QANUN MEDIKA Vol 10 | No 2 July 2026
DOI: 10.30651/jqm.v10i02.30861

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

Research Article

The Influence of Aerobic Exercise on Intraocular Pressure in Normal Subjects in Late Adolescence

Hasna Fauziyyah[1], Nur Shani Meida[2*]

1) Medical Study Program, Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Indonesia
2) Department of Ophthalmology, Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, Indonesia

ARTICLE INFO

Submitted : 20 th February 2026
Accepted : 19 th May 2026
Published : 25 th July 2026

Keywords:

Eye Health; Motor Activity; Tonometry, Ocular

****Correspondence:***

nurshani_meida@yahoo.com

ABSTRACT

Intraocular pressure (IOP) is an important ocular health parameter and a major modifiable risk factor related to glaucoma. Evidence regarding the acute effect of aerobic exercise on IOP remains inconsistent, particularly in healthy late adolescents. Objective: This study analyzed changes in IOP before and after one session of aerobic exercise. A pre-experimental one-group pretest-posttest design was conducted among 67 university students aged 19-22 years who met the eligibility criteria. Participants performed 20 minutes of jogging at a pace of 6:00-8:00 min/km. IOP in the right eye (OD) and left eye (OS) was measured before exercise and within 2 minutes after exercise using a handheld transpalpebral tonometer. Because the data were not normally distributed, pre-post differences were analyzed using the Wilcoxon signed-rank test. Mean IOP decreased from 17.90 to 15.24 mmHg in OD, representing a mean reduction of 2.66 mmHg. Mean IOP in OS decreased from 18.40 to 15.18 mmHg, representing a mean reduction of 3.22 mmHg. IOP decreased in most participants in OD (48/67) and OS (50/67). The Wilcoxon signed-rank test showed statistically significant pre-post differences in OD ($Z = -4.948$; $p < 0.001$; $r = 0.604$) and OS ($Z = -4.945$; $p < 0.001$; $r = 0.604$). IOP decreased significantly after a single session of aerobic exercise in healthy late adolescents. However, because this study used a one-group design without a control group, the findings should be interpreted as reflecting an acute physiological response rather than evidence of therapeutic efficacy.

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

INTRODUCTION

Intraocular pressure (IOP) refers to the pressure inside the eye, which is determined by the balance between aqueous humor production and drainage. The normal IOP range is approximately 10–21 mmHg (D. Zhang et al., 2022). An IOP value above 21 mmHg may increase the risk of serious ocular conditions and is considered a major risk factor for glaucoma (Kim et al., 2020). Several factors can influence IOP, including age, gender, ethnicity, cardiovascular health, and blood pressure (Janaswamy et al., 2025). Among these factors, blood pressure has received particular attention for its potential to alter ocular circulation and aqueous humor outflow.

The relationship between blood pressure and IOP remains inconsistent. Increased blood pressure may alter ocular blood flow and raise episcleral venous pressure, thereby reducing aqueous humor drainage through the trabecular meshwork. However, previous studies have reported different findings. A study done in Japan for people aged above 40 years reported that blood pressure (BP) can be a risk factor in elevating IOP (Yasukawa et al., 2022). However, another study reported that blood pressure did not have any effect to IOP from two different groups, namely the hypertensive group and the normotensive group (Parajuli et al., 2020). Beyond blood pressure itself, physical activity, such as exercise, may also influence IOP by modifying cardiovascular function, ocular blood flow, and aqueous humor dynamics.

Exercise is a planned physical activity that influences cardiovascular function and hemodynamic responses, potentially affecting aqueous humor production and drainage. Physical inactivity can also be a cause of cardiovascular disease and other diseases (Dewi et al., 2025). According to the American College of Sports Medicine (ACSM), aerobic exercise involves rhythmic, continuous movement of large muscle groups. Aerobic exercise is useful for regulating blood glucose levels (Haris et al., 2023), increasing quality of life (Qurrotunnada & Rochmawati, 2025). Both high and medium intensity aerobic were proven to reduce the IOP in healthy individuals (Alfaqeeh et al., 2022; Yuan et al., 2021). Also, it can reduce IOP in primary open-angle glaucoma (Ma et al., 2022). Among various aerobic exercises, jogging is one of the most accessible and commonly practiced activities, particularly among adolescents and young adults.

Jogging is a simple, accessible form of aerobic exercise that requires no special equipment and is commonly incorporated into daily physical activity. In late adolescents, ranging from 18 to 22 years old (Chauhan & Dubey, 2022; Pamungkas et al., 2024), this type of exercise is relevant because this age group is generally physically active and may experience cardiovascular and hemodynamic changes during exercise. Given the potential effects of aerobic exercise on IOP, further investigation is needed to determine how jogging affects IOP in late adolescents.

METHODS

This study used a pre-experimental one-group pretest-posttest design to assess changes in intraocular pressure before and after one session of aerobic exercise. The study population consisted of male and female students at Universitas Muhammadiyah Yogyakarta in late adolescence, defined as ages 17-22. The inclusion criteria were male or female sex, age 17-22 years, willingness to participate and provide informed consent, and healthy, normal eyes. The sample size was determined using the Lemeshow formula: $n = Z^2 \times P(1-P)/d^2$.

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

Using Z = 1.64 for 90% confidence, P = 0.50, and d = 0.10, the estimated minimum sample was n = 1.64^2 x 0.50(1-0.50)/0.10^2 = 67.24, rounded to 67 participants. The exclusion criteria were myopia greater than 3 diopters, current or previous glaucoma, previous high IOP value, history of ocular surgery, including cataract surgery, trabeculectomy, glaucoma surgery with shunt or stent implantation, vitrectomy, laser iridotomy, laser trabeculoplasty, or intraocular lens implantation, long-term corticosteroid use for more than 6 weeks, non-cooperation, or refusal to continue participation. The intraocular pressure in the right and left eyes was measured before and after the aerobic exercise session using a handheld device that measures intraocular pressure through the eyelids. The intervention consisted of 20 minutes of jogging. Exercise pace was maintained between 6:00 and 8:00 minutes per kilometer and was monitored using Relive, Strava, or a similar exercise application to support pace consistency. IOP was measured immediately before the intervention and within 2 minutes after jogging. Measurements were performed in a seated upright position with the head elevated according to the device procedure. The right and left eyes were measured sequentially at the superior palpebra using a handheld transpalpebral tonometer, following the manufacturer's instructions. The use of transpalpebral tonometry was selected because it is portable, non-invasive, and does not require direct corneal contact or topical anesthesia. However, because Goldmann applanation tonometry remains the reference standard, the potential influence of eyelid thickness, scleral rigidity, blinking, device positioning, and operator technique was considered in interpreting the findings. Data was analyzed using SPSS. Normality was assessed using the Kolmogorov-Smirnov test because the sample size was greater than 50. Because the pre- and post-exercise IOP data were not normally distributed, differences between measurements were analyzed using the Wilcoxon signed-rank test. Statistical significance was set at $p < 0.05$. The effect size for the Wilcoxon signed-rank test was calculated as r = |Z|/sqrt(N).

This study received ethical approval from the Health Research Ethics Committee, Faculty of Medicine and Health Sciences, Universitas Muhammadiyah Yogyakarta, No. 291/EC-KEPK FKIK UMY/IX/2025. The approval was valid from September 11, 2025, to September 11, 2026. All participants provided informed consent before participating. Participant anonymity and confidentiality were maintained throughout the study. The study was conducted in accordance with ethical principles for human research and the Declaration of Helsinki.

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

RESULTS

Respondent Characteristics

Table 1. Characteristics of Research Respondents

Respondent Characteristics	Frequency	Percentage
Age		
18 years	0	0
19 years	4	5.97
20 years	17	25.37
21 years	32	47.76
22 years	14	20.90
Gender		
Male	35	52.24
Female	32	47.76

Table 2. Normality Test of Right Eye Data

Right eye	Significance	
	Kolmogorov-Smirnov	Shapiro-Wilk
Pre test	0.006	0.023
Post test	0.010	0.023

Table 1 shows that, based on age characteristics, respondents are aged 19–22 years. The majority of respondents were 21 years old, namely 32 people (47.76%), followed by respondents aged 20 years, as many as 17 people (25.37%), respondents aged 22 years, as many as 14 people (20.90%), and respondents aged 19 years, as many as 4 people (5.97%). There were no respondents aged 17 and 18 years. By gender, there were 35 male respondents (52.24%) and 32 female respondents (47.76%).

The normality test using the Kolmogorov–Smirnov test in Table 2 showed that the right eye's intraocular pressure data before and after the test had significance values of 0.006 and 0.010, respectively ($p < 0.05$), indicating that the data were not normally distributed.

Based on the results of the normality test using the Kolmogorov–Smirnov test, as shown in Table 3, the left eye intraocular pressure data in the pre-test and post-test had significance values of 0.002 and 0.005, respectively ($p<0.05$), so the data were declared not normally distributed.

Based on the Wilcoxon signed-rank test, 48 respondents showed lower OD IOP after jogging, 13 respondents showed higher OD IOP, and 6 respondents showed unchanged values (Table 4). Mean OD IOP decreased from 17.90 mmHg before exercise to 15.24 mmHg after exercise, representing a mean reduction of 2.66 mmHg. The pre-post difference was statistically significant ($Z = -4.948$; $p < 0.001$), with a large effect size ($r = 0.604$).

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

Table 3. Normality Test for Left Eye Data

Left eye	Significance	
	Kolmogorov-Smirnov	**Shapiro-Wilk**
Pre test	0.002	0.003
Post test	0.005	0.010

Table 4. Results of the Effect of Aerobic Exercise on IOP OD

Category	n	Mean rank	Sum of ranks
Negative ranks (post-test < pre-test)	48	33.99	1631.50
Positive ranks (post-test > pre-test)	13	19.96	259.50
Ties (post-test = pre-test)	6	-	-
Mean IOP before exercise (mmHg)	67	17.90	-
Mean IOP after exercise (mmHg)	67	15.24	-
Mean absolute reduction (mmHg)	67	2.66	-
Z	-	-4.948	-
p-value	-	<0.001	-
Effect size r	-	0.604	-

Table 5. Results of the Effect of Aerobic Exercise on IOP OS

Category	n	Mean rank	Sum of ranks
Negative ranks (post-test < pre-test)	50	34.57	1728.50
Positive ranks (post-test > pre-test)	13	22.12	287.50
Ties (post-test = pre-test)	4	-	-
Mean IOP before exercise (mmHg)	67	18.40	-
Mean IOP after exercise (mmHg)	67	15.18	-
Mean absolute reduction (mmHg)	67	3.22	-
Z	-	-4.945	-
p-value	-	<0.001	-
Effect size r	-	0.604	-

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

Based on the Wilcoxon signed-rank test, 50 respondents showed lower OS IOP after jogging, 13 respondents showed higher OS IOP, and 4 respondents showed unchanged values (Table 5). Mean OS IOP decreased from 18.40 mmHg before exercise to 15.18 mmHg after exercise, representing a mean reduction of 3.22 mmHg. The pre-post difference was statistically significant ($Z = -4.945$; $p < 0.001$), with a large effect size ($r = 0.604$).

DISCUSSION

This study found that IOP decreased after a single session of aerobic exercise in healthy late adolescents. The mean reductions were 2.66 mmHg in the right eye and 3.22 mmHg in the left eye, and most participants showed lower post-exercise IOP values in both eyes. These findings are consistent with recent studies reporting that aerobic exercise may be followed by an acute reduction in IOP among healthy individuals and patients with primary open-angle glaucoma (Alfaqeeh et al., 2022; Ma et al., 2022; Yuan et al., 2021). However, because this study used a one-group pretest–posttest design without a sedentary control group, the reduction should be interpreted as a post-exercise change rather than definitive causal evidence that jogging alone produced the observed effect. This interpretation is consistent with methodological literature indicating that pretest–posttest findings without an appropriate comparison group are vulnerable to bias and provide limited causal inference (Gorman, 2022).

The observed decrease may be explained by several physiological mechanisms proposed in recent literature. Aerobic exercise can modify cardiovascular function, ocular perfusion, autonomic nervous system activity, and aqueous humor dynamics (Ma et al., 2022; Nie et al., 2022; Prayitnaningsih et al., 2021; Q. Zhang et al., 2024). Exercise-related hemodynamic changes may influence ocular blood flow and aqueous humor outflow, while changes in plasma osmolarity and lactate concentration during physical activity may create a transient osmotic gradient that contributes to lower IOP (Agadagba et al., 2025; Bariesheff, 2025; Ma et al., 2022; Sidoti et al., 2025). Nevertheless, these mechanisms were not directly measured in this study; therefore, they should be regarded as plausible explanations rather than confirmed pathways.

The magnitude of IOP reduction in this study was statistically significant and may be physiologically relevant as an acute response. However, clinical significance requires cautious interpretation. Post-exercise IOP reduction may be transient and does not necessarily indicate long-term glaucoma prevention or treatment benefit. Although recent literature suggests that aerobic activity may support IOP regulation, the duration, reproducibility, and sustained clinical effect of jogging-related IOP reduction remain uncertain (Ma et al., 2022; Rahmawati et al., 2022). Therefore, jogging should be discussed as a healthy lifestyle activity that may support ocular health, not as a substitute for standard ophthalmologic care or glaucoma therapy.

The use of a handheld transpalpebral tonometer is both a practical strength and a methodological limitation. The device allows non-invasive, rapid, and field-compatible IOP assessment without direct corneal contact, which was useful for immediate post-exercise measurement. However, Goldmann applanation tonometry remains widely regarded as the reference standard for IOP measurement (Brusini et al., 2021). Transpalpebral measurements may be influenced by eyelid characteristics, scleral rigidity, blinking, device positioning, and operator technique. These factors may contribute to measurement variability, particularly when IOP changes are assessed over a short interval.

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

Several additional limitations should be considered. First, the absence of a control group means that circadian IOP variation, hydration status, emotional stress, regression to the mean, and measurement variability could not be fully excluded. Second, caffeine intake, smoking status, obesity, and recent physical activity were not clearly documented as exclusion or control variables, although these factors may influence cardiovascular and ocular responses. Third, sex-based subgroup analysis was not performed, although sex-related physiological and hormonal factors may influence IOP. Fourth, IOP was measured only once shortly after exercise; therefore, the duration of the IOP reduction and the time needed to return to baseline remain unknown. Future studies should use randomized controlled or crossover designs, matched sedentary controls, repeated post-exercise measurements, standardized control of caffeine and smoking, and more accurate tonometry methods such as Goldmann applanation tonometry.

CONCLUSION

In this one-group pretest-posttest study, IOP decreased significantly following 20 minutes of jogging among healthy late adolescents, with mean reductions of 2.66 mmHg in the right eye and 3.22 mmHg in the left eye. These findings suggest that aerobic exercise may produce an acute post-exercise reduction in IOP. However, because the study did not include a control group and used transpalpebral tonometry, the results should be interpreted with caution and should not be generalized as evidence of therapeutic efficacy or of glaucoma prevention.

REFERENCES

Agadagba, S. K., Yau, S., Liang, Y., Dalton, K., & Thompson, B. (2025). Bidirectional causality of physical exercise in retinal neuroprotection. *Neural Regeneration Research*, *20*(12), 3400. https://doi.org/10.4103/NRR.NRR-D-24-00942

Alfaqeeh, F., Djemai, H., Hammad, R., Hammad, S., Noirez, P., & Dabayebeh, I. M. (2022). Effect of Aerobic Exercise at Different Intensities on Intraocular Pressure in Young Males. *Journal of Glaucoma*, *31*(11), 868–873. https://doi.org/10.1097/IJG.0000000000002110

Bariesheff, N. (2025). *Molecular Mechanisms of Exercise-Mediated Protection in the Aging Retina*. https://hdl.handle.net/1885/733794304

Brusini, P., Salvetat, M. L., & Zeppieri, M. (2021). How to Measure Intraocular Pressure: An Updated Review of Various Tonometers. *Journal of Clinical Medicine*, *10*(17), 3860. https://doi.org/10.3390/jcm10173860

Chauhan, A. R. K., & Dubey, P. (2022). A Study of Psychological well being among Late Adolescence. *Journal of Advance Research in Science and Social Science*, *5*(1), 39. https://doi.org/10.46523/jarssc.05.01.04

Dewi, P. E. N., Tasminatun, S., Kurniawan, N., Putri, H. Y., Galistiani, G. F., Syaifabila, I. A., & Ghozali, M. T. (2025). Pre–Post Evaluation of a Rural Indonesian Posbindu Cadre-Led Health Promotion Program on Cardiovascular Knowledge, Physical Health, and Mental Well-Being. *Media Publikasi Promosi Kesehatan Indonesia (MPPKI)*, *8*(11), 1424–1437. https://doi.org/10.56338/mppki.v8i11.8484

Gorman, D. M. (2022). Can a registered trial be reported as a one-group, pretest-posttest study with no explanation? A critique of Williams et al. (2021). *Health & Justice*, *10*(1), 2. https://doi.org/10.1186/s40352-021-00165-3

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

Haris, F., Jan, Y.-K., Liau, B.-Y., Hsieh, C.-W., Shen, W.-C., Tai, C.-C., Shih, Y.-H., & Lung, C.-W. (2023). The effects of different inner pressures of air insoles and walking durations on peak plantar pressure. *Medicine*, *102*(43), e35704. https://doi.org/10.1097/MD.0000000000035704

Janaswamy, S., Bindhu, V. H., Rao, A. N., Raju, R. S., & Rao, A. T. (2025). An Observational study on the correlation between Intraocular Pressure and Blood Pressure. *European Journal of Cardiovascular Medicine*, *15*, 146–151. https://doi.org/10.61336/ejcm/25-10-28

Kim, K. E., Kim, J. M., Lee, J., Lee, M.-Y., & Park, K. H. (2020). Significant intraocular pressure associated with open-angle glaucoma: Korea National Health and Nutrition Examination Survey 2010-2011. *PLOS ONE*, *15*(7), e0235701. https://doi.org/10.1371/journal.pone.0235701

Ma, Q.-Y., Zhou, J., Xue, Y.-X., Xia, Y.-T., Wu, J.-G., & Yang, Xy.-X. (2022). Analysis of aerobic exercise influence on intraocular pressure and ocular perfusion pressure in patients with primary open-angle glaucoma: A randomized clinical trial. *Indian Journal of Ophthalmology*, *70*(12), 4228–4234. https://doi.org/10.4103/ijo.IJO_1195_22

Nie, L., Cheng, D., Cen, J., Ye, Y., Qiao, Y., Fang, J., Zhu, X., Wu, M., Xu, J., Liang, Y., & Shen, L. (2022). Effects of Exercise on Optic Nerve and Macular Perfusion in Glaucoma and Normal Subjects. *Journal of Glaucoma*, *31*(10), 804. https://doi.org/10.1097/IJG.0000000000002082

Pamungkas, D. S., Sumardiko, D. N. Y., & Makassar, E. F. (2024). Dampak-Dampak yang terjadi Akibat Disregulasi Emosi pada Remaja Akhir: Kajian Sistematik. *Jurnal Psikologi*, *1*(4), 15. https://doi.org/10.47134/pjp.v1i4.2598

Parajuli, S., Shrestha, P., & Shrestha, J. K. (2020). *Comparison of intraocular pressure among individuals with systemic hypertension and those with normal blood pressure*. In Review. https://doi.org/10.21203/rs.3.rs-80171/v1

Prayitnaningsih, S., Rohman, M. S., Sujuti, H., Abdullah, A. A. H., & Vierlia, W. V. (2021). *Pengaruh Hipertensi terhadap Glaukoma*. Universitas Brawijaya Press.

Qurrotunnada, F., & Rochmawati, E. (2025). Quality of Life in Breast and Gynecological Cancer: A Review of Systematic Reviews, 1985–2025. *Asia-Pacific Journal of Clinical Oncology*. https://doi.org/10.1111/ajco.70052

Rahmawati, M. Y., Siswoyo, S., Nistiandani, A., & Kushariyadi, K. (2022). Terapi Latihan Aerobik untuk Menurunkan Tekanan Intraokular (TIO) sebagai Pencegahan Glaukoma: Literature Review. *Bima Nursing Journal*, *4*(1), 69–83. https://doi.org/10.32807/bnj.v4i1.913

Sidoti, M., Harris, A., Coleman-Belin, J., Verticchio Vercellin, A., Antman, G., Oddone, F., Carnevale, C., Tessone, I., & Siesky, B. (2025). The impact of different forms of exercise on intraocular pressure, blood flow, and the risk for primary open angle glaucoma. *European Journal of Ophthalmology*, *35*(3), 834–843. https://doi.org/10.1177/11206721241296027

Yasukawa, T., Hanyuda, A., Yamagishi, K., Yuki, K., Uchino, M., Ozawa, Y., Sasaki, M., Tsubota, K., Sawada, N., Negishi, K., Tsugane, S., & Iso, H. (2022). Relationship between blood pressure and intraocular

QANUN MEDIKA
Jurnal Kedokteran
Fakultas Kedokteran FKUM Surabaya
http://journal.um-surabaya.ac.id/index.php/qanunmedika

pressure in the JPHC-NEXT eye study. *Scientific Reports*, *12*(1), 17493. https://doi.org/10.1038/s41598-022-22301-1

Yuan, Y., Lin, T. P. H., Gao, K., Zhou, R., Radke, N. V., Lam, D. S. C., & Zhang, X. (2021). Aerobic exercise reduces intraocular pressure and expands Schlemm's canal dimensions in healthy and primary open-angle glaucoma eyes. *Indian Journal of Ophthalmology*, *69*(5), 1127–1134. https://doi.org/10.4103/ijo.IJO_2858_20

Zhang, D., Wang, L., Jin, L., Wen, Y., Zhang, X., Zhang, L., Zhu, H., Wang, Z., Yu, X., Xie, C., Tong, J., & Shen, Y. (2022). A Review of Intraocular Pressure (IOP) and Axial Myopia. *Journal of Ophthalmology*, *2022*, 1–10. https://doi.org/10.1155/2022/5626479

Zhang, Q., Jiang, Y., Deng, C., & Wang, J. (2024). Effects and potential mechanisms of exercise and physical activity on eye health and ocular diseases. *Frontiers in Medicine*, *11*. https://doi.org/10.3389/fmed.2024.1353624