Review Article

Effect of yoga on intra-ocular pressure in patients with glaucoma: A systematic review and meta-analysis

Dipak Chetry, Jayvindra Singh, Archana Chhetri[1], Vinod Kumar Katiyar, Daya Shankar Singh[2]

Glaucoma is the second leading cause of blindness in the world, with an estimated 57.5 million people suffering from glaucoma globally. Treatment of glaucoma focuses on lowering intra-ocular pressure to prevent progression of visual field defects, which is the only proven method for treating this disease. Yoga practices are believed to lower intra-ocular pressure in the eyes and prevent further damage in patients with glaucoma. Therefore, this systematic review was planned to explore the available scientific studies on yoga and intra-ocular pressure in glaucoma patients. PubMed, Cochrane Library, and Google Scholar were the basis for the investigation of the literature. The Jadad Scale was used to assess the quality of included clinical trials, and the JBI Critical Appraisal Checklist was used to assess the quality of included case studies. Based on the quality assessment and eligibility, six studies on yoga and intra-ocular pressure in glaucoma patients carried out between 2007 and 2021 were included in the final review. The results showed a reduction in intra-ocular pressure in patients with glaucoma through *Jyoti-trataka* (gazing steadily on a point or candle flame) and some other slow yogic breathing techniques, whereas studies on inversion *Asanas* (yoga postures) showed a rapid increase in intra-ocular pressure soon after starting. The three high-quality RCTs included in the meta-analysis showed a greater improvement in intra-ocular pressure in the yoga groups in both eyes than in the control groups; however, there were some limitations related to a small sample size, study quality, a long-term follow-up period, and variations in the yoga practices. Therefore, further studies with larger sample sizes and long-term follow-up are needed to overcome the limitations for a better understanding.

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Glaucoma is a group of eye conditions that can lead to vision loss or total blindness within a few years by damage to the optic nerves, which is the second leading cause of blindness worldwide.[1-5] Available data estimate that more than 57.5 million people are affected by glaucoma globally, including about 11.2 million in the elderly in India and about 3 million in the United States.[3,6-8] The symptoms of glaucoma begin very slowly, and patients do not notice a change in vision until the condition is in an advanced stage, which worsens over time, and the fact is that 50% of people with glaucoma do not even know that they have glaucoma.[9] The only way to diagnose glaucoma is with a comprehensive dilated eye exam, and if glaucoma is detected early enough, then vision loss can be slowed or prevented.[10] Vision loss because of glaucoma cannot be recovered, but early treatment (medicines and surgery) can often prevent further damage or slow the progression of the disease.[11] The damage is often associated with a build-up of abnormally high pressure in the eyes (called intra-ocular pressure) as well as other risk factors including an increasing age, a family history of glaucoma, and use of steroid medications.[10,11] Treatment of glaucoma focuses on lowering intra-ocular pressure, which prevents progression of visual field defects, and this reduction of intra-ocular pressure is the only proven method for treating this disease.[12-15]

Yoga is a widely accepted physical, mental, and spiritual practice that has been found to be beneficial to human physiology in many ways and is also believed to reduce intra-ocular pressure in the eyes of patients with glaucoma. Previously published reviews included a holistic approach of various yoga practices on patients with glaucoma, showing that yoga-based practices used for patients with glaucoma could reduce intra-ocular pressure and further damage can be prevented.[16-18] Concurrently, some other reviews in this area also suggested that commonly used complementary and alternative therapies may have significant adverse effects and lack reliable evidence to support their use in patients with glaucoma.[19-21] There are several experimental studies reporting the effects of various yoga practices on intra-ocular pressure in patients with glaucoma, yet there are no systematic reviews to support this. Therefore, this systematic review is planned to review the effects of various yoga practices on intra-ocular pressure in patients with glaucoma based on the available literature.

Department of Yoga, University of Patanjali, Haridwar, [1]Department of Yoga, Uttarakhand Sanskrit University, [2]Department of Shalakya Tantra (ENT), Patanjali Bhartiya Ayurvigyan Evam Anusandhan Sansthan, Haridwar, Uttarakhand, India

Correspondence to: Mr. Dipak Chetry, Research Scholar, University of Patanjali, Haridwar, Uttarakhand - 249 405, India. E-mail: dipakchetry4u@gmail.com

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Methods

This systematic review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[22]

Information sources and search strategy

Related literature search methods included the following electronic bibliographic databases from their inception through April 2022: PubMed/Medline, Cochrane Library, and Google Scholar. The mentioned databases were searched by two researchers (DC, JS), and the search strategy was optimized for each database that included terms related to or describing yoga and glaucoma. No language restrictions were applied during the search. In addition, the reference lists of included studies were manually searched to identify whether any other study was available for the same topic. Studies identified through the database were screened by two independent review authors (DC, JS). After removing duplicate studies, the titles and abstracts of all potentially eligible articles were read by two review authors (DC, JS) to determine whether they met the eligibility criteria. Database searches were conducted in successive steps using the search terms 'Yoga', '*Pranayama*', '*Asana*', 'Meditation', 'Glaucoma', 'Intraocular pressure', and 'Eye' as search words in the title, abstract, or keywords using Boolean search techniques. The keywords and complete search strategy necessary for each of the databases are mentioned in Table 1.

Inclusion and exclusion criteria

Studies had to meet the following eligibility criteria for study selection:

(1) Types of studies: All clinical trials (including case reports) were considered eligible. The methodological quality of the studies was assessed using the Jadad scale for clinical trials and the Joanna Briggs Institute (JBI) critical appraisal for case studies. Only high-quality RCTs were considered for conducting meta-analyses based on ratings. On the other hand, conference abstracts, review papers, website articles, and research protocols were excluded.

(2) Types of participants: Studies conducted on adult patients with any type of glaucoma were eligible. On the other hand, studies that included healthy participants or those with no history of glaucoma were excluded.

(3) Types of interventions: Studies that only included yoga practice as an intervention were eligible. Studies were excluded if yoga was not the main intervention but a part of a multiple intervention, such as mindfulness, acupressure, and so on. No restrictions were made regarding the yoga tradition, length, frequency, or duration of the program.

(4) Types of outcome measures: Studies were eligible if they assessed intra-ocular pressure as an outcome measure. Studies with no related results of intra-ocular pressure were excluded.

Data extraction and management

Data from individual studies such as details of participants (e.g., number of participants, age group, health condition), methods (e.g., design of the study, published year, country of publication), interventions (e.g. yoga style, frequency, and duration), outcomes, and results were independently extracted by two review authors (JS, AC) using Microsoft Excel Spreadsheet.

Table 1: The full search strategy identified through different databases

PubMed/Medline
#1 (Yoga[Title/Abstract]) AND (Glaucoma[Title/Abstract])
#2 (Yoga[Title/Abstract]) AND (Eye[Title/Abstract])
#3 (Yoga[Title/Abstract]) AND (Intraocular pressure[Title/Abstract])
#4 (Pranayama[Title/Abstract]) AND (Glaucoma[Title/Abstract])
#5 (Pranayama[Title/Abstract]) AND (Eye[Title/Abstract])
#6 (Pranayama[Title/Abstract]) AND (Intraocular pressure[Title/Abstract])
#7 (Asana[Title/Abstract]) AND (Glaucoma[Title/Abstract])
#8 (Asana[Title/Abstract]) AND (Eye[Title/Abstract])
#9 (Asana[Title/Abstract]) AND (Intraocular pressure[Title/Abstract])
#10 (Meditation[Title/Abstract]) AND (Glaucoma[Title/Abstract])
#11 (Meditation[Title/Abstract]) AND (Eye[Title/Abstract])
#12 (Meditation[Title/Abstract]) AND (Intraocular pressure[Title/Abstract])
Cochrane Library (Cochrane Reviews) (Word variations have been searched)
#1 Yoga in Title Abstract Keyword AND Glaucoma in Title Abstract Keyword
#2 Yoga in Title Abstract Keyword AND Eye in Title Abstract Keyword
#3 Yoga in Title Abstract Keyword AND Intraocular pressure in Title Abstract Keyword
#4 Pranayama in Title Abstract Keyword AND Glaucoma in Title Abstract Keyword
#5 Pranayama in Title Abstract Keyword AND Eye in Title Abstract Keyword
#6 Pranayama in Title Abstract Keyword AND Intraocular pressure in Title Abstract Keyword
#7 Asana in Title Abstract Keyword AND Glaucoma in Title Abstract Keyword
#8 Asana in Title Abstract Keyword AND Eye in Title Abstract Keyword
#9 Asana in Title Abstract Keyword AND Intraocular pressure in Title Abstract Keyword
#10 Meditation in Title Abstract Keyword AND Glaucoma in Title Abstract Keyword
#11 Meditation in Title Abstract Keyword AND Eye in Title Abstract Keyword
#12 Meditation in Title Abstract Keyword AND Intraocular pressure in Title Abstract Keyword
Google Scholar
"Yoga" AND "Glaucoma"; "Pranayama" AND "Glaucoma"; "Asana" AND "Glaucoma"; "Meditation" AND "Glaucoma" were searched as keywords and sorted by relevance and the first 50 results from each pair of keywords were listed and screened for eligibility. (Total 50 X 4=200 results)

Quality assessments

The methodological quality of each individual study was assessed independently by two researchers (DC, AC) using two methodological scales: (i) the modified Jadad scale for the included trials[23,24] and (ii) the Joanna Briggs Institute (JBI) critical appraisal checklist for included case reports.[25] Discrepancies between two authors on the rating were discussed with the authors (VKK, DSS) until a consensus was reached. Both scales contain eight methodological items. Only high-quality RCTs were considered for conducting meta-analyses based on ratings.

The eight methodological items contained in the modified Jadad scale were as follows: (1) Was the study described as randomized?, (2) was the method of randomization appropriate?, (3) was the study described as blinding?, (4) was the method of blinding appropriate?, (5) was there a description of withdrawals and dropouts?, (6) was there a clear description of the inclusion/exclusion criteria?, (7) was the method used to assess adverse effects described?, and (8) was the method of statistical analysis described?. For item numbers 1, 3, 5, 6, 7 and 8, there were two available options for answering (i.e., either 'yes', which gets 1 mark, or 'no', which gets 0 mark). On the other hand, for items 2 and 4, there were three available options for answering (i.e., 'yes', which scores 1 mark, or 'no', which scores -1 mark, or 'not described', which scores 0 mark). The total score for each article was calculated by summing the scores of each item and ranged from 0 to 8. Studies that scored 0 to 3 were considered low-quality studies, and studies that scored 4 to 8 were considered high-quality studies.[23,24]

The eight methodological items contained in the JBI critical appraisal checklist were as follows: (1) Were the patient's demographic characteristics clearly described?, (2) was the patient's history clearly described and presented as a timeline?, (3) was the current clinical condition of the patient on presentation clearly described?, (4) were diagnostic tests or assessment methods and the results clearly described?, (5) was the intervention(s) or treatment procedure(s) clearly described?, (6) was the post-intervention clinical condition clearly described?, (7) were adverse events (harms) or unanticipated events identified and described?, and (8) does the case report provide takeaway lessons?. There were four available options ('yes', 'no', 'unclear', and 'not applicable') for answering in each item in the checklist of JBI critical appraisal for case studies. Only 'yes' option gets 1 mark, and other options get no mark. The total score for each article was calculated by summing the scores of each item and ranged from 0 to 8. Case studies that scored high were considered higher-quality studies than studies that scored low.[25]

Data analysis

The effects of yoga on intra-ocular pressure in patients with glaucoma compared to various control interventions were analyzed. Only high-quality RCTs were considered for conducting meta-analyses based on ratings. Meta-analyses were conducted by a random-effects model using Review Manager 5 software (version 5.3, The Nordic Cochrane Center, Copenhagen, Denmark) if at least two high-quality studies assessing intra-ocular pressure were available. The standardized mean difference (SMD) with 95% confidence intervals (CIs) was calculated as the difference in means between groups divided by the pooled standard deviation.[26] Where no standard deviation was available, they were calculated from standard errors, CI, or t-values. A negative SMD was defined to indicate beneficial effects of yoga compared to the control intervention. Cohen's categories were used to evaluate the magnitude of the overall effect size with SMD (0.2 to 0.5 categorized as small, 0.5 to 0.8 as medium, and above 0.8 as large-effect sizes).[27]

Assessment of heterogeneity

Statistical heterogeneity between studies was analyzed using the I^2 statistic. I^2 is a measure of how much of the variance between studies can be attributed to differences between studies rather than to chance. The magnitude of heterogeneity was categorized in four parts as low heterogeneity (i.e. $I^2 = 0–24\%$), moderate heterogeneity (i.e. $I^2 = 25–49\%$), substantial heterogeneity (i.e. $I^2 = 50–74\%$), and considerable heterogeneity (i.e. $I^2 = 75–100\%$).[26] The $\chi 2$ test was used to assess whether differences in outcomes were compatible with chance alone. Given the low power of this test when only a few studies or studies with low sample sizes were included in the meta-analysis, a *P* value less than or equal to .10 was considered to indicate significant heterogeneity.[26]

Sub-group and sensitivity analyses were not performed to examine the sources of heterogeneity because there were limited (little) high-quality studies available on yoga and intra-ocular pressure on glaucoma patients. The high-quality studies included in the meta-analyses showed almost the same type of follow-up duration and the same type of control, although the intervention in between the studies was different (i.e., one study is on *Jyoti-tataka*, one study is on breathing techniques, and one study in meditation focused on breathing). Furthermore, we also did not assess the risk of publication bias because of the small number of studies included in the analysis, so it was not possible to generate funnel plots by the Cochrane Review Manager 5 software.[26]

Results

Following the searched keywords in mentioned databases, 544 results were identified; after removing the duplication records, 412 studies were screened and 24 papers were assessed for full text reading. Eighteen studies were excluded with the following reasons: (i) Eight studies were without yoga interventions or yoga combined with other therapies,[28-35] (ii) eight studies were on healthy participants or no history of glaucoma,[36-43] and (iii) two were conference abstracts.[44,45] Six studies were included in the final systematic review for qualitative synthesis based on eligibility criteria.[46-51] The PRISMA flow diagram of the studies is presented in Fig. 1.

Study characteristics

Six studies took place on yoga and intra-ocular pressure in glaucoma patients between 2007 and 2021, including three randomized controlled trials, two case studies, and one prospective single-center observational study. These six studies included a total of 234 adult participants (age ranged from 23 to 77 years); four studies were on both sexes, and two case studies only included female participants. Five studies included primary open angle glaucoma patients, and one study is on congenital glaucoma patients. The classified geographical regions showed that two studies were conducted from India, two studies were from USA, and one study each was from Switzerland and Egypt. The follow-up period of the yoga intervention was classified as short term (i.e., less than 1 month), intermediate term (i.e., ≥1 months to 12 months), and long term (i.e., ≥12 months), with one study as short term, five studies as intermediate term, and no studies as long term. The outcome variables evaluated in the included studies showed that all six studies assessed intra-ocular pressure, including other eye examinations. The yogic interventions included in the studies were *Jyoti-trataka* (gazing steadily at a point or candle flame), *Pranayamas* (yoga breathing techniques) including diaphragmatic breathing, *Nadishodhanam*/*Anuloma Viloma Pranayama* (alternate nostril yoga breathing), meditation focused on breathing and *Asanas* (yoga postures) including

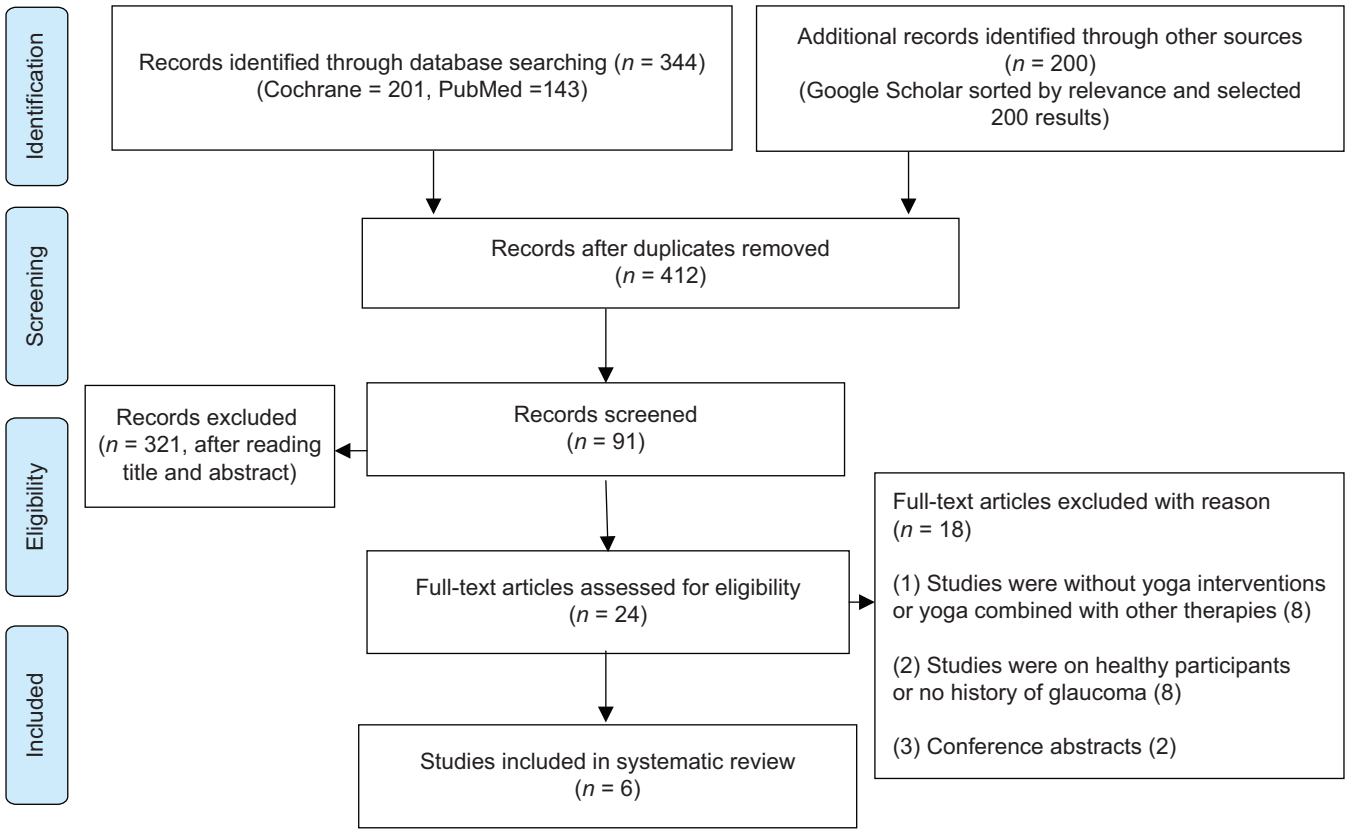

Figure 1: The PRISMA flow diagram of the studies

Sirsasna (headstand pose), *Adhomukha Svanasana* (downward facing dog pose), *Uttanasana* (standing forward bend pose), *Halasana* (plough pose), and *Viparita Karani* (legs up the wall pose).

Quality assessments

Methodological quality of each individual study was assessed using two scales based on their study design: (i) the modified Jadad scale for included trials and (ii) the JBI critical appraisal checklist for included case reports. The details of the quality assessments of each individual included study using Jadad scale are presented in Table 2a, and the details of the quality assessments of each individual included study using JBI critical appraisal checklist for case studies are presented in Table 2b. Three high-quality RCTs were selected for conduct of meta-analysis based on the quality rating.

Systematic review

Three high-quality RCTs conducted in yoga and intra-ocular pressure for the intermediate period (i.e., ≥1 months to 12 months) showed that yoga practices (i.e., *Jyoti-trataka*/gazing steadily at a point or candle flame, diaphragmatic breathing, *Nadishodhanam*/*Anuloma viloma pranayama*/alternate nostril yoga breathing, meditation focused breathing) decreased intra-ocular pressure in both eyes compared to control groups. The percentage reduction in intra-ocular pressure was much greater in the yoga group compared to controls.[46-48]

The other three studies (i.e., two case studies and one prospective single-center observational study) showed head-down yoga postures (i.e., *Sirsasna*/headstand pose, *Adhomukha Svanasana*/downward facing dog pose, *Uttanasana*/standing forward bend pose, *Halasana*/plough pose, and *Viparita Karani*/legs up the wall pose) and increased intra-ocular pressure during the practice, and over a period of time, it becomes normal after the practice.[49-51]

The findings also showed that *Jyoti-trataka*/gazing steadily at a point or candle flame significantly reduced systolic blood pressure, diastolic blood pressure, pulse rate, respiratory rate, and fasting blood glucose compared to the control group.[47] Meditation focused breathing showed significant reductions in mean serum cortisol, serum interleukin-6 levels, and reactive oxygen species compared to the control group. Simultaneously, there was also a significant increase in oxygenated hemoglobin in the prefrontal cortex as well as an increase in quality of life, mean serum beta endorphin, serum BDNF, and total antioxidant capacities in meditation focused breathing group compared to the control group.[48] The details of each individual study included are presented in Table 3.

Meta-analysis

Three high-quality randomized controlled trials[46–48] involving 212 patients evaluated the effect of yoga interventions on intra-ocular pressure in glaucoma patients, who were selected for meta-analysis. A random-effects model was adopted for the analysis. Pooled results showed greater improvement in intra-ocular pressure in the yoga groups in both eyes compared to the control groups [MD right eye: −1.50 (−2.82, −0.17), $P = 0.03$, $I^2 = 76\%$; MD left eye: −1.30 (−2.28, −0.32), $P < 0.01$, I2 = 93%]. The forest plot of yoga versus control on intra-ocular pressure is presented in Fig. 2.

Table 2: The quality assessments of each included study

2a. The modified Jadad scale scores of the included trials:

Citation	Q1.	Q2 .	Q3 .	Q4 .	Q5.	Q6.	Q7.	Q8.	Total Jadad score
Udenia *et al.*, 2021[46]	Yes	Yes	Yes (Single-blinded)	Not described	Yes	Yes	Yes	Yes	6.5
Ismail *et al.*, 2021[47]	Yes	Yes	No	Not described	Yes	Yes	No	Yes	5
Gagrani *et al.*, 2018[48]	Yes	Yes	No	Not described	Yes	Yes	No	Yes	5
Jasien *et al.*, 2015[49]	Yes	Not described	No	Not described	Yes	No	No	Yes	3

2b. The Joanna Briggs Institute (JBI) critical appraisal checklist scores for included case reports:

Citation	Q1.	Q2 .	Q3 .	Q4 .	Q5.	Q6.	Q7.	Q8.	Total JBI score
Barros *et al.*, 2008[50]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	8
Bertschinger *et al.*, 2007[51]	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	7

NB: The Jadad scale is a tool to independently assess the methodological quality of clinical trials. The three options available in the checklist for each item were Yes, No, and Not described. The eight methodological items contained in the modified Jadad scale were (Q1) was the study described as randomized?, (Q2) was the method of randomization appropriate?, (Q3) was the study described as blinding?, (Q4) was the method of blinding appropriate?, (Q5) was there a description of withdrawals and dropouts?, (Q6) was there a clear description of the inclusion/exclusion criteria?, (Q7) was the method used to assess adverse effects described?, and (Q8) was the method of statistical analysis described?. *Double-blinded study got 1 score; single-blinded study got 0.5 score in Item 3. Joanna Briggs Institute (JBI) critical appraisal checklist for case studies assesses the methodological quality of case studies. The four options available in the checklist for each item were Yes, No, Unclear, and Not applicable. The eight methodological items contained in the Joanna Briggs Institute (JBI) critical appraisal checklist were (Q1) were the patient's demographic characteristics clearly described?, (Q2) was the patient's history clearly described and presented as a timeline?, (Q3) was the current clinical condition of the patient on presentation clearly described?, (Q4) were diagnostic tests or assessment methods and the results clearly described?, (Q5) was the intervention(s) or treatment procedure(s) clearly described?, (Q6) was the post-intervention clinical condition clearly described?, (Q7) were adverse events (harms) or unanticipated events identified and described?, and (Q8) does the case report provide takeaway lessons?

Adverse events

None of the included studies on yoga practices (i.e. *Jyoti-tataka*/gazing steadily at a point or candle flame, diaphragmatic breathing, *Nadishodhanam*/*Anuloma Vilom Pranayama*/alternate nostril yoga breathing, and meditation focused breathing) reported any negative effects or adverse events such as worsening of intra-ocular pressure or any physical discomfort resulting from participation in the study. However, studies on yoga postures (i.e. *Sirsasna*/headstand pose, *Adhomukha Svanasana*/downward facing dog pose, *Uttanasana*/standing forward bend pose, *Halasana*/plough pose, and *Viparita Karani*/legs up the wall pose) reported an increase in intra-ocular pressure during the practice.

Discussion

Taken as a whole, the included studies reported a reduction of intra-ocular pressure in patients with glaucoma following the practice of *Jyoti-tataka*/gazing steadily at a point or candle flame and *Pranayamas*/yoga breathing practices,[46–48] whereas studies on *Asanas* (yoga postures) have shown evidence of a rapid increase in intra-ocular pressure shortly after beginning.[49-51] Pooled results from three high-quality studies showed a greater improvement in intra-ocular pressure in the yoga groups in both eyes than in the control groups, and the magnitude of intra-ocular pressure reduction was also significantly greater in the yoga group than in the controls.

Jyoti-trataka/gazing steadily at a point or candle flame, *Nadishodhanam*/*Anuloma Vilom Pranayama*/alternate nostril yoga breathing, diaphragmatic breathing, and meditation focused breathing can be used to reduce intra-ocular pressure in patients suffering from glaucoma.[46-48] This may imply that short-term yogic practices including *Jyoti-trataka* and yoga breathing exercises may have some positive effect on intra-ocular pressure dynamics in patients with glaucoma and may be considered as non-pharmacological interventions to reduce intra-ocular pressure. These yogic exercises can be a useful tool for the management and treatment planning of various eye diseases or disorders associated with ocular hypertension to intentionally reduce intra-ocular pressure. It provides evidence of intra-ocular pressure reduction through yoga, which is a cost-effective technique that can be easily adopted by patients with glaucoma. It can be used to significantly reduce pain in patients with glaucoma and reduce the need for medication. These yoga practices may be recommended as an adjunctive therapy in patients with glaucoma and may potentially reduce the risk of glaucoma progression; however, the findings do not support it as a substitute for drugs or treatment options.

Although *Jyoti-trataka* and yoga breathing exercises have been found to be useful in lowering the intra-ocular pressure in glaucoma, yogic breathing exercises sometimes performed with breath holding may increase intra-ocular pressure in glaucoma itself. That is why one should avoid doing pranayama by holding the breath. Also, the available studies on glaucoma showed no significant changes in visual field analysis (perimetry, contrast, RNFL thickness, progression of disc cupping) during the follow-up periods of yoga intervention.[46,48] Furthermore, it is unclear whether yoga exercises have an effect on visual field function and RNFL.

However, practice of *Asanas* (yoga postures) with the head down position showed an increase in intra-ocular pressure during the practice.[49-51] Elevated intra-ocular pressure is a major risk factor for patients with glaucoma, and yoga postures with the head down position are associated with increased intra-ocular pressure, which may increase the risk of glaucoma progression. This study has found the importance of how particular yoga posture practices affect in ophthalmologic pathologies. Therefore, patients suffering from glaucoma should be advised against practicing all yoga postures with the head down, that is, *Sirsasna*/headstand pose, *Adhomukha Svanasana*/downward facing dog pose, *Uttanasana*/standing

Table 3: Summary of included eligible studies on effects of yoga on intraocular pressure in glaucoma patients

Citation	Study characteristics	Interventions and variables assessed	Results
Udenia *et al*., 2021[46]	**Participants:** 90 moderate and severe primary open angle glaucoma patients (45 in yoga group combined with glaucoma medication and 45 in control group with glaucoma medication only), aged above 40 years, both genders. **Study design and country:** RCT, India.	**Yoga interventions and follow-up:** Diaphragmatic breathing and *Nadishodhanam/Anuloma viloma pranayama* (Alternate nostril yoga breathing) were practiced for 30 minutes per day over a period of 6 months. Assessments were taken at baseline, after 1 month, after 3 months, and after 6 months. **Variables:** Intraocular pressure using Goldmann applanation tonometer and visual field analysis using Humphrey 30-2 SITA standard test.	The results showed that both groups showed a significant decrease in intra-ocular pressure in both eyes at all time points. The magnitude of decrease at all time points was higher in yoga group compared to control group. No other significant changes were observed in any other variables at any time points.
Ismail *et al*., 2021[47]	**Participants:** 62 type 2 diabetes mellitus patients with high tension primary open angle glaucoma (31 in yoga group combined with glaucoma medication and 31 in control group with glaucoma medication only), age ranged 52 to 67 years, both genders. **Study design and country:** RCT, Egypt.	**Yoga interventions and follow-up:** *Jyoti-trataka* (gazing steadily on a point or candle flame) was practiced for 55 minutes per day over a period of 1 month. Assessments were taken at baseline and after 1 month. **Variables:** Intraocular pressure using Goldmann applanation tonometer, systolic blood pressure and diastolic blood pressure using mercury sphygmomanometer, radial pulse rate, respiratory rate, and fasting blood glucose using on call plus blood glucose meter.	The yoga group showed a significant decrease in intraocular pressure in both eyes, systolic blood pressure, diastolic blood pressure, pulse rate, respiratory rate, and fasting blood glucose compared to control group.
Gagrani *et al*., 2018[48]	**Participants:** 60 moderate and severe primary open angle glaucoma patients (30 in yoga group with standard medical treatment and 30 in control group with standard medical treatment only), aged above 45 years, both genders. **Study design and country:** RCT, India.	**Yoga interventions and follow-up:** Meditation focused on breathing for 45 minute per day over a period of 6 weeks. Assessments were taken at baseline and after 6 weeks. **Variables:** Intraocular pressure using Goldmann applanation tonometer, brain oxygenation (prefrontal cortex) using 16-channel fNIRS system, quality of life using WHOQOL-BREF, and biochemical markers (serum cortisol, β-endorphins, BDNF, interleukin-2, interleukin-6, reactive oxygen species, and total antioxidant capacity) using commercially available kits.	The yoga group showed a significant decrease in intraocular pressure, mean serum cortisol, serum interleukin-6 level, and reactive oxygen species after 6 weeks as compared to control group. The percentage reduction in intraocular pressure was very high in yoga group compared to control. The functional near-infrared spectroscopy data showed a significant increase in oxygenated hemoglobin in prefrontal cortex in yoga group as compared to control. The quality of life, mean serum beta endorphin, serum BDNF, and total antioxidant capacities were also significantly increased in yoga group compared to control group.
Jasien *et al*., 2015[49]	**Participants:** 20 (10 primary open angle glaucoma patients with standard medical treatment and 10 normal individuals), 23 to 77 years, both genders. **Study design and country:** CT (prospective single-center observational study), USA.	**Yoga interventions and follow-up:** Adhomukha Svanasana (downward facing dog pose), Uttanasana (standing forward bend pose), Halasana (plough pose), and Viparita Karani (legs up the wall pose) were practiced for 60 minutes. Assessments were taken at baseline, immediately after the position, after 2 minutes of position, post and after 10 minutes of post. **Variables:** Intraocular pressure using Reichert model 30 pneumatonometer.	All head-down yoga poses (i.e., *Adhomukha svanasana, Uttanasana, Halasana,* and *Viparita karani*) were associated with a significant rise in intraocular pressure within 1 minute after assuming the yoga position in glaucoma patients as well as normal individuals. The highest significant intraocular pressure increase was measured in the *Adhomukha svanasana* position followed by the *Uttanasana, Halasana*, and finally the *Viparita karani* position. Intraocular pressure dropped back to baseline values within 2 minutes after returning to a sitting position.
Barros *et al*., 2008[50]	**Participants:** 1 congenital glaucoma patient with history of surgery, aged 47 years, female.	**Yoga interventions and follow-up:** *Sirsasna* (headstand pose) was practiced for 10 minutes. Assessments were taken	The case report showed during 10 minutes practice of head-down position increased intraocular pressure

Contd...

Table 3: Contd...

Citation	Study characteristics	Interventions and variables assessed	Results
	Study design and country: Case report, USA.	at baseline, during and post. **Variables:** Intraocular pressure using Goldmann applanation tonometer.	in both eyes. The intraocular pressure after the headstand position decreased to a normal range but was higher than the baseline.
Bertschinger *et al.*, 2007[51]	**Participants:** 1 bilateral juvenile open-angle glaucoma patient, aged 46 years, female. **Study design and country:** Case report, Switzerland.	**Yoga interventions and follow-up:** *Sirsasna* (headstand pose) was practiced and follow-up period was not mentioned. Assessments were taken at baseline, during and post. **Variables:** Intraocular pressure using tono-pen.	The case report showed an increase in intraocular pressure during the practice of head-down position. The headstand position showed a twofold increase of intraocular pressure compared to sitting position. The case report also mentioned that after immediate stopping of head-down position (some months later) showed improvement in the visual field defects of the patient.

CT=Clinical trial, RCT=Randomised controlled trial

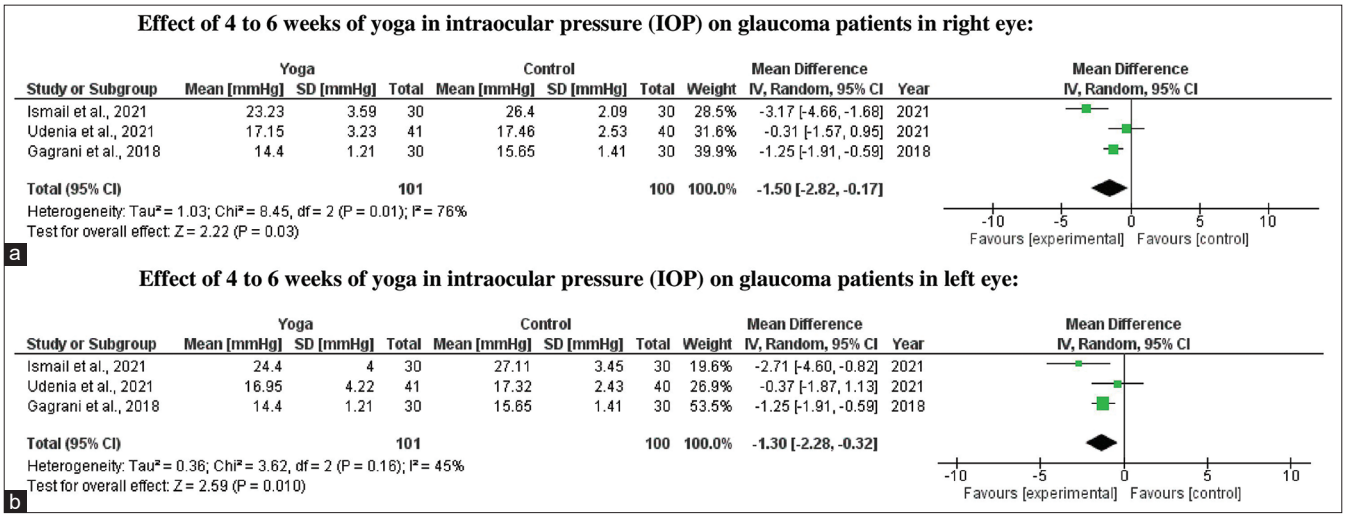

Figure 2: Forest plot examining the effect of yoga compared to non-yoga controls on intra-ocular pressure (Figure 1a. right eye and Figure 1b. left eye) over an intermediate period in patients with glaucoma

forward bend pose, *Halasana*/plough pose, and *Viparita Karani*/legs up the wall pose.

In addition to intra-ocular pressure, a short-term course of meditation focused breathing was also associated with a reduction in stress bio-markers, along with a significant improvement in cerebral oxygenation and quality of life.[48]

Limitations

The studies had several limitations, including the use of a small sample size, lack of blinding, and the exercise yoga components that appeared to differ between the included studies. The included studies were also designed to assess the effects of yoga exercises over short to intermediate periods of time; it is unclear whether yoga practice has any sustained effect in long-term follow-up. In addition, the database search was specifically limited to medical databases, so non-medical databases were excluded in order to obtain research on yoga related to other disciplines. This systematic review was also not registered in any of the possible registration platforms for systematic reviews, raising the possibility of unintended duplication of reviews, although we checked and found that no such review was ongoing at the time. Depending on the nature of the training, it is very difficult to blind participants and researchers in yoga RCTs, but in future research, the study may be assessed and analyzed blinded. Hence, more rigorous well-designed studies with larger sample sizes and long-term follow-up are needed to address all the above limitations and to determine whether yoga practice is associated with long-term improvement and whether these practices reduce or prevent vision loss progression or vision restoration in long run.

Conclusion

In conclusion, yoga practitioners with glaucoma or optic nerve damage from various causes should take care while choosing their yoga exercises. Evidence of reduction of intra-ocular pressure in patients with glaucoma through *Jyoti-tratak* and slow yoga breathing exercises (such as *Nadishodhanam*/*Anuloma Vilom Pranayama*/alternate nostril yoga breathing, diaphragmatic breathing, and meditation focused breathing) have been presented, whereas studies performed on yoga head down postures showed a rapid increase in intra-ocular pressure immediately after starting yoga *Asanas* (yoga postures). Hence, the practice of *Jyoti-trataka* and performing slow yoga breathing practices, which are relaxing, rejuvenating, and revitalizing,

and following the medications very sincerely are advised for the glaucoma patients. However, any yoga head-down posture can lead to an increase in intra-ocular pressure, so yoga head-down postures should be avoided. By following the mentioned points and practicing *Jyoti-tratak* and slow yoga breathing exercises, patients with glaucoma may improve their vision-related quality of life and manage the progression of glaucoma in the future.

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Conflicts of interest

There are no conflicts of interest.

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