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The Effect of Swimming Goggles on Intraocular Pressure

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The effect of swimming goggles on IOP lies in understanding how swimming goggles affect eye health. This research can help identifying the risk factors associated with prolonged use of swimming goggles, and guiding the use of swimming goggles in individuals with ocular diseases or conditions. The study objective was to assess how intraocular pressure changed through swimming goggles and to check the effect of increased IOP on axial length. In this study total 28 number of participants, both male and female, were included. The age ranging from 18 to 25 years. Only emmetropes were included in the study visiting the University of Lahore Teaching Hospital, Ophthalmology department. IOP and axial length were measured by using air-puff tonometer and automatic biometry, respectively. Readings were taken before wearing goggles, immediately after wearing goggles for 5 minutes and at 10 minutes of interval after the goggles removed. Mean age was 22 years. Readings were taken before goggles wore, 5 minutes after goggles were put on and 10 minutes after the goggles removed. Mean IOP measured before wearing goggles was 15.20 mmHg, SD=1.7. Mean IOP after wearing swimming goggles for 5 minutes was 17.48 mmHg, SD=2.7. After 10 minutes of interval IOP came back to its normal value but remain increased (mean=15.55mmHg, SD=2.09). Significantly, the IOP was increased when the goggles were put on (2.3 mmHg, SD=1.0; p=0.0005). Also there was no significant change in axial length at three intervals, in both eyes (mean p= 0.841, right eye and mean p=0.954, left eye. The study indicates significant results after 5 minutes of interval (P=0.000; right eye and P=0.001; left eye). IOP was increased about 2-3mmHg then came back to normal value after 10 minutes, but remain increased (mean=15.55mmHg, SD=2.09). The findings also indicate that there was no significant change in axial length in both eyes (.841, right eye and .954, left eye).

Keywords: IOP, axial length, swimming goggles.

INTRODUCTION

The intraocular pressure of eyes is one mechanical factor that can provide health and functioning of the eye. The regulation of intraocular pressure (IOP) involves a complex physiological pathway that includes the production, circulation, and drainage of the aqueous humour within the eye. (Intra ocular Pressure and Your Eye Health: What to Know [Internet].WebMD).

The drainage of aqueous humour involves two pathways; trabecular meshwork and uveoscleral outflow. The IOP is determined by the balance between aqueous humour production and its drainage. If the production exceeds or if the drainage is compromised, the IOP can increase, leading to elevated intraocular pressure (Vera J et al. 2017) OP measures the pressure that fluid puts on the anterior of the eye within surface area. P = (F/C) + P, where F corresponds to water flow rate, C for water outflow, and P for episcleral venous pressure, can potentially be used to calculate IOP. IOP is measured in millimeters of mercury (mmHg) (Bhardwaj and Rajeshbhai, 2013) Normal IOP ranges from 11-21mmHg, However, there is variations between individuals. Intraocular pressure may be high or low (Fan et al. 2022). An abnormal increase in intraocular pressure, known as ocular hypertension that can be a risk factor for various eye conditions, including glaucoma. Ocular hypertension can increase the burden of scleral stretching and cause axial lengthening. The relationship between IOP and axial length is complex and can be influenced by various factors, including genetics, environmental factors, and individual variations.

Axial length is the important component in intraocular lens measurement. It measures the distance

from the corneal surface to an interference peak corresponding to the retinal pigment epithelium/Bruch's membrane (Anonymous, 2019) It consists of anterior chamber depth, lens thickness and vitreous chamber depth (Katuzny and and Koszewska-Kołodziejczak, 2005). It allows light rays to focus on retina. It helps to find the exact number of intraocular lens power before cataract extraction. It's also commonly used in diagnosing some pathological disorders before surgery. In early ocular development, the lens and cornea decrease the power but axial length increases throughout this period. At birth, human axial length is 14-16mm but over the time the ocular structures develop and the distance increases (Anonymous 2015). The mean adult values for axial length are 22-25mm14. A-scan is used to measure the axial length of the eye(Khan et al. 2012).Applanation A-scan ultrasonography is a common technique for determining axial length(Khan et al. 2012). Optical biometry and ultrasound biometry are two essential methods for calculating axial length (Bhardwaj and Rajeshbhai, 2013).Different formulas are used to measure IOL power (Machiele et al. 2021).The Sanders-Retzlaff-Kraff I (SRK-I) formula was the most useful regression formula at the time (Anonymous 2022). This formula proved adequate for eyes with a mean axial length of 22 and 24.5 mm. For the eyes which are <22mm, Hoffer- Q formula will be used to calculate the power of lens (Vera et al. 2017)

Swimming is a well-liked form of exercise, and many swimmers use goggles to protect their eyes from chlorinated water, which reduces the risk of eye infections, redness, and irritation and improves underwater vision. It happens because of pH level is too high in swimming pools. Assuming that pH is too high, the chlorine in the water will not be able to disinfect appropriately and keep both the pool and water clean. By wearing swimming goggles, which create a stretch between eyes, due to this stretching IOP may rise by 4-5mmHg (about a 20–30% increase). Swimming goggles will raise IOP with the tightness or size of the goggles. Using swimming goggles may cause glaucoma worse or increase the risk of developing it. (MDJCT.High Eye Pressure and Glaucoma| glaucoma.org [Internet].glaucoma.org.2017)

MATERIALS AND METHODS

The main objective of the research was to evaluate the effect of swimming goggles on intraocular pressure (IOP) and axial length in healthy young adults. The participants visiting the University of Lahore Teaching Hospital, Ophthalmology Department, were included of age 18 to 25 years. Both males and females were included in the study. Informed consent were given to all volunteers, and the process were explained with all the possible benefits and risks of the study. The participants were selected based on the inclusion and exclusion criteria. Basic history taking was initiated, and any systemic disease, refractive error, or any other ocular pathology were excluded. Medical history of surgeries, trauma, autoimmune disease, etc., were omitted. Pen torch examination was performed to check pupillary response, light reflex, ocular alignment, extra ocular muscles, palpebral symmetry, lid abnormalities, present of any discharge, and assessment of adnexa.

Visual acuity was taken by using a Snellen chart, at a distance of 6 meters or 20 feet. Only those with 6/6 vision were considered. A slit lamp examination was done to rule out any ocular infection or disease. Swimming goggles were given to each participant. Accurate fitting of glasses was accessed because proper fit was necessary for the accurate results.

Intraocular pressure was measured using a non-contact air puff tonometer (Canon TX-20).Axial length was measured using Tomey Optical Biometry (OA-2000) Measurements of IOP and axial length were taken at three intervals; before the goggles were put on, 5 minutes after goggles wore, and 10 minutes after the removal. The measurements taken were then compared between three intervals to determine whether there was a significant change in IOP or axial length or not. By collecting data at multiple time points, the purpose of study was to determine that wearing swimming goggles had any effect on IOP or axial length in healthy young adults.

RESULTS

The study type was analytical study conducted on 28 healthy young adults. Average age were 22 years. Participants were instructed to wear swimming goggles for 5 minutes. IOP and axial length were taken at three intervals, before wearing goggles, at 5 minutes of interval after wearing goggles and then after 10 minutes of interval. The results shows significant change in IOP when goggles wore for 5 minutes in both eyes i.e. (P=0.000 for right eye and P=0.001 for left eye). While after 10 minutes of interval IOP come back to its normal value but remain increased (mean=15.1714 ± 1.7, right eye and mean=15.3321 ± 1.6, left eye). There is no significant difference in the values of before wearing goggles (P=0.431) and after ten minutes of interval (P=.431).

In comparison there is no significant change in the values of axial length at three intervals, before wearing goggles, at 5 minutes of interval and 10 minutes after the goggles removed (P=0.941, P=0.990, P=0.931 respectively) in right eye while for left eye (P=0.763, P=0.992, P=0.770 respectively).

Table 1: Frequency distribution of age of 28 participants

Age	Frequency	Percent
18	3	10.7
19	3	10.7
20	3	10.7
21	1	3.6
22	2	7.1
23	5	17.9
24	5	17.9
25	6	21.4
Total	28	100.0

Table shows the frequency distribution of age of 28 participants which were distributed into different age groups such as patient of age 18 were 3(10.7%), 19 were 3(10.7%), 20 were 3(10.7%), 21 was 1(3.6%), 22 were 2(7.1%), 23 were 5(17.9%), 24 were 5(17.9%) and 25 were 6(21.4%).

Table 2: Distribution of participants on the basis of gender.

	Frequency	Percent
Male	12	42.9
Female	16	57.1
Total	28	100.0

The patients were distributed on the basis of gender. Total of 28 patients were included out of which 12(42.9%) are male and 16(57.1%) are female.

Table 3: Intraocular pressure and Axial length of both eyes at three intervals.

	Intraocular pressure and Axial length of both eyes at three intervals		Mean Difference ± Std. Error	Sig.
IOP_OD	Before wearing goggles	At baseline	-2.68929* ± 0.66992	.000
		After wearing goggles for 10 minutes	-.18571 ± .66992	.782
	At baseline	Before wearing goggles	2.68929* ± .66992	.000
		After wearing goggles for 10 minutes	2.50357* ± .66992	.000
	After wearing goggles for 10 minutes	Before wearing goggles	.18571± .66992	.782
		At baseline	-2.50357* ± .66992	.000
IOP_OS	Before wearing goggles	At baseline	-1.77143* ± .52293	.001
		After wearing goggles for 10 minutes	-.41429 ± .52293	.431
	At baseline	Before wearing goggles	1.77143* ± .52293	.001
		After wearing goggles for 10 minutes	1.35714* ± .52293	.011
	After wearing goggles for 10 minutes	Before wearing goggles	.41429 ± .52293	.431
		At baseline	-1.35714 ±* .52293	.011
AXIAL_LENGTH_OD	Before wearing goggles	At baseline	-.00250 ± .19216	.990
		After wearing goggles for 10 minutes	.01429 ± .19216	.941
	At baseline	Before wearing goggles	.00250 ±.19216	.990
		After wearing goggles for 10 minutes	.01679 ± .19216	.931
	After wearing goggles for 10 minutes	Before wearing goggles	-.01429 ± .19216	.941
		At baseline	-.01679 ± .19216	.931
AXIAL_LENGTH_OS	Before wearing goggles	At baseline	.00179 ± .18780	.992
		After wearing goggles for 10 minutes	.05679 ± 0.18780	.763
	At baseline	Before wearing goggles	-.00179 ± 0.18780	.992
		After wearing goggles for 10 minutes	.05500 ± .18780	.770
	After wearing goggles for 10 minutes	Before wearing goggles	-.05679 ± .18780	.763
		At baseline	-.05500 ± .18780	.770

DISCUSSION

The study was based on the understanding of how swimming goggles effects on intraocular pressure. This research could help in developing safer swimming

goggles, identifying the risk factors associated with prolonged use of swimming goggles, and guiding the use of glasses in individuals with ocular diseases or conditions. The study objective was to evaluate the change in intraocular pressure through swimming goggles, compare IOP values before wearing goggles, 5 minutes after wearing goggles and 10 minutes after the removal, and also to check the effect of increased IOP on axial length. There are many studies which shows that IOP was increased when swimming goggles were worn for example;

Chen and Mudumbai, 2008 purposed the research to evaluate intraocular pressure of subjects after wearing swimming goggles for 3 minutes. Mean age was 51.5 years. IOP measured at initial was 14.7 mmHg, SD=2.6. After swimming goggles were worn for about 3 minutes the IOP was 18.8mmHg, SD=4.0. Significantly the increase in IOP after wearing glasses was 4.1mmHg, SD=2.6 ($P < 0.0001$). Present study also showed that IOP measured at initial was 15.20 mmHg, SD 1.70. After wearing swimming goggles for 5 minutes, the IOP was 17.48mmHg, SD=2.7. Significantly the increase in IOP after wearing glasses was 2.3mmHg, SD =1.0 ($P= 0.0005$). Both study findings shows that IOP increases significantly after wearing swimming goggles.

Scott A. Read et al.2011arried out another study in Australia in 2011. The research focus on the short-term effects of increased intraocular pressure on axial length. The primary finding of this study was that the axial length and IOP both significantly changed while swimming goggles were used, which could be partial agreement to the results of this study. Mean axial length at 5 minutes of interval was 24.10 ± 1.1mm. It showed the average difference in axial length before and after swimming goggle use. Wearing swimming goggles caused a noticeable rise in axial length (mean increase of 18-± 12 mm, or roughly a 0.05 D myopic shift in refraction). Present study also showed mean axial length before and after wearing swimming goggles was 23.29mm and 23.28 respectively. Results shows swimming goggles have no significant effect on axial length at three intervals, in both eyes (mean p= 0.841, right eye and mean p=0.954, left eye).

Another research by Paula et al. 2011 was on the topic of “Factors related to IOP elevation due to compression of the periocular region by the use of swimming goggles” that conducted in 2011. Total 12 healthy participants were included. The main objective of this study was to access the increase in IOP by wearing swimming goggles. According to this article, an elevation was observed when the goggles were put on (6.2±2.8 mmHg; P=0.0025). The study showed the differences in Goldmann applanation tonometry at T0, T1 and T2 (12.8 mmHg, 19.0 mmHg and 8.7 mmHg respectively; P<0.0001). The study findings agreed with present study which also showed the increase in IOP before wearing swimming goggles were 15.7 mmHg at initial, 17.86 mmHg at 5 minutes of interval and 15.35 mmHg after 10 minutes of interval. The results came up with the range that IOP before wearing swimming goggles were normal and it increased after wearing swimming goggles for 5 minutes, then 10 minutes after removal. The present study findings also showed that IOP came back to normal values after ten minute of interval but remain increases 2-3 mmHg.

Jimenez et al. 2022 made a research on the topic of “Short-term effect of swimming goggles on corneal biomechanics” in 2022, Spain on 31 young adults. The main outcome of this article was differences in values of IOP and bIOP after wearing swimming goggles ($F6180=11.14$, $p<0.001$, $n 2=0.27$ and $F6180=11.35$, $p<0.001$, $n2=0.28$, respectively). The IOP was raised after 5 minutes as compared to the baseline level IOP (p corrected=0.025, d=0.60). IOP readings were obtained at 30seconds, 2minutes, and 5 minutes in comparison. The current study shows that the initial IOP measurement was 15.20 mmHg, SD 1.70, ($P=0.431$). After using the swimming goggles for 5 minutes, the IOP was 17.48mmHg, SD 2.7, and $P=0.001$. After wearing glasses, IOP significantly rose by 2.3mmHg with an SD of 1.0. The results of the current investigation revealed an increase in intraocular pressure, which is consistent with earlier research.

CONCLUSIONS

The study conclude that swimming goggles elevate the intraocular pressure. When swimming goggles were worn for 5 minutes it indicates significant change in IOP ($P=0.000$; right eye and $P=0.001$; left eye) with the mean of 17.86±3.05. IOP was increased about 2-3mmHg then came back to normal value after 10 minutes, but remain increased (mean=15.55±2.09mmHg). The findings also revealed that there was no significant change in axial length in both eyes (.841, right eye and .954, left eye). Since, swimming goggles can elevate IOP so, prolonged use of glasses may cause glaucoma as the development of glaucoma is linked to the elevated pressure.

Supplementary materials

The supplementary material / supporting for this article can be found online and downloaded at: https://www.isisn.org/article/10.3390/antiox12081524/s1,

Author contributions

S.S give the concept of experiment; I.Z. and S.S. performed the experiment, I.Z., S.S., A.Q., and K.A.D.; collected the data; A.B. methodology; I.Z. performed the statistical analysis of data; investigation; I.Z. gathered all the results, I.Z., S.S., A.Q., K.A.D. and A.B. writing-original draft preparation, I.Z., writing-review and editing,

T.K.; supervision. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement
The study was approved by the Bioethical Committee of the University of Lahore, Pakistan

Data Availability Statement
All of the data is included in the article/Supplementary Material.

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Conflict of interest
The authors declared that present study was performed in absence of any conflict of interest.

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