




# Physical Exercise for Reducing Intraocular Pressure in Glaucoma

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## ABSTRACT

**Introduction:** Glaucoma is a common eye condition that poses a risk to vision, as it involves elevated intraocular pressure (IOP) and can lead to vision impairment. Elevated intraocular pressure (IOP) and inadequate ocular perfusion are the basic theories of glaucoma development and progression. **Methods:** Literature within the last 10 years was searched through PubMed and Google using the specified keywords: "Glaucoma" (title), "Intraocular Pressure (IOP)" (all fields), and "Physical Exercise" (all fields). The PRISMA method is used to process journal selection. **Results:** Dynamic exercises such as cycling and jogging have been shown to significantly reduce intraocular pressure (IOP), particularly in patients with glaucoma, whereas isometric activities like weightlifting or head-down yoga poses temporarily increase IOP. Breathing exercises such as yogic pranayama can lower IOP by stimulating parasympathetic activity and improving aqueous humor outflow without elevating ocular venous pressure. **Conclusion:** The decrease in IOP and increase in OPP after dynamic exercises such as cycling and jogging were related to the intensity of the exercise. No cure is available; management is to prevent further damage and vision loss. Physical exercise influences the IOP, ocular perfusion, neuroprotection, and mental health in patients with glaucoma. This article discusses the benefits of physical exercise in reducing IOP and its potential risks in glaucoma patients.

**Keywords:** Glaucoma, intraocular pressure, physical exercise.

## ABSTRAK

**Pendahuluan:** Glaukoma adalah kondisi mata umum yang berisiko terhadap penglihatan, karena melibatkan peningkatan tekanan intraokular (TIO) dan dapat menyebabkan gangguan penglihatan. Peningkatan tekanan intraokular (TIO) dan perfusi okular yang tidak memadai merupakan teori dasar perkembangan dan progresi glaukoma. **Metode:** Pencarian literatur dalam 10 tahun terakhir melalui PubMed dan Google menggunakan kata kunci yang ditentukan: *"Glaucoma" (title), "Intraocular Pressure (IOP)" (all fields),* dan *"Physical Exercise" (all fields).* Metode PRISMA digunakan untuk memproses pemilihan jurnal. **Hasil:** Latihan dinamis seperti bersepeda dan joging telah terbukti secara signifikan mengurangi tekanan intraokular (TIO), terutama pada pasien glaukoma, sedangkan aktivitas isometrik seperti angkat beban atau pose yoga kepala di bawah meningkatkan TIO untuk sementara. Latihan pernapasan seperti pranayama yoga dapat menurunkan TIO dengan merangsang aktivitas parasimpatis dan meningkatkan aliran keluar humor akuos tanpa meningkatkan tekanan vena okular. **Kesimpulan:** Penurunan TIO dan peningkatan OPP setelah latihan dinamis seperti bersepeda dan joging berkaitan dengan intensitas latihan. Tidak ada obat yang tersedia; penanganannya adalah untuk mencegah kerusakan lebih lanjut dan kehilangan penglihatan. Latihan fisik memengaruhi TIO, perfusi okular, neuroproteksi, dan kesehatan mental pada pasien glaukoma. Artikel ini membahas manfaat latihan fisik dalam menurunkan TIO dan potensi risikonya pada pasien glaukoma. **Ni Putu Dian Apriandary, Ni Nyoman Kompyang Rahayu. Latihan Fisik untuk Menurunkan Tekanan Intraokular pada Glaukoma.**

**Kata Kunci:** Glaukoma, tekanan intraokular, latihan fisik.



## INTRODUCTION

Glaucoma is a common eye condition that poses a risk to vision, as it involves elevated intraocular pressure (IOP) and can lead to vision impairment. In the United States, an estimated 80 million people are affected by glaucoma.[1] In Indonesia, glaucoma is the second most common cause of blindness after cataracts; the prevalence is 0.46%–

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4 to 5 out of 1,000 people suffer from glaucoma.[2] The occurrence of glaucoma is mostly in individuals aged 40–80 years old. It is expected to increase significantly from 76 million in 2020 to 111.8 million in 2040 due to the aging population.[1] Numerous factors, including heart rate, breathing, exercise, hydration status, systemic drugs, time of day, alcohol intake, patient posture, and topical treatments, can cause IOP change throughout the day.[3]

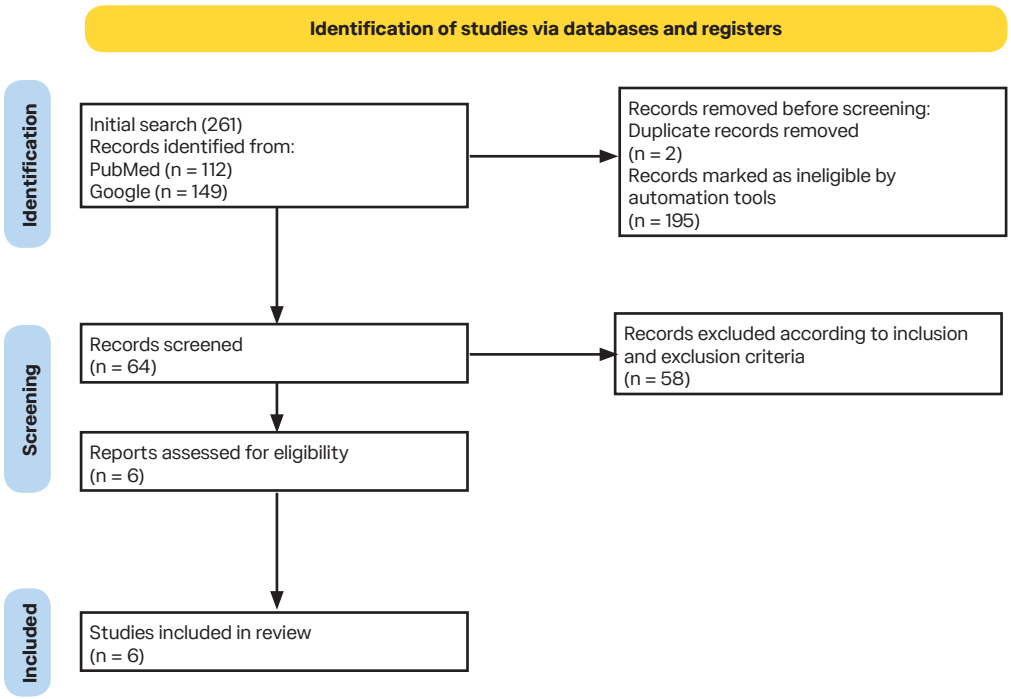
Treatment for glaucoma is tailored to the individual's type and severity. Currently, there is no cure for the already-acquired vision loss. The treatments can only prevent more harm and loss of eyesight. Researchers have assessed the benefits of physical exercise in treating chronic disorders such as glaucoma. Two types of physical exercise are isometric and dynamic exercise. Jogging and cycling are examples of dynamic exercise involving a change in muscle length, whereas hand clutching, weightlifting, and yoga are examples of isometric exercise done in a static position.[4] Physical exercise affects IOP, ocular perfusion, neuroprotection, and mental wellness in glaucoma patients.[4]

Retinal and choroidal circulation contribute to the ocular blood flow. It is strongly associated with IOP. The link between systemic blood pressure (BP) and IOP is known as the ocular perfusion pressure (OPP), and it represents the net pressure gradient indicating blood flow to the eye. The mean arterial pressure (MAP) - IOP is the formula for the mean OPP (MPP); MAP = diastolic BP + 1/3 (systemic BP–diastolic BP).[5] The low OPP is more likely to develop glaucoma; dynamic and isometric activity that can increase OPP may show positive effects in glaucoma patients.[6,7] This article looked at the advantages of exercise in lowering IOP and the possible risks associated with exercise in primary open-angle glaucoma (POAG).

## METHODS

Literature within the last ten years was searched through PubMed and Google using the specified keywords: "Glaucoma" (title), "Intraocular Pressure (IOP)" (all fields), and "Physical Exercise" (all fields). Case reports and articles in languages other than English and Indonesian were excluded. Randomized Control Trials (RCT), clinical trials, comparison studies, and original studies were included for assessment. The PICO was as follows: P (population): Primary open-angle glaucoma (POAG); I (intervention): The dynamic or isometric exercise; C (comparison): The IOP values after dynamic or isometric exercises; O (outcome): The dynamic exercise can reduce IOP in glaucoma patients. The PRISMA method is used to process journal selection. The PRISMA flow diagram is shown in the **Scheme**.

The initial search generated 261 data based on searches with keywords through PubMed and Google. Furthermore, the data is sorted based on inclusion and exclusion criteria. The data that has been sorted will be assessed for feasibility using the SRQR checklist to assess the quality of the article with 21 items.[8] All literature discussed in this research meets the minimum achievement of 15 checklist components (**Appendix).** The data extraction process was performed independently by the author to compare the type of exercise and level of significance, as well as the potential for implementing physical exercise to reduce IOP in glaucoma patients.




**Scheme.** Flowchart of identifying related studies.

## RESULTS

**Table.** Resume of the physical exercise of glaucoma patients.

| Category | Study | Design | Sample | Intervention | Result |
|---|---|---|---|---|---|
| Bicycle ergometer | Ma, *et al.*[9] | Prospective study, RCT | 123 patients with POAG. | Population was divided into 2 groups:<br>a. Intervention group (n = 61): exercise with moderate intensity (20% maximal work rate for 10 minutes) and high intensity (60% maximal work rate for 5 minutes).<br>b. Control group (n = 62): irregular exercises. | After 10 minutes of exercise of moderate intensity, the subjects had a significant IOP decrease in (2.37 ± 2.67 mmHg) ($p$ = 0.00).<br><br>After 5 minutes of high-intensity exercise, the subjects had a significant IOP decrease in (5.95 ± 3.80 mmHg) ($p$ = 0.00). |
| Bicycle ergometer | Yang, Li, Wang, *et al.*[10] | Prospective control clinical study | 80 patients with POAG and myopia were categorized as per their degree of myopia. | Population was divided into 3 groups:<br>a. Myopes 6 D or more (n = 30)<br>b. Myopes –0.76 and –5.99 D (n = 29)<br>c. Non-myopia (n = 21)<br><br>All groups received 2 protocol measurements.<br>Protocol 1: The IOP measurements over 24 hours at resting conditions (without physical exercise)<br>Protocol 2: The IOP measurements after exercise 20% maximal work rate for 10 minutes, followed by exercise at 60% maximal work rate for 5 minutes | Result for protocol 1:<br>The IOP fluctuations at resting conditions in 24 hours were not statistically significant in all groups ($p$ = 0.58).<br><br>Result for protocol 2:<br>After 10 minutes of moderate intensity exercise, all subjects had a significant IOP decrease (3.50 ± 2.76 mmHg) ($p$ = 0.02).<br>After 5 minutes of high-intensity exercise, all subjects had a significantly IOP decrease (7.57 ± 3.47 mmHg) ($p$ = 0.00). |
| Jogging | Ma, *et al.*[9] | Prospective, RCT. | 123 patients with POAG. | Population was divided into two groups:<br>a. Intervention group (n = 50): the subjects received exercise for 30 minutes at 6 am–10 am for 3 months, with frequency around 20 times per month.<br>b. Control group (n = 50): with irregular exercises. | Intervention group: The IOP in 24 hour after long-term exercise in 3 months of jogging was generally lower than the baseline.<br>Control group: No significant difference in IOP before and after 3 months. |
| Yoga | Sankalp, *et al.*[11] | RCT | 30 patients with POAG. All subjects were assessed at baseline, day 1, day 14, and day 28. | Population was divided into two groups:<br>a. Intervention group (n = 30): standard medical treatment with Yoga-based lifestyle intervention (YBLI), including Yogic ocular exercises (YOE) and modified *Tratak Kriya* (mTk) in 60 minutes a day for 2 weeks. | Only the right eyes showed a decrease in IOP on day 14 (15.54 ± 2.81 mmHg) and day 28 (15.24 ± 3.1 mmHg), $p$ = 0.006 and 0.001 in the intervention group. |

| Category | Study | Design | Sample | Intervention | Result |
|---|---|---|---|---|---|
| | | | | b. Control group (n = 30): standard medical treatment. | |
| Yoga | Udenia, Mittal, *et al.*[12] | Prospective, RCT | 90 patients with POAG. | Population was divided into two groups:<br>a. Intervention group: *yogic pranaya* and diaphragmatic breathing exercise.<br>b. Control group: standard medical treatment. | The group that practiced diaphragmatic breathing exercises and yogic pranayama had a significantly lower IOP.<br>- Right eye: 20.85 ± 3.39 to 14.90 ± 2.86 mmHg with $p < 0.001$.<br>- Left eye: 20.30 ± 4.12 to 14.25 ± 3.85 mmHg with $p < 0.001$. |
| Yoga | Jasien, *et al.*[13] | Prospective, observational study | 10 subjects with POAG and 10 normal individuals | The subjects engaged in two minutes of each of the following yoga poses: *Adho Mukha Svanasana*, *Uttanasana*, *Halasana*, and *Viparita Karani*. | Within one minute of establishing the yoga position, there was a significant ($p < 0.01$) increase in IOP for all poses that involved the head down.<br>- IOP levels in *Adho Mukha Svanasana* position: (17 ± 3.2 mmHg to 28 ± 3.8 mmHg) in glaucoma patients; (17 ± 2.8 mmHg to 29 ± 3.9 mmHg) in normal individuals.<br>- IOP levels in *Uttanasana* position: (17 ± 3.9 mmHg to 27 ± 3.4 mmHg in glaucoma patients); (18 ± 2.5 mmHg to 26 ± 3.6 mmHg) in normal individuals.<br>- IOP levels in *Halasana* position: (18 ± 2.8 mmHg to 24 ± 3.5 mmHg) in glaucoma patients; (18 ± 2.7 mmHg to 22 ± 3.4 mmHg) in normal individuals.<br>- IOP levels in *Viparita Kirani* position: (17 ± 4 mmHg to 21 ± 3.6 mmHg) in glaucoma patients; (17 ± 2.8 to 21 ± 2.4 mmHg in normal individuals. |

| Category | Study | Design | Sample | Intervention | Result |
|---|---|---|---|---|---|
| Weightlifting | Polikoff, *et al.*[14] | Prospective, observational study | 8 POAG patients performed weightlifting exercises at least twice a week, including flat bench press, leg press, standing triceps extension, seated rows, and stomach crunches. | IOP assessment is performed at 3 phases of exercise.<br>1. Pre-exercise IOP was assessed while performing each exercise: leg press and stomach crunches, supine for bench press; sitting for seated rows; standing for triceps extensions.<br>2. Intra-exercise IOP was assessed with the machine held at full extension on the 5 times repetition for every exercise except stomach crunches<br>3. Post-exercise IOP was assessed one minute after exercise. | Intra-exercise IOP increases for seated rows and bench presses were 0.3–8.7 mmHg and 0.3–7.3 mmHg, respectively.<br><br>IOP reduction for triceps extension in 1 minute's post exercise. |

## DISCUSSION

Literature reviews consistently demonstrate that intraocular pressure decreases following dynamic exercise. The increase in colloidal osmotic pressure in plasma due to sweating during exercise causes a decrease in the production of aqueous humor (AH).[15] This condition along with increased plasma osmolarity, ocular blood flow, blood lactate, and decreased blood pH, can reduce intraocular pressure (IOP).[16] Decreased production of AH can significantly lower IOP.

Limited evidence exists on the type of dynamic exercise. In Ma, *et al.*,[9] 123 glaucoma patients experienced a notable reduction in IOP (2 mmHg) after cycling for 10 minutes at a moderate intensity (20% maximum work rate) using only prostaglandin analogs. The intensity of exercise is comparable to a brisk walk in our daily lives.[9] This describes a short-term exercise. Prior research indicates that cycling for 10 minutes at a moderate intensity level (20% of maximum work rate) led to a notable decrease in intraocular pressure (IOP) of approximately 2–3 mmHg for patients with primary open-angle glaucoma and high myopia (POAG-HM).[10] This research also discovered a notable fluctuation in intraocular pressure in patients with POAG-HM following physical activity. The anatomical features of highly myopic eyes include elongated axial length, a larger and tilted optic disc, peripapillary atrophy, thinning of the retinal nerve fiber layer, and insufficient blood flow in the choroid and retina. It is possible that these unusual anatomical features, specifically inadequate blood flow in the choroid and retina, cause limited autoregulation and contribute to fluctuations in IOP.[10]

While engaging in intense cycling at 60% of the maximum work rate for 5 minutes, there was a significant decrease in post-exercise IOP.[9] Previous research using a similar approach found a decrease in IOP following high-intensity dynamic exercise.[10] Both studies indicated decreased post-exercise IOP and were associated with exercise intensity.

Prior research has shown that intraocular pressure measurements within one day of long-term jogging training after three months are generally lower than initial values.[9] This reduction is noticeable at all points throughout the 24-hour intraocular pressure curve, especially at 6:00 am and 10:00 am. Consistent physical exercise reduces intraocular pressure and protects the optic nerve in people with primary open-angle glaucoma (POAG).[9]

Previous reviews have shown that the impact of isometric exercise on increased IOP varies. There is scarce information on assessing IOP in glaucoma patients following isometric exercise.[17,18] Yoga practice includes various movements that may influence intraocular pressure (IOP). Certain Yoga poses can be categorized as isometric workouts and may consist of body inversion, which has been shown to affect intraocular pressure (IOP) significantly.[4] Yoga routines involving head-down positions were linked to a quick increase in IOP among individuals with glaucoma and those with healthy eyes. Jasien, *et al.*,[13] reported IOP in 4 yoga poses on patients with glaucoma. The initial position is *Adho Mukha Svanasana*, commonly called "downward facing dog", followed by *Uttanasana*, commonly known as "forward bending pose". The third position executed is *Halasana*, also called "plow pose". Finally, *Viparita Karani*, also known as "foot on the wall pose," is done to finish the series. All participants demonstrated a significant and quick rise in IOP when practicing yoga poses that involve bending the head downwards. Regardless of the yoga poses, the increase varied from 6–11 mmHg, occured one minute after adopting the yoga position, and the IOP returned to baseline within two minutes after sitting again, with no more notable changes afterward.

The increase in IOP during a yoga pose is

due to higher pressure in the episcleral and orbital veins where aqueous humor drains, impacting IOP according to the Goldman equation. Another element that may play a role in position-induced alterations in eye pressure is an alteration in the thickness of the choroid. The choroid is emptied by the vortex veins, leading to the superior ophthalmic vein and the intracranial cavernous sinus. Changes in body position can indirectly affect the pressure in the choroid's veins, as well as the thickness and volume of the choroid due to alterations in intracranial cerebrospinal fluid pressure.[13] Another research on yoga conducted by Sankalp, *et al*.,[11] found that yogic ocular exercises (YOE) such as extraocular muscle exercise and *Tratak Kriya* (TK) had shown unequal effects, with a significant decrease in IOP observed only in the right eye and a non-significant decrease in the left eye. This research concluded that this approach is not advised for controlling elevated intraocular pressure in individuals with glaucoma.

Yogic Pranayama and Diaphragmatic Breathing (YPDB) can lessen intraocular pressure in individuals with POAG.[19] YPDB is a yoga position that does not involve being upside-down. YPDB stimulating the parasympathetic system could lead to the contraction of the ciliary muscle. This may help widen the angle of the anterior chamber by stretching the trabecular meshwork, allowing for better drainage of aqueous humor and a decrease in IOP.[12] Additionally, YPDB is a relaxation technique that deeply calms the nervous system. The calming effects of pranayama are thought to come from the higher levels of melatonin produced during slow pranayama breathing routines. Parasympathetic activity is more dominant than sympathetic activity in this state. In a peaceful state of mind, sympathetic activity decreases. The decreased sympathetic activity could also result in a decrease in the production of the eye's fluid.[12]

Weightlifting has been proven to raise intraocular pressure in both individuals with good health and those with glaucoma. Research on weightlifting exercise in individuals with glaucoma is limited. Polikoff, *et al*.,[14] reported increases in intraocular pressure during bench press and seated rows were varied between 0.3–7.3 mmHg and 0.3–8.7 mmHg, respectively. The rise in intraocular pressure while weightlifting might be due to a Valsalva maneuver.[20] This happens when coughing, vomiting, lifting heavy items, and playing wind instruments. This condition, along with contracting abdominal and thoracic muscles, leads to a further rise in intrathoracic venous pressure and compression of the intrathoracic venous system. The increase in pressure within the thoracic veins is carried by the jugular, orbital, and vortex veins to the choroid, leading to vascular swelling, an expansion of choroidal volume, and a rise in intraocular pressure.[20]

Elevated intraocular pressure is also associated with alterations in ocular perfusion pressure (OPP). Lack of proper OPP and abnormally high IOP are the primary causes of glaucoma. People who have low OPP are more likely to develop glaucoma.[9] Dynamic workouts can significantly increase OPP, but the relationship between OPP and blood flow to the back of the eye is complicated because of autoregulation. Autoregulation is a process that ensures consistent blood flow even when there are fluctuations in OPP. There is a regulating mechanism in the ocular blood supply to modulate blood flow and prevent significant changes in ocular perfusion with increased OPP.[4] Dynamic exercise results in a notable increase in ocular blood flow in retinal and choroidal vessels, which is associated with the intensity of the exercise.[21] Higher intensity of dynamic exercise and practicing yoga without head-down positions leads to a more significant decrease in intraocular pressure and an increase in ocular perfusion pressure.

## STUDY LIMITATION

This study only addresses the role of various physical exercises in influencing the outcome of IOP and explains the types of physical activity performed to reduce IOP in glaucoma patients.

## CONCLUSION

In conclusion, dynamic exercise can reduce IOP in glaucoma patients. The decrease in IOP and increase in OPP after dynamic exercises such as cycling and jogging were related to the intensity of the exercise. In addition, not all isometric exercises significantly improved IOP. Yogic pranayama and diaphragmatic breathing directly lower IOP and have a calming effect that may reduce sympathetic activity and decrease aqueous humor secretion. This study suggests that dynamic exercise and yogic pranayama with diaphragmatic breathing can reduce intraocular pressure. It can be recommended as exercise and adjuvant therapy in patients with primary open-angle glaucoma.

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**Appendix.** Alignment of the 21 Standards for Reporting Qualitative Research (SRQR) with recommendations from 6 original sources.

| No | Topic | Reference | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Ma QY, *et al.*[9]** | **Yang Y, Li Z, Wang N, *et al.*[10]** | **Sankalp, *et al.*[11]** | **Udenia H, Mittal S, *et al.*[12]** | **Jasien, *et al.*[13]** | **Polikoff, *et al.*[14]** |
| S1 | Title | * | - | * | * | - | - |
| S2 | Abstract | * | * | * | * | * | * |
| S3 | Problem formulation | * | * | * | * | * | * |
| S4 | Purpose or research question | * | * | * | * | * | * |
| S5 | Qualitative approach and research paradigm | * | * | * | * | * | * |
| S6 | Researcher characteristics, reflexivity | * | * | * | * | * | * |
| S7 | Context | * | * | * | * | * | * |
| S8 | Sampling strategy | * | * | * | * | * | * |
| S9 | Ethical issue pertaining to human subjects | - | * | * | - | * | - |
| S10 | Data collection methods | * | * | * | * | * | * |
| S11 | Data collection instruments/ technologies | * | * | * | * | * | * |
| S12 | Units of study | * | * | * | * | * | * |
| S13 | Data processing | * | - | * | * | * | * |
| S14 | Data analysis | * | * | * | * | * | * |
| S15 | Techniques to enhance trustworthiness | - | - | - | - | * | - |
| S16 | Synthesis and interpretation | * | * | * | * | * | * |
| S17 | Link to empirical data | * | * | * | * | * | * |
| S18 | Integration with prior work, implications, transferability, and contribution (s) | * | * | * | * | * | * |
| S19 | Limitations | * | * | * | * | - | - |
| S20 | Conflicts of interest | - | - | - | - | - | - |
| S21 | Funding | * | - | - | - | - | - |
| | Total | 18 | 16 | 18 | 17 | 17 | 15 |

* The reference has met the criteria on the topic in SRQR
- The reference does not meet the criteria on the topic in the SRQR