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REVIEW ARTICLE

Psychological interventions to reduce intraocular pressure (IOP) in glaucoma patients: a review

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Abstract

Purpose Glaucoma has been increasing recognised to cause significant mental health burden to patients while psychological factors also play important roles in the development and progression of glaucoma. This review presents the current evidence of the impact of psychological interventions in glaucoma patients to improve their holistic care in terms of both physical and mental health by modulating psychological symptoms and supporting glaucoma control.

Methods A literature search was conducted on PubMed for relevant studies up to February 2022. Types of psychological interventions include meditation, autogenic relaxation, music, hypnosis, motivational interviewing, psychological nursing and bright light exposure. Outcomes investigated were ocular parameters including intraocular pressure, mental health, patient motivation and satisfaction, and overall quality of life.

Results Seventeen studies investigating the effects of psychological interventions on improving the care of glaucoma patients were reviewed. Daily meditation for 30 to 60 min has been shown to be effective in improving glaucoma control in terms of reducing intraocular pressure by 1.5 to 6.1 mmHg and improving ocular perfusion and quality of life. The impacts of music, autogenic training and psychological nursing on glaucoma control, vision outcomes and psychological symptoms are also promising while bright light exposure has shown some effects on sleeping quality. However, there is insufficient basis to support the adoption of motivational interviewing or hypnosis in glaucoma patients yet.

Conclusion Psychological interventions, especially meditation, can play a bigger role in the holistic care of glaucoma patients by controlling disease progression as an adjunct to conventional approaches and alleviating the mental health burden caused by the disease through stress reduction and emotional regulation. They empower patients to gain greater control of their disease and provides additional advantages of low cost, non-invasiveness and minimal side effects. Future research should involve well-conducted randomised trials with larger sample sizes and longer duration of intervention and follow-up to establish the long-term benefits for glaucoma patients.

Keywords Glaucoma: Mental health · Psychological · Meditation · Intraocular pressure · Quality of life

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Key messages

- Glaucoma is associated with significant mental health burden and psychological factors contribute to the development and progression of glaucoma.
- Daily meditation for 30 to 60 minutes improves glaucoma control in terms of reducing intraocular pressure by 1.5 to 6.1 mmHg and improving ocular perfusion and quality of life.
- Music, autogenic training and psychological nursing provide promising effects on glaucoma control and psychological symptoms while bright light exposure improves sleep quality in glaucoma patients.
- Multidisciplinary collaboration is essential to overcome potential challenges including manpower and time constraints, treatment standardisation and patient compliance.

Introduction

Glaucoma is a chronic optic neuropathy due to the progressive loss of retinal ganglion cells with characteristic structural and functional changes and is one of the top causes of irreversible blindness [1]. The global prevalence of glaucoma among the adult population was 3.54% in 2013 affecting 64 million patients, and this is estimated to increase by 74% to 112 million in 2040, representing a significant global burden [2].

Glaucoma and mental health are closely related with a bi-directional relationship. Psychological stress, depression and anxiety are risk factors for developing glaucoma in susceptible individuals [3]. The systemic stress response, which is mediated through the autonomic nervous system and inflammatory mediators, contributes to the development of glaucoma through the dysregulation of intraocular pressure (IOP) and ocular perfusion [4]. On the other hand, glaucoma, often referred to as the "silent thief of sight", also compromises patient's mental well-being. Mental health symptoms in patients with glaucoma arise through a combination of factors including constant psychological distress from the potential of loss of vision and independence and possible side effects of treatment, as well as a poor quality of life due to vision-related functional disability in activities of daily living [5, 6]. As a result, there is a high prevalence of depression, anxiety and sleep disorders in glaucoma patients at 19%, 25% and 47%, respectively, and they tend to experience more severe symptoms than the general population [5]. These mental health problems, in turn, may accelerate the progression of glaucoma through perpetuating the stress response and causing poor drug adherence, ultimately forming a vicious cycle [5, 7].

Psychological interventions have been increasingly applied to other chronic diseases with promising results, such as in patients with hypertension [8–10], coronary heart disease [11], diabetes mellitus [12, 13], asthma [14, 15], obesity [16] and cancer [17, 18]. Similarly, there is a potential role of psychological interventions in improving the holistic care of glaucoma patients in terms of both physical and mental health by modulating psychological symptoms and supporting glaucoma control as an adjunct to conventional pharmacological, laser and surgical approaches, as well as complementary therapies involving exercise and nutrition. For example, dynamic exercises including running and cycling can effectively reduce IOP [19], while weight control and dietary modifications such as increasing the consumption of antioxidant-rich fruits and vegetables and minimising the intake of coffee may have beneficial effects on glaucoma [20]. This review summarises the current evidence of the impact of psychological interventions in glaucoma patients.

Methodology

A literature search was conducted on PubMed using the following keywords: glaucoma AND (mental health, mental well-being, psycholog*, psychotherap*, cognitive-behav* therap*, meditati*, music*, mindful*, motivati*, autogenic*, hypno*, relaxation, yoga, OR breathing exercise*). The initial search generated 463 articles published from 1947 to February 2022. Titles and abstracts were screened, and relevant full papers and their reference lists were reviewed. Studies investigating the effects of psychological interventions on improving the care of glaucoma patients were included. Articles not involving glaucoma patients, not available in English and review articles were excluded (Fig. 1). Risk of bias analysis for the effect of assignment to intervention was conducted using the Risk of Bias 2 (RoB 2) tool for randomised controlled trials (RCTs) [21], and Risk of Bias in Non-randomised Studies – of Interventions (ROBINS-I) tool for observational studies [22].

Results

A total of 17 studies were reviewed (Table 1), covering interventions including meditation ($n=8$), autogenic relaxation ($n=2$), music ($n=2$), hypnosis ($n=1$), motivational interviewing ($n=2$), psychological nursing ($n=1$) and bright light exposure ($n=1$). Potential outcomes investigated were

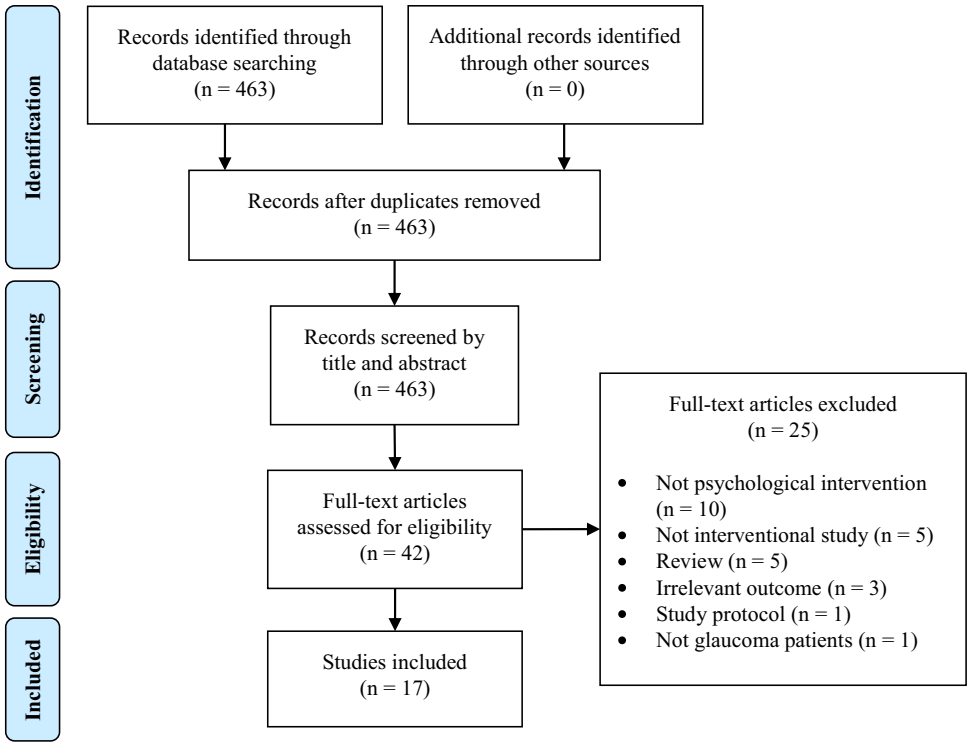


Fig. 1 PRISMA flow diagram of study selection

ocular parameters including IOP, mental health, patient motivation and satisfaction, and overall quality of life.

Risk of bias assessment

The RoB 2 tool showed that all the RCTs included were of low risk of bias ($n=2$) or some concern of bias ($n=9$) [21], while the ROBINS-I tool identified 3 non-randomised studies with moderate risk of bias and 2 studies with serious risk of bias [22]. The main concerns arose from the lack of blinding of the outcome assessor and loss to follow-up. The detailed results are available in Fig. 2.

Meditation

Meditation is a technique to alleviate psychological stress through achieving a relaxation response. It involves concentrating at the present moment, with a focus on breathing regulation including chest and abdominal movements during long deep breathing and airflow through the nostrils, as well as integration of self with heightened awareness and patience and minimal distraction [23]. In glaucoma patients, daily meditation has been shown to improve various clinical, biological, genetic and psychosocial parameters.

Meditation and IOP

Meditation consistently improves IOP in glaucoma patients by a range of 1.5–6.1 mmHg depending on the type of meditation technique and duration of intervention. Dada et al. [24] first demonstrated a 5.9–6.1 mmHg IOP reduction in primary open angle glaucoma (POAG) patients after 21 consecutive days of 60-min daily mindfulness meditation and the practice of slow deep breathing exercises under supervision, which was significantly greater than the controls. These results were replicated by Dada et al. [23] who demonstrated a 5.11 mmHg drop after 3 weeks of 45-min daily supervised meditation, and among the initial responders who achieved an IOP of < 15 mmHg after 3 weeks, this effect was maintained after 6 additional weeks of self-meditation at home, resulting in a cumulative IOP reduction of 5.44 mmHg. Gagrani et al. [25] and Dada et al. [26] demonstrated a 1.5 mmHg and 1.72 mmHg significant IOP decrease respectively after 6 weeks of 45-min daily meditation. An observational study by Gillmann et al. [27] evaluated the impact of daily life activities on IOP variation measured with contact lens sensors over 2 periods of 24 h each. Activities classified as "yoga or meditation" caused a non-significant trend in IOP reduction sustained through 120 min after the event, but the interpretation of the results were limited by the lack of differentiation between IOP-increasing yoga positions and IOP-lowering meditation practices, as well as the low frequency of events recorded as compared to daily meditation in the above interventional studies.

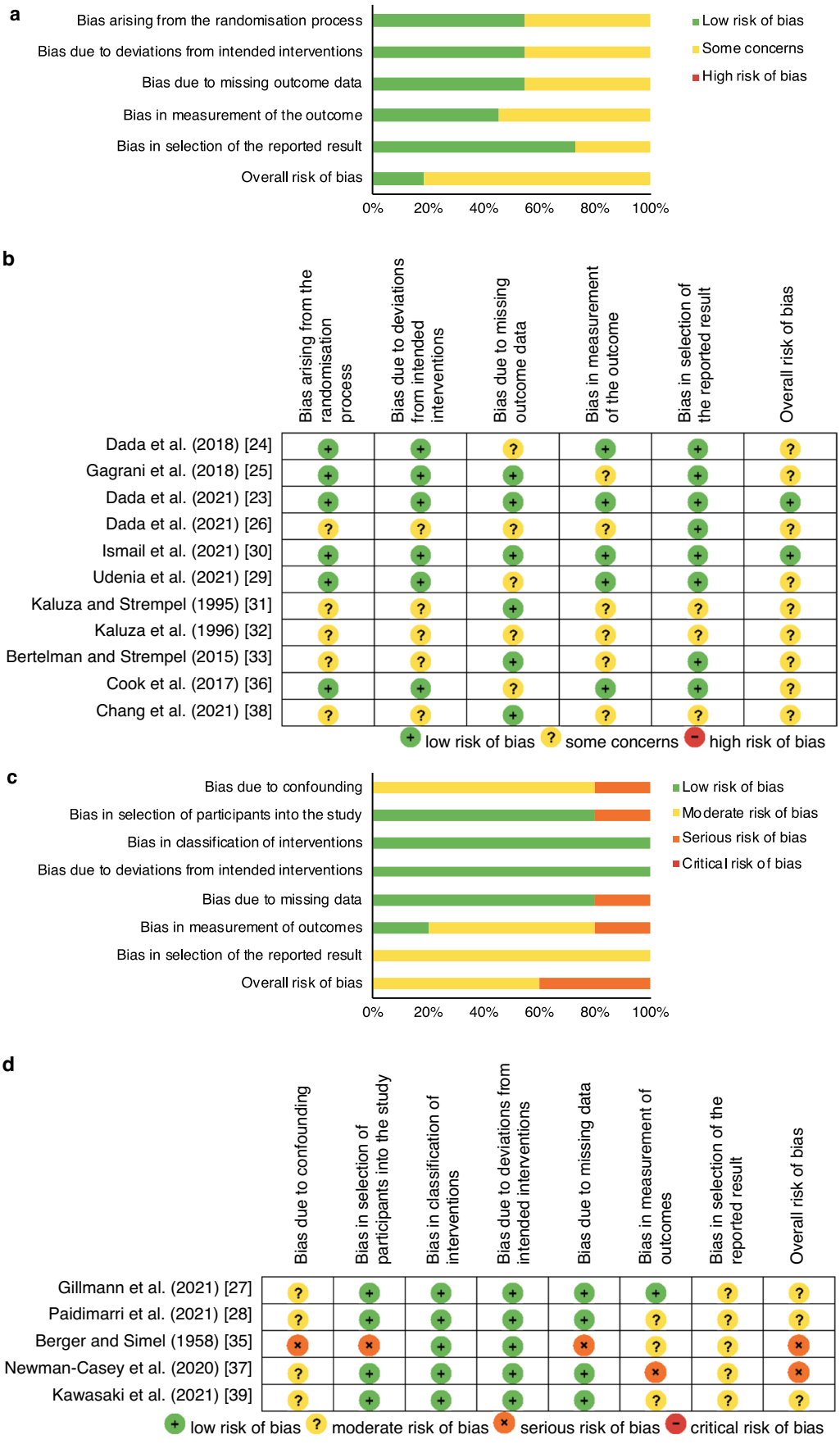
Specific yogic meditation practices have been evaluated in glaucoma patients. Pranayama is a type of yoga focusing on controlled breathing to calm the body and mind, regulate the flow of vital energy and achieve homeostasis

Table 1 Summary of included studies on psychological interventions for glaucoma patients

Intervention type	Authors	Study design	Country	Total sample size (intervention + control)	Sample population	Intervention protocol	Duration of follow-up	Control group	Change in IOP (mmHg)	Other main findings
Meditation	Dada et al. (2018) [24]	RCT	India	90 (45 + 45)	POAG	21 days, 60 min daily	None	Usual care	Right eye: 18.8 to 12.7 (Δ = −6.1) Left eye: 19.0 to 13.1 (Δ = −5.9)	Stress biomarkers: cortisol, IL-6, TNF-α and ROS decreased, β-endorphin, BDNF and TAC increased Gene expression: anti-inflammatory and neuroprotective genes upregulated, proinflammatory and apoptotic genes downregulated Quality of life: improved Visual field: not significant
	Gagrani et al. (2018) [25]	RCT	India	60 (30 + 30)	POAG	6 weeks, 45 min daily	None	Usual care	15.9 to 14.4 (Δ = −1.5)	Cerebral oxygenation: oxygenated haemoglobin level in the prefrontal cortices increased on fNIRS Stress biomarkers: cortisol, IL-6 and ROS decreased; β-endorphin and BDNF increased Quality of life: improved
	Dada et al. (2021) [23]	RCT	India	60 (30 + 30)	POAG scheduled for trabeculectomy	3 weeks, 45 min daily (after 3 weeks, patients with IOP ≥ 15 mmHg underwent trabeculectomy, patients with IOP < 15 mmHg continued meditation at home for 6 weeks)	None	Usual care	20.16 to 15.05 (Δ = −5.11)	Trabecular meshwork gene expression: vasoprotective and neuroprotective genes upregulated, proinflammatory gene downregulated Quality of life: improved
	Dada et al. (2021) [26]	RCT	India	60 (30 + 30)	POAG	6 weeks, 45 min daily	None	Usual care	18.06 to 16.34 (Δ = −1.72)	Optic disc perfusion: circumpapillary vessel density, circumpapillary vascular perfusion and flux index increased Heart rate, systolic blood pressure, diastolic blood pressure: decreased
	Gillmann et al. (2021) [27]	Cross-sectional	USA	41	POAG or suspect	Self-report of "yoga/meditation" activities during usual daily activities for 24 h, repeated at least 7 days apart	120 min after each activity	No control	Not significant	-
	Ismail et al. (2021) [30]	RCT	Egypt	60 (30 + 30)	High-tension POAG with type 2 diabetes mellitus	4 weeks, 55 min daily Jyoti-Trataka yoga	None	Usual care	Right eye: 26.06 to 23.23 (Δ = −2.83) Left eye: 27.10 to 24.40 (Δ = −2.70)	Heart rate, systolic blood pressure, diastolic blood pressure, respiratory rate, fasting blood glucose: decreased
	Paidimarri et al. (2021) [28]	Cross-sectional	India	73 (19 + 28 + 26)	Glaucoma	4 min of Nadi Shuddhi pranayama (10 cycles, 24 s per cycle)	10 min	1. Healthy individuals with intervention 2. Healthy individuals without intervention	Not significant	-
	Udenia et al. (2021) [29]	RCT	India	90 (45 + 45)	POAG	6 months, 30 min daily Anuloma-Viloma pranayama and diaphragmatic breathing	None	Usual care	Right eye: 20.85 to 14.90 (Δ = −5.95) Left eye: 20.30 to 14.25 (Δ = −6.05)	Visual field, retinal nerve fibre layer thickness: not significant

Table 1 (continued)

Intervention type	Authors	Study design	Country	Total sample size (intervention + control)	Sample population	Intervention protocol	Duration of follow-up	Control group	Change in IOP (mmHg)	Other main findings
Autogenic relaxation	Kaluza and Strempel (1995) [31]	RCT	Germany	23 (11 + 12)	POAG	8 weeks of 90-min weekly basic training (BT) (autogenic relaxation) + 8 weeks of rest + 8 weeks of 90-min weekly advanced training (AT) (ocular relaxation, visual imagination of aqueous humour drainage)	5 months	Usual care	After each session: BT: not significant AT: 16.2 to 15.6 (Δ = −0.6) After all sessions: BT: 18.6 to 16.8 (Δ = −1.8) AT: 16.6 to 15.3 (Δ = −1.3)	Medication adjustment: medication was reduced in 43% of all patients and 56% of patients initially on medications after completion of all sessions (including the intervention group and waitlist control group after intervention) Visual field: not significant
	Kaluza et al. (1996) [32]	RCT	Germany	23 (11 + 12)	POAG	8 weeks, 90 min weekly (followed by a 10-min mental stress test after 8 weeks)	None	Usual care	Not significant	Short-term psychological strain: decreased Heart rate: not significant
Music	Salvatore et al. (2011) [34]	Case report	Italy	1	Right eye ERM with bilateral OAG	5 weeks, 10 min (for each eye) weekly acoustic biofeedback rehabilitation with Mozart's Sonata for Two Pianos	None	No control	-	Right eye: BCVA and character size improved Both eyes: fixation stability, retinal sensitivity and reading speed improved Quality of life: improved
	Bertelman and Strempel (2015) [33]	RCT	Germany	41 (25 + 16)	POAG	10 days, 30 min daily relaxation music, subliminal binaural beats, nature sounds, instructions for breathing and relaxation, visual imagination of aqueous humour drainage	None	Usual care	13.79 to 13.64 (Δ = −0.15)	Best corrected visual acuity: increased from 0.88 to 0.97 (Δ = +0.09) Short-term psychological strain: decreased Visual field, stress biomarkers (adrenaline, cortisol, endothelin-1), long-term mental well-being: not significant
Hypnosis	Berger and Simel (1958) [35]	Cross-sectional	USA	15 (11 + 4)	Glaucoma	3 sessions of hypnosis with suggestion of symptom relief and anxiety	None	Healthy individuals	Not significant	-
Motivational interviewing	Cook et al. (2017) [36]	RCT	USA	195 (65 + 58 + 72)	OAG or ocular hypertension	3 face-to-face sessions (at weeks 1, 4 and 8) + 3 telephone calls (at weeks 2, 6 and 12)	None	1. Reminder calls 2. Usual care	Not significant	Patient satisfaction: higher compared to reminder calls and usual care Visual field, quality of life: not significant
	Newman-Casey et al. (2020) [37]	Cross-sectional	USA	102	Glaucoma	6.4 ± 5.1 min	None	No control	-	Patient satisfaction with staff communication: higher only in a subgroup of patients who rated the staff above average for autonomy supportive care Health activation, eye drop instillation self-efficacy: not significant
Psychological nursing	Chang et al. (2021) [38]	RCT	China	90 (45 + 45)	Glaucoma undergoing trabeculectomy	10–15 min daily after trabeculectomy until discharge	3 months	Eyeball massage after trabeculectomy	-	Negative emotions (HAMA, HAMD), sleep quality (PSQI): improved Best correct visual acuity: 0.26 before operation, 0.61 at 1 month, 0.74 at 3 months post-operation (compared to control group at 0.25, 0.49 and 0.57 respectively) (Δ at 1 month = +0.12, Δ at 3 months = +0.17) Quality of life, complication rate: improved
Bright light exposure	Kawasaki et al. (2021) [39]	Cross-sectional	Switzerland	20	Glaucoma	4 weeks, 30 min daily exposure to 10,000 lx polychromatic bright white light box	None	No control	-	PIPR, subjective sleep quality: improved 24-h rest-activity cycles, sleep parameters, PSQI: not significant


a
Bias arising from the randomisation process
Bias due to deviations from intended interventions
Bias due to missing outcome data
Bias in measurement of the outcome
Bias in selection of the reported result
Overall risk of bias
0%
20%
40%
60%
80%
100%
Low risk of bias
Some concerns
High risk of bias
b
Bias arising from the randomisation process
Bias due to deviations from intended interventions
Bias due to missing outcome data
Bias in measurement of the outcome
Bias in selection of the reported result
Overall risk of bias
Dada et al. (2018) [24]
Gagrani et al. (2018) [25]
Dada et al. (2021) [23]
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low risk of bias
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c
Bias due to confounding
Bias in selection of participants into the study
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Bias due to deviations from intended interventions
Bias due to missing data
Bias in measurement of outcomes
Bias in selection of the reported result
Overall risk of bias
0%
20%
40%
60%
80%
100%
Low risk of bias
Moderate risk of bias
Serious risk of bias
Critical risk of bias
d
Bias due to confounding
Bias in selection of participants into the study
Bias in classification of interventions
Bias due to deviations from intended interventions
Bias due to missing data
Bias in measurement of outcomes
Bias in selection of the reported result
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Gillmann et al. (2021) [27]
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Berger and Simel (1958) [35]
Newman-Casey et al. (2020) [37]
Kawasaki et al. (2021) [39]
low risk of bias
moderate risk of bias
serious risk of bias
critical risk of bias

◂**Fig. 2** Results of risk of bias assessment using RoB 2 and ROBINS-I. **a** Bar chart overview of risk of bias assessment for RCTs using RoB 2. **b** Results of risk of bias assessment for RCTs using RoB 2. **c** Bar chart overview of risk of bias assessment for non-randomised studies using ROBINS-I. **d** Results of risk of bias assessment for non-randomised studies using ROBINS-I

of the body [28]. Nadi-Shuddhi or Anuloma-Viloma pranayama, in particular, is a low intensity, slow, prolonged breathing exercise that involves alternate nostril breathing [28]. A cycle lasts about 24 s and involves closing the right nostril with the thumb and inhaling through the left nostril for 4 s, then releasing the thumb and closing the left nostril with the ring finger to exhale through the right nostril for 8 s, and vice versa [28]. Paidimarri et al. [28] showed no significant short-term effects of Nadi-Shuddhi pranayama on IOP after 10 cycles, while a similar study by Udenia et al. [29] showed significant long-term effects on the IOP in glaucoma patients. Udenia et al. [29] evaluated the effects of Anuloma-Viloma pranayama for 4 cycles and diaphragmatic breathing for 5 cycles daily over 6 months. IOP decreased significantly by 5.95–6.05 mmHg over 6 months, while visual field analysis and optical coherence tomography (OCT) retinal nerve fibre layer (RNFL) measurement did not significantly change. Another technique called Jyoti-Trataka yoga refers to the practice of gazing steadily at a candle flame from 4 feet, which significantly decreased IOP by 2.70–2.83 mmHg in high-tension POAG patients with type 2 diabetes mellitus after 1 month of daily practice [30].

Meditation and ocular perfusion and cerebral oxygenation

Impaired optic nerve head perfusion and oxygenation are key mechanisms of glaucoma development through oxidative stress induction. Optic disc perfusion can be measured with optical coherence tomography-angiography (OCT-A) in terms of circumpapillary vessel density (cpVD) and circumpapillary vessel perfusion (cpVP), which refer to the length and area of perfused vessels per unit area of measurement at the optic nerve head respectively. Dada et al. [26] showed that after 6 weeks of daily meditation in POAG patients, cpVD increased in the superior and nasal quadrants by an absolute percentage of 1.6–2.3%, while cpVP improved in all quadrants by 2.2–3.7%. The flux index, which measures the mean flow rate of blood cells through retinal vessels, also significantly improved by 0.02, indicating improved retinal perfusion [26].

Cerebral oxygenation can be measured by functional near-infrared spectroscopy (fNIRS) to map the level of oxygenated haemoglobin in bilateral prefrontal cortices. Gagrani et al. [25] demonstrated significant improvements in oxygenated haemoglobin levels in the left, right and medial prefrontal cortices compared to the control group after 6 weeks of daily meditation in patients with glaucoma. The prefrontal cortex modulates vision processing in glaucoma potentially through functional connectivity across brain networks and is associated with anxiety and depression which are prevalent among glaucoma patients [25]. Future studies may also explore any direct effects of meditation on the oxygenation of the visual cortices.

Meditation and stress biomarkers

Psychological stress contributes to glaucoma pathogenesis by inducing an inflammatory state with increased oxidative stress, endometrial dysfunction and neurotoxicity. Stress biomarkers provide more objective measures of the body's response to stress and reflects the effectiveness of meditation techniques to manage stress.

Dada et al. [24] and Gagrani et al. [25] demonstrated that stress and inflammatory markers were significantly reduced after daily meditation, including serum cortisol, interleukin-6 (IL-6), reactive oxygen species (ROS) and tumour necrosis factor-α (TNF-α). Markers of stress modulation and well-being were significantly elevated, including β-endorphins, brain-derived neurotrophic factor (BDNF) and total antioxidant capacity (TAC). These changes were also found to be significantly correlated with IOP changes after meditation [24].

Meditation and gene expression

Meditation modulates gene expression related to the regulation of inflammation, vascular flow and neuronal growth and survival, which are key components in the pathogenesis of glaucoma. Studies have shown that anti-inflammatory genes and neuroprotective genes are upregulated while proinflammatory and apoptotic genes are downregulated after daily meditation.

Dada et al. [24] investigated the gene expression using blood samples of glaucoma patients after 21 days of meditation and found that 54 genes were upregulated while 55 genes were downregulated compared to the control group. These changes were also shown to be correlated with IOP changes in the patients. In general, anti-inflammatory and neuroprotective genes involved in neuronal growth, synaptic maturation and regulation of glutamate toxicity were significantly upregulated, including nerve growth factor receptor (NGFR), WW domain-containing transcription regulator 1 (WWTR1/TAZ), B-type natriuretic peptide (BNP), interleukin-2 (IL-2), interleukin-4 (IL-4), fibroblast growth factor receptor 1 (FGFR1) and metallothionein 1E (MT1E) genes. On the contrary, expression of genes promoting inflammation and neuronal apoptosis were decreased after meditation,

such as retinoic acid receptor beta (RARB), cytochrome P450 family 26 subfamily A member 1 (CYP26A1), nuclear factor kappa B inhibitor alpha (NFKBIA), epidermal growth factor receptor (EGFR), mitogen-activated protein kinase 15 (MAPK15), prostaglandin E receptor 3 (PTGER3) and interleukin-21A (IL-21A) genes.

Dada et al. [23] obtained similar findings from gene expression analysis of trabecular meshwork tissue from glaucoma patients undergoing trabeculectomy after 3 weeks of mindfulness meditation training. Significantly upregulated genes include vasoprotective genes with vasodilative effects such as nitric oxide synthetases 1 (NOS1) and 3 (NOS3), and neuroprotective genes regulating neuronal apoptosis, degeneration, inflammation and oxidative stress including melatonin receptor 1A (MNTR1A), neuregulin 1 (NRG1), neuroglobulin (NGB), nerve growth factor receptor (NGFR), nuclear receptor subfamily 3 group C member 1 (NR3C1) and metallothionein 1E (MT1E) genes. Downregulation was observed in proinflammatory genes such as caspase recruitment domain family member 8 (CARD8), mitogen-activated protein kinase 10 (MAPK10) and 15 (MAPK15), epidermal growth factor receptor (EGFR), fibroblast growth factor receptor 1 (FGFR1), interleukin-4 (IL-4), nuclear factor kappa B (NFκB), transforming growth factor-beta 1 (TGF-β), tumour necrosis factor-α (TNF-α) and B-cell lymphoma 2 like 11 (BCL2L11) genes.

Meditation and quality of life

Quality of life is an overall measure of well-being that incorporates physical, mental, social and functional aspects of health. Quality of life in glaucoma patients has been shown to improve after mediation.

Dada et al. [24] and Gagrani et al. [25] reported a significant increase in the abbreviated World Health Organisation Quality of Life Questionnaire (WHOQOL-BREF) score across all domains including physical health, psychological, social relationships and environment after 6 weeks of meditation compared to the control group.

The Glaucoma Quality of Life 15 (GQL-15) is a glaucoma-specific questionnaire consisting of 4 domains of visual function including outdoor mobility, peripheral vision, near vision, and glare and dark adaptation. Dada et al. [23] showed that after 3 weeks of meditation, GQL-15 score significantly deceased compared to the controls, showing improvement in functional disability in daily life.

In summary, daily meditation has been shown to improve the IOP and optic nerve head perfusion in glaucoma patients. These changes are likely mediated through the regulation of stress and inflammation, as reflected by the changes in stress biomarkers and relevant gene expression. These improvements in physical parameters may account for better overall well-being as shown in the quality of life assessments. Future research may explore the effects of meditation on mental health parameters such as anxiety and depressive symptoms and whether there are differential effects on high-risk and low-risk patients in terms of baseline mental well-being to explain the inter-individual variations in intervention effect.

Autogenic relaxation

Autogenic training was developed by Schultz as a means to allow patients to relax through a series of exercises including heaviness, warmth, respiration, abdominal warmth and forehead cooling [31]. Other types of relaxation training include ocular muscle relaxation exercises using the techniques of progressive muscle relaxation, and guided visual imagery exercises visualising the aqueous humour drainage pathway [31].

Kaluza and Strempel [31] conducted a 2-phase relaxation training programme, consisting of a basic programme of 8 weekly autogenic training sessions and an advanced programme of 8 weekly ocular relaxation and visual imagery exercise sessions for POAG patients. The basic programme produced a non-significant trend of IOP reduction after each training session and a significant IOP reduction of 1.8 mmHg over the 8 weeks. The subsequent advanced programme further resulted in a significant reduction in IOP of 0.6 mmHg after each session and 1.3 mmHg over 8 weeks. After completion of both phases spanning across 6 months, the average drop in IOP was 3.3 mmHg. Twenty-four-hour IOP profile measurements and water drinking tests to provoke IOP increase also showed significantly improved IOP profiles during both basic and advanced programmes, but the change was not significantly different compared to the control group, possibly as a result of the waitlist control group also practicing relaxation exercises on their own in preparation for the intervention phase. After completion of both phases, 56% of patients initially on treatment had their medications reduced.

A further trial by the same group investigated the effect of autogenic training on stress reactivity to a 10-min mental stress test [32]. Short-term mental state was significantly reduced in the intervention group compared to the control group after training; however, autogenic training failed to demonstrate significant changes in the IOP and heart rate responses to stress.

The effects of autogenic relaxation on IOP control and short-term mental state are promising, but there is no evidence that it modulates stress reactivity. Further studies with well-designed control groups would be needed to establish conclusive evidence of benefit for glaucoma patients.

Music

Music has been used as a relaxation technique to reduce psychological stress [33] and may potentially enhance

spatial–temporal performance and synaptic plasticity through acoustic biofeedback [34].

Bertelmann and Strempel [33] showed that relaxation music has the potential to improve the physical and mental health of POAG patients. Their intervention regimen involved 10 consecutive days of 30-min exposure to harmonic music at a tempo of 60 beats per minute through headphones, accompanied by subliminal binaural beats, sounds of nature, visualisation of the aqueous humour drainage pathway and breathing instructions. There were slight but significant improvements in physical parameters such as best corrected visual acuity (BCVA) by 0.09 and IOP by 0.15 mmHg, while visual field testing yielded no significant change. Patients also showed improved short-term mental state as assessed by the Kurzfragebogen zur aktuellen Beanspruchung (KAB) score compared to the control group, but no effects on the long-term mental well-being were demonstrated. Serum stress biomarkers such as cortisol, endothelin-1 and adrenaline did not significantly differ between the groups.

Salvatore et al. [34] reported a case of bilateral open angle glaucoma and right eye epiretinal membrane which showed improvement after acoustic biofeedback rehabilitation in terms of fixation stability, retinal sensitivity and reading speed for both eyes and the National Eye Institute – Visual Functioning Questionnaire (NEI-VFQ-25). The patient was subjected to 5 weekly sessions lasting 10 min for each eye involving acoustic biofeedback rehabilitation with the Macular Integrity Assessment (MAIA) microperimetry system. The training involved asking the patient to move his eyes towards a monotone sound which would change into Mozart's Sonata for Two Pianos upon visual fixation to the target.

There are small but significant effects of music on the physical and mental health of glaucoma patients, which may be limited by the short duration of intervention. Further research with larger sample size and longer duration is warranted to establish any sustained impact of music on optimising the care of glaucoma patients.

Hypnosis

Hypnosis aims to establish a trance state of focused attention to influence the physical and mental state of individuals. Berger and Simel [35] attempted to induce IOP changes through hypnosis in glaucoma patients. However, there was no significant difference in IOP during the trance state of hypnosis, after suggestion of symptom relief during hypnosis or after hypnotic suggestion of anxiety state. Interestingly, glaucoma patients demonstrated an IOP reduction ranging from 2.1 to 11.1 mmHg after suggestion of symptom relief during wakefulness. There is no evidence to support the use of hypnosis to benefit glaucoma patients.

Motivational interviewing

Motivational interview is a counselling technique aiming at improving patient motivation and treatment adherence. It emphasises on the use of a guidance approach to promote behavioural change as opposed to direct paternalistic instruction and education [36]. Principles of empathy, autonomy and partnership with interactive patient engagement build the foundation for cultivating change [37]. Specific strategies include asking open-ended questions and using complex reflective statements to elicit change talk through which patients identify their own motivations and barriers to change [37]. Interviewers can then assess patients' awareness of glaucoma and its complications, their acceptance of and adherence to treatment, as well as their stage of change to provide appropriate reflective feedback [36].

Cook et al. [36] demonstrated that motivational interviewing in the form of 3 face-to-face sessions and 3 telephone calls resulted in no significant differences in IOP and visual field outcomes. However, patient satisfaction in terms of the level of individualised support and the degree of patient-centred care received was significantly improved after motivational interviewing compared to both reminder phone calls and usual care.

In another study by Newman-Casey et al. [37], glaucoma patients were subjected to a single session of motivational interviewing by para-professional staff lasting for an average of 6.4 min. Patient satisfaction was similarly found to be improved in terms of satisfaction with staff communication as assessed by the Clinician and Group Survey of the Consumer Assessment of Healthcare Providers and Systems (CG-CAHPS) provider communication sub-scale, but only among a subgroup of patients who rated the staff above average for providing autonomy supportive care based on the Health Care Climate Questionnaire (HCCQ). Otherwise, motivational interviewing showed no significant effects on health activation or self-efficacy of eye drop instillation.

Based on the above evidence, the effects of motivational interviewing on improving glaucoma care in terms of IOP, visual field changes and patient satisfaction are inconclusive with variable effects across different patients and settings.

Psychological nursing

Chang et al. [38] introduced the use of psychological nursing during the perioperative period for glaucoma patients undergoing trabeculectomy. Patients received 10–15 min of daily psychological counselling until discharge involving an assessment of the patient's psychological state and potential worries, sharing of methods to reduce anxiety and stress, explanation of how emotions and sleep quality affect glaucoma outcomes, and reassurance by sharing successful cases of trabeculectomy. Patients receiving psychological nursing on top of ocular massage

reported improved physical and functional outcomes in terms of better BCVA and better outcome of trabeculectomy, such as improvement in filtering blebs, compared to the control group that performed ocular massage only. BCVA increased by 0.12 and 0.17 more than the controls at 1 month and 3 months after operation, respectively. However, the reasons underlying better filtering blebs after psychological nursing were not addressed. In addition, psychological outcomes were significantly in favour of psychological nursing, with greater improvements in negative emotions assessed by the Hamilton Anxiety Scale (HAMA) and Hamilton Depression Scale (HAMD) and sleep quality reflected by the Pittsburgh Sleep Quality Index (PSQI) upon discharge, as well as better overall quality of life based on the Generic Quality of Life Inventory-74 (GQOL-74) at 3 months. With the promising results above, future research may extend the use of psychological nursing to other types of glaucoma procedures and other clinical settings.

Bright light exposure

Glaucoma patients are at higher risks of poor sleep quality and sleep disturbances potentially due to progressive loss of intrinsically photosensitive retinal ganglion cells (ipRGCs) and subsequent impaired melanopsin signalling to the suprachiasmatic nuclei for circadian rhythm regulation [39]. Daytime bright light exposure aims to modulate melanopsin activity to improve sleep quality in glaucoma patients.

There is evidence by Kawasaki et al. [39] that 30 minof bright light exposure every morning for 4 weeks using a 10,000 lx polychromatic bright white light box can significantly increase pupillometry post-illumination pupil response (PIPR), which is a surrogate marker of melanopsin activation, suggesting the ability of the melanopsin system to adapt to light exposure through viable ipRGCs. The improvement of PIPR was significantly correlated with the relative circadian amplitude, i.e. high daytime and low night-time activity, and inter-daily stability of the rest-activity rhythm, which further suggests a central role of melanopsin response to bright light exposure. Patients also reported significantly improved subjective sleep quality but this was not echoed by the Pittsburgh Sleep Quality Index (PSQI) or other objective sleep parameters derived from the rest-activity recordings. Future studies may explore whether the improvements in PIPR and subjective sleep quality translate to better mental well-being among glaucoma patients.

Limitations

The duration of most studies was relatively short with a lack of follow-up. Long-term studies with adequate follow-up are required to evaluate whether there are sustained impacts on IOP control. Besides, the possible impacts on other structural outcomes such as retinal nerve fibre layer measurements and functional outcomes including visual field changes may only be revealed by studies with longer duration of intervention and follow-up as glaucoma progression usually takes years to develop. Secondly, the outcome measures were largely focused on IOP changes in current studies. This is probably because IOP is easy to be measured, compared to other glaucoma related parameters. Other important parameters that reflect glaucoma progression include changes in retinal nerve fibre layer thickness, optic disc and ocular perfusion, while stress biomarkers and gene expression can provide additional biochemical evidence of the effects of psychological interventions. Patient-oriented outcomes such as visual field, mental health symptoms and quality of life should also be included to better inform clinical practice. Nonetheless, with the promising result that certain psychological interventions, such as meditation, significantly lower IOP, we anticipate more long-term studies to evaluate these psychological interventions in glaucoma control would be coming up in the near future. Thirdly, the intervention protocols vary across studies resulting in considerable heterogeneity in the type, duration and delivery of the psychological interventions. The level of treatment fidelity and patient adherence also affect the reliability of the results but this can be difficult to accurately measure in psychological therapies. Lastly, the interpretation of the applicability of the studies may be limited by the small sample size of studies on these psychological interventions. This may be partially due to time and manpower implications since the delivery of these interventions often require face-to-face supervision from instructors or clinical psychologists. However, as healthcare professionals are getting more used to telemedicine and virtual workshops in recent years, we may explore how these psychological interventions could be delivered in a more convenient way using online platform.

Considerations on the implementation of psychological interventions

Current glaucoma management largely focuses on directly improving physical parameters such as IOP and visual field through pharmacological, laser-based and surgical approaches, while the mental well-being of glaucoma patients is often neglected. Given the close interrelationship between mental health and glaucoma, psychological interventions can play a bigger role in the holistic care of glaucoma patients by controlling disease progression and alleviating the mental health burden caused by the disease. Besides, they can be provided at a lower cost compared to the use of medications or procedures, and are non-invasive and free of side effects which are often major concerns for patients with glaucoma. Psychological interventions treat

not only the eyes, but the person as a whole through stress reduction and emotional regulation with systemic benefits on physical health including reductions in heart rate, blood pressure and blood glucose, as well as improvements in mental health and quality of life [26, 30]. More importantly, these interventions often involve active patient engagement and can empower patients to have a greater sense of control over their own disease. This is especially important in an irreversible and chronic disease as patient adherence to medication and follow-up could be crucial to halt glaucoma progression.

On the other hand, some of the challenges of incorporating these mental health interventions in glaucoma patients include manpower and time constraints especially in the setting of the busy ophthalmology clinics. For example, the delivery of meditation or mindfulness-based stress reduction strategies, which have the most proven benefits in this review, require multidisciplinary input from yoga or mindfulness instructors or clinical psychologists. Although one study showed that the effect on IOP reduction can be maintained by self-meditation at home, patients still underwent an initial phase of instructor-supervised meditation [23]. Alternatively, the use of Web-based or app-based modules with audio instructions and video demonstrations could be a possible option to deliver these interventions [40, 41]. Another issue is the heterogeneity of meditation-based interventions with various techniques and methods preferred by different instructors, so a standardised protocol of intervention delivery would be essential to ensure optimal practice and outcomes. Finally, patient commitment and compliance would also play key roles in the effectiveness of psychological interventions. Studies which have shown benefits on glaucoma outcomes required daily practice of meditation for 30–60 min. While face-to-face sessions are ideal for ensuring compliance, the use of logbooks or reminders, as in the case of other chronic diseases [42–45], may be useful strategies to monitor and promote long-term compliance at home. Home-based interventions also provide additional advantages of convenience and potentially more optimal practice of mindfulness in a familiar and comfortable environment. Ultimately, the successful implementation of these psychological interventions would depend on local cultural practices including patient counselling and their acceptability and beliefs regarding meditation techniques for glaucoma management, as well as effective collaboration across various parties including ophthalmologists, nurses, yoga instructors, clinical psychologists, and most importantly patients themselves.

Conclusion

Daily meditation for 30–60 min is generally effective in improving glaucoma control in terms of IOP, ocular perfusion and quality of life among glaucoma patients. The impacts of music, autogenic training and psychological nursing on glaucoma control, vision outcomes and psychological symptoms are promising and warrant further studies to confirm their effectiveness. Bright light exposure has also shown some effects on sleeping quality, while there is insufficient basis to support the adoption of motivational interviewing or hypnosis in glaucoma patients based on the currently available evidence.

Future research should involve well-conducted randomised trials with larger sample sizes and longer duration of intervention and follow-up to establish the long-term benefits for glaucoma patients. The measurement of mental health parameters such as anxiety and depressive symptoms and sleep quality as well as quality of life analysis should also be incorporated, because these are important factors affecting the overall well-being in patients with glaucoma and they may be potentially reversible through psychological interventions. The impact of the mode of intervention delivery, i.e. instructor-supervised versus self-delivered interventions, can be explored since this would have resource implications especially in resource-tight settings. The potential effects of other psychotherapies such as cognitive behavioural therapy, interpersonal therapy and biofeedback techniques on improving mental health symptoms and stress management in glaucoma patients are also worth investigating.

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Declarations

Conflict of interest The authors declare no competing interests.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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