressive optic neuropathy and this patient had routinely practiced the Sirsasana (headstand) yoga posture for several years.[17] Baskaran et al., in their study on 75 healthy individuals who frequently use the Sirsasana pose during regular yoga practice, reported that IOP nearly doubled during this particular pose.[13] They reported that it is not necessary to examine for glaucoma for the healthy and young population in which they conducted the study, but for those who practice yoga at an advanced age, examination and follow-up are required for glaucoma. However, there are no studies evaluating whether certain yoga practices are associated with an increased risk of developing glaucoma or glaucoma progression. As the present study is a cross sectional one, no evaluation of the consequences of the IOP increase was possible. Follow-up

of patients with glaucoma who regularly practice yoga is necessary to understand whether this acute increase in IOP causes glaucoma progression.

The study presented here has some limitations. One of the most important limitations is the small number of patients. However, we should point out that it is very difficult to find patients who can manage these yoga poses, who do not have any systemic or ocular diseases other than glaucoma, who are willing to perform these poses. Another limitation may be that the patients and controls included in the study were not regular yoga practitioners. The same results may not be achieved in those who practice yoga regularly. In addition, our study population consisted of relatively young participants. Longitudinal studies on older yoga practitioners are needed to accurately determine the incidence of glaucoma and glaucoma progression.

CONCLUSION

Some poses that require the head down pose used in basic yoga classes increase IOP significantly. However, this increment in IOP value returns to baseline values as soon as the pose is terminated. Intervention studies with more participants are needed to understand whether the IOP fluctuation during these movements causes progression in glaucoma patients.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Sevinç Şahin Atik, Şeyda Uğurlu;* ***Design:*** *Sevinç Şahin Atik, Şeyda Uğurlu;* ***Control/Supervision:*** *Sevinç Şahin Atik, Şeyda Uğurlu;* ***Data Collection and/or Processing:*** *Sevinç Şahin Atik;* ***Analysis and/or Interpretation:*** *Sevinç Şahin Atik, Şeyda Uğurlu;* ***Literature Review:*** *Sevinç Şahin Atik;* ***Writing the Article:*** *Sevinç Şahin Atik, Şeyda Uğurlu;* ***Critical Review:*** *Şeyda Uğurlu;* ***References and Fundings:*** *Sevinç Şahin Atik, Şeyda Uğurlu;* ***Materials:*** *Sevinç Şahin Atik, Şeyda Uğurlu.*

REFERENCES

1. Kitazawa Y, Horie T. Diurnal variation of intraocular pressure in primary open-angle glaucoma. Am J Ophthalmol. 1975;79(4):557-66. [Crossref] [PubMed]
2. Lee PP, Sultan MB, Grunden JW, Cioffi GA; IOP Consensus Panel. Assessing the importance of IOP variables in glaucoma using a modified delphi process. J Glaucoma. 2010;19(5):281-7. [Crossref] [PubMed]
3. Nouri-Mahdavi K, Hoffman D, Coleman AL, Liu G, Li G, Gaasterland D, et al; Advanced Glaucoma Intervention Study. Predictive factors for glaucomatous visual field progression in the Advanced Glaucoma Intervention Study. Ophthalmology. 2004;111(9):1627-35. [Crossref] [PubMed]
4. De Moraes CG, Jasien JV, Simon-Zoula S, Liebmann JM, Ritch R. Visual field change and 24-hour IOP-related profile with a contact lens sensor in treated glaucoma patients. Ophthalmology. 2016;123(4):744-53. [Crossref] [PubMed]
5. Jain MR, Marmion VJ. Rapid pneumatic and Mackey-Marg applanation tonometry to evaluate the postural effect on intraocular pressure. Br J Ophthalmol. 1976;60(10):687-93. [Crossref] [PubMed] [PMC]
6. Liu JH, Kripke DF, Twa MD, Hoffman RE, Mansberger SL, Rex KM, et al. Twenty-four-hour pattern of intraocular pressure in the aging population. Invest Ophthalmol Vis Sci. 1999;40(12):2912-7. [PubMed]
7. Sultan M, Blondeau P. Episcleral venous pressure in younger and older subjects in the sitting and supine positions. J Glaucoma. 2003;12(4):370-3. [Crossref] [PubMed]
8. Hirooka K, Shiraga F. Relationship between postural change of the intraocular pressure and visual field loss in primary open-angle glaucoma. J Glaucoma. 2003;12(4):379-82. [Crossref] [PubMed]
9. Kiuchi T, Motoyama Y, Oshika T. Relationship of progression of visual field damage to postural changes in intraocular pressure in patients with normal-tension glaucoma. Ophthalmology. 2006;113(12):2150-5. [Crossref] [PubMed]
10. Kiuchi T, Motoyama Y, Oshika T. Postural response of intraocular pressure and visual field damage in patients with untreated normal-tension glaucoma. J Glaucoma. 2010;19(3):191-3. [Crossref] [PubMed]
11. Mizokami J, Yamada Y, Negi A, Nakamura M. Postural changes in intraocular pressure are associated with asymmetrical retinal nerve fiber thinning in treated patients with primary open-angle glaucoma. Graefes Arch Clin Exp Ophthalmol. 2011;249(6):879-85. [Crossref] [PubMed]
12. Cramer H, Ward L, Steel A, Lauche R, Dobos G, Zhang Y. Prevalence, patterns, and predictors of yoga use: results of a U.S. nationally representative survey. Am J Prev Med. 2016;50(2):230-5. [Crossref] [PubMed]

13. Baskaran M, Raman K, Ramani KK, Roy J, Vijaya L, Badrinath SS. Intraocular pressure changes and ocular biometry during Sirsasana (headstand posture) in yoga practitioners. Ophthalmology. 2006;113(8):1327-32. [Crossref] [PubMed]
14. Jasien JV, Jonas JB, de Moraes CG, Ritch R. Intraocular pressure rise in subjects with and without glaucoma during four common yoga positions. PLoS One. 2015;10(12):e0144505. [Crossref] [PubMed] [PMC]
15. Chiquet C, Custaud MA, Le Traon AP, Millet C, Gharib C, Denis P. Changes in intraocular pressure during prolonged (7-day) head-down tilt bedrest. J Glaucoma. 2003;12(3):204-8. [Crossref] [PubMed]
16. Bertschinger DR, Mendrinos E, Dosso A. Yoga can be dangerous--glaucomatous visual field defect worsening due to postural yoga. Br J Ophthalmol. 2007;91(10):1413-4. [Crossref] [PubMed] [PMC]
17. de Barros DS, Bazzaz S, Gheith ME, Siam GA, Moster MR. Progressive optic neuropathy in congenital glaucoma associated with the Sirsasana yoga posture. Ophthalmic Surg Lasers Imaging. 2008;39(4):339-40. [Crossref] [PubMed]
18. Gallardo MJ, Aggarwal N, Cavanagh HD, Whitson JT. Progression of glaucoma associated with the Sirsasana (headstand) yoga posture. Adv Ther. 2006;23(6):921-5. [Crossref] [PubMed]
19. Ozkok A, Tamcelik N, Capar O, Atalay E. Posture-induced changes in intraocular pressure: comparison of pseudoexfoliation glaucoma and primary open-angle glaucoma. Jpn J Ophthalmol. 2014;58(3):261-6. [Crossref] [PubMed]
20. Lee JY, Yoo C, Jung JH, Hwang YH, Kim YY. The effect of lateral decubitus position on intraocular pressure in healthy young subjects. Acta Ophthalmol. 2012;90(1):e68-72. [Crossref] [PubMed]
21. Malihi M, Sit AJ. Effect of head and body position on intraocular pressure. Ophthalmology. 2012;119(5):987-91. [Crossref] [PubMed]
22. Lee TE, Yoo C, Kim YY. Effects of different sleeping postures on intraocular pressure and ocular perfusion pressure in healthy young subjects. Ophthalmology. 2013;120(8):1565-70. [Crossref] [PubMed]
23. Lee JY, Yoo C, Kim YY. The effect of lateral decubitus position on intraocular pressure in patients with untreated open-angle glaucoma. Am J Ophthalmol. 2013;155(2):329-35.e2. [Crossref] [PubMed]
24. Buys YM, Alasbali T, Jin YP, Smith M, Gouws P, Geffen N, et al. Effect of sleeping in a head-up position on intraocular pressure in patients with glaucoma. Ophthalmology. 2010;117(7):1348-51. [Crossref] [PubMed]
25. Yeon DY, Yoo C, Lee TE, Park JH, Kim YY. Effects of head elevation on intraocular pressure in healthy subjects: raising bed head vs using multiple pillows. Eye (Lond). 2014;28(11):1328-33. [Crossref] [PubMed] [PMC]
26. Hamilton-Maxwell KE, Feeney L. Walking for a short distance at a brisk pace reduces intraocular pressure by a clinically significant amount. J Glaucoma. 2012;21(6):421-5. [Crossref] [PubMed]
27. Wylęgała A. The effects of physical exercises on ocular physiology: a review. J Glaucoma. 2016;25(10):e843-e9. [Crossref] [PubMed]
28. Haynes WL, Johnson AT, Alward WL. Inhibition of exercise-induced pigment dispersion in a patient with the pigmentary dispersion syndrome. Am J Ophthalmol. 1990;109(5):601-2. [Crossref] [PubMed]
29. Brody S, Erb C, Veit R, Rau H. Intraocular pressure changes: the influence of psychological stress and the Valsalva maneuver. Biol Psychol. 1999;51(1):43-57. [Crossref] [PubMed]
30. Kim JH, Caprioli J. Intraocular pressure fluctuation: is it important? J Ophthalmic Vis Res. 2018;13(2):170-4. [Crossref] [PubMed] [PMC]
31. Buguet A, Py P, Romanet JP. 24-hour (nyctohemeral) and sleep-related variations of intraocular pressure in healthy white individuals. Am J Ophthalmol. 1994;117(3):342-7. [Crossref] [PubMed]
32. Fortune B, Choe TE, Reynaud J, Hardin C, Cull GA, Burgoyne CF, et al. Deformation of the rodent optic nerve head and peripapillary structures during acute intraocular pressure elevation. Invest Ophthalmol Vis Sci. 2011;52(9):6651-61. [Crossref] [PubMed]
33. Bengtsson B, Heijl A. Diurnal IOP fluctuation: not an independent risk factor for glaucomatous visual field loss in high-risk ocular hypertension. Graefes Arch Clin Exp Ophthalmol. 2005;243(6):513-8. [Crossref] [PubMed]