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The Effects of Swimming Goggles on Intraocular Pressure in Children

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ABSTRACT The aim of this study is to evaluate the effects of wearing swimming goggles on intraocular pressure in children. The study comprises of 20 eyes from 10 children, 4 male (40%) and 6 female (60%). The median age was 10.4 with a range of 9 to 11 years (mean age was 10.4). Before the study, the height (cm), weight (kg) and intraocular pressure values of children were measured by using two different appliances. Upon the durations of stay in water, 3 different periods were set at 5 minutes, 10 minutes and 20 minutes. Two different eye doctors measured intraocular pressure values of children with specified appliances after the end of each period and then immediately after the goggles were taken off. The average height of the children was 146.5cm ranging from 140 to 163 cm and the average weight was 42.84kg ranging from 33 to 51.6 kg. Before the goggles were worn, the average intraocular pressure value was measured at 16.5 ranging from 12 to 23 mmHg with a tono-pen and at 16.3 ranging from 11 to 22 mmHg with a non-contact tonometer for the right eye, while it was 16.6 ranging from 11 to 21 mmHg with a tono-pen and 16.2 ranging from 11 to 21mmHg with non-contact tonometer for the left eye. At the end of the first period (after 5 minutes), the average intraocular pressure value of right eye was 17.2 (12-23) mmHg measured with a tono-pen and 16.8 (12-23) mmHg measured with a non-contact tonometer, at the end of second period values were 17.0 (10-23) mmHg and 17.3 mmHg, respectively, at the end of the third period the values were 17.30 (13-24) mmHg and 17.60 (12-24) mmHg, respectively. The average intraocular pressure values of the left eye were 16.7 (11-22) mmHg and 16.3 (10-24) mmHg, respectively, at the end of second period values were 16.7 (10-25) mmHg, 16.6 (11-23) mmHg, respectively, and at the end of the third period the values were 17.70 (13-24), 17.10 (12-23) mmHg, respectively. The researchers considered that patients with glaucoma and suspected glaucoma should use well fitting swimming goggles, which do not have overly tightened straps and a small rim diameter.

INTRODUCTION

Glaucoma still takes place near the top as one of the leading causes of legal blindness in developed countries (Yilmaz et al. 2007). It is an optical neuropathy causing characteristic structural damage to the optic nerve accompanying defects such as, progressive ganglion cell degeneration, nerve fibers loss and visual field loss (Kurtulmusoglu and Onol 2007). Swimming is one of the rare sports that enables physical progress of body outstandingly well in water (Gokhan et al. 2011).

Swimming goggles are frequently used in races, and for fun and games to protect the eyes against bacteria and chemical agents and to keep vision clear under water. However, using swimming goggles may be related with periorbital and ocular damages and diseases (Craig 1984; Wu et al. 2011). Elevation of intraocular pressure is an important risk factor in the progression of glaucoma. Swimming goggles induce pressure around the periocular area and might have an influence on the intraocular pressure. Swimmers wearing goggles are exposed to this pressure (Kyoung et al. 2007). While there have been case reports linking swimming goggles to migraine, supraorbital neuralgia, eyelid swelling, skin irritation, diplopia and optic nerve avulsion followed by a trauma, the investigators point out that the association between IOP and goggles had not been explored (Morgan et al. 2008)

In this study, the researchers evaluated the relationship between the duration of wearing goggles and the change in intraocular pressure values during swim training of children. In the analysis of the data, the Wilcoxon signed-rank test, and a non-parametric statistical hypothesis test were used to compare the first measurement with the rest of the measurements. The level of significance was agreed as $p<0.05$.

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MATERIAL AND METHODS

This study was performed in the swimming pool of Duzce University with the participation of 20 eyes from 10 children who were attending the summer school organized by Duzce University in July 2014. At the beginning, the study was approved by the Ethical Committee of Duzce University. Also, the researchers were submitted permission letters from parents of participating children.

The study included healthy children with no glaucoma history in their family. Height (cm), weight (kg) and intraocular pressure values were measured before putting on goggles. Proparacaine solution, which comprises 0.01 percent benzalconium used in opthalmology as a preservative, was dropped in each participant's eyes. Then, the intraocular pressure of each eye was measured with the tono-pen (Tono-Pen XL, Medtronic Solan, USA) and non-contact tonometer (NT-510, NidekCo, Tokyo, Japan), respectively. In those periods, the children were asked to swim without touching their goggles under the researchers' observance. After making at least two-minute phase differences, the suitable fitting goggles were worn. Intraocular pressure values of children were measured by two different eye doctors with determined appliances after the end of each period and then immediately after the goggles were taken off.

RESULTS

The study comprised of 20 eyes from 10 children, 4 male (40%) and 6 female (60%). The median age was 10.4 with a range of 9 to 11 years (mean age was 10.4). The average height of the children was 146.5cm ranging from 140 to 163 cm and average weight was 42.84kg ranging from 33 to 51.6 kg. Before the goggles were worn, the average intraocular pressure value was measured at 16.5 ranging from 12 to 23 mmHg with a tono-pen and 16.3 ranging from 11 to 22 mmHg with a non-contact tonometer for the right eye while it was 16.6 ranging from 11 to 21 mmHg with a tono-pen and 16.2 ranging from 11 to 21mmHg with non-contact tonometer for left eye. At the end of the first period, which was after 5 minutes, the average intraocular pressure value of right eye was 17.2 (12-23) mmHg measured with tono-pen and 16.8 (12-23) mmHg measured with non contact tonometer, at the end of second period values were 17.0 (10-23) mmHg and 17.3 mmHg, respectively, and at the end of the third period the values were 17.30 (13-24) mmHg and 17.60 (12-24) mmHg, respectively. The average intraocular pressure values of the left eye were 16.7 (11-22) mmHg, 16.3 (10-24) mmHg respectively, at the end of second period values were 16.7 (10-25) mmHg, 16.6 (11-23) mmHg, respectively, and at the end of the third period the values were 17.70 (13-24), 17.10 (12-23) mmHg.

At the end of this statistical analysis, the researchers determined that there was no meaningful relationship between the duration of wearing goggles and intraocular pressure (Tables 1-12).

No significant difference was found between the first measurement performed with a tono-pen on right eye and tono-pen after 5 minutes (Z= -1.276, p= .202) (p>0.05).

No significant difference was found between the first measurement performed with a tono-pen on right eye and a tono-pen after 10 minutes (Z= -.779 p= .436) (p>0.05).

No significant difference was found between the first measurement performed with a tono-

Table 1: TONO-PEN measurements of right eye (first measurement and after 5 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
TONO-PEN First Measurement Right	10	16.50	2.799	-1.276	.202
TONO-PEN After 5 minRight	10	17.20	3.765		

Table 2: TONO-PEN measurements of right eye (first measurement and after 10 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
TONO-PEN First Measurement Right	10	16.50	2.799	-.779	.436
TONO-PEN After 10 minRight	10	17.00	3.590		

Table 3: TONO-PEN measurements of right eye (first measurement and after 20 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
TONO-PEN First Measurement Right	10	16.50	2.799	-1.532	.104
TONO-PEN After 20 minRight	10	17.30	3.165		

No significant difference was found between the first measurement performed with a tono-pen on right eye and a tono-pen after 20 minutes (Z= -1.532, p= .104) (p>0.05).

Table 4: TONO-PEN measurements of left eye (first measurement and after 5 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
TONO-PEN First Measurement Left	10	16.60	3.204	-.302	.763
TONO-PEN After 5 minLeft	10	16.70	3.199		

Table 5: TONO-PEN measurements of left eye (first measurement and after 10 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
TONO-PEN First Measurement Left	10	16.60	3.204	-.566	.572
TONO-PEN After 10 minLeft	10	16.70	4.218		

Table 6: TONO-PEN measurements of left eye (first measurement and after 20 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
TONO-PEN First Measurement Left	10	16.60	3.204	-1.467	.142
TONO-PEN After 20 minRight	10	17.70	4.001		

Table 7: NON-CONTACT measurements of right eye (first measurement and after 5 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
NON-CONTACTFirst Measurement Right	10	16.30	3.498	-1.667	.096
NON-CONTACTAfter 5 min Right	10	16.80	3.706		

Table 8: NON-CONTACT measurements of right eye (first measurement and after 10 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
NON-CONTACT First Measurement Right	10	16.30	3.498	-1.340	.180
NON-CONTACTAfter 10 min Right	10	17.30	3.945		

Table 9: NON-CONTACT measurements of right eye (first measurement and after 20 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
NON-CONTACT First Measurement Right	10	16.30	3.498	-1.481	.139
NON-CONTACT After 20 min Right	10	17.60	4.142		

No significant difference was found between the first measurement performed with non-c pen on right eye and a tono-pen after 20 minutes (Z= -1.532, p= .104) (p>0.05).

No significant difference was found between the first measurement performed with a tono-pen on left eye and a tono-pen after 5 minutes (Z= -.302, p= .763) (p>0.05).

No significant difference was found between the first measurement performed with a tono-pen on left eye and a tono-pen after 10 minutes (Z= -.566, p= .572) (p>0.05).

No significant difference was found between the first measurement performed with a tono-pen on left eye and a tono-pen after 20 minutes (Z= -1.467, p= .142) (p>0.05).

No significant difference was found between the first measurement performed with non-contact on right eye and non-contact after 5 minutes (Z= -1.667, p= .096) (p>0.05).

No significant difference was found between the first measurement performed with non-contact on right eye and non-contact after 10 minutes (Z= -1.340, p= .180) (p>0.05).

No significant difference was found between the first measurement performed with non-contact on right eye and non-contact after 20 minutes (Z= -1.481, p= .139) (p>0.05).

No significant difference was found between the first measurement performed with non-contact on left eye and non-contact after 5 minutes (Z= -.285 p= .776) (p>0.05).

No significant difference was found between the first measurement performed with non-contact on left eye and non-contact after 10 minutes (Z= -.108 p= .914) (p>0.05).

No significant difference was found between the first measurement performed with non-contact on left eye and non-contact after 20 minutes (Z= -1.119, p= .263) (p>0.05).

DISCUSSION

Swimming goggles are used widely in fitness and training swimming by most of the swimmers in order to allow better vision underwater in water sports. The tightened straps around the head with a strap buckle hold the goggles in place. This effective strength imposed by goggles can induce high intraocular pressure due to the stress on orbital veins and other structures. Frequentative high IOP is an important risk factor in the progression of glaucoma (Sommer 2008; Leske et al. 2004).

It is indicated in previous studies that significant IOP elevation was observed throughout the duration of goggle wear. Accordingly, it is asserted that regular swimmers are under increased risk of glaucoma pathogens and its progression (Maria et al. 2014).

In a study performed by Radcliffe et al. (2009) while swimming goggles were put on intraocular pressure of healthy participants was measured as +1.5mmHg (12.5% average increase) after one minute and also three minutes, which they found meaningfully high. In a small sub-

Table 10: NON-CONTACT measurements of left eye (first measurement and after 5 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
NON-CONTACT First Measurement Left	10	16.20	3.293	-.285	.776
NON-CONTACT After 5 min Left	10	16.30	4.423		

Table 11: NON-CONTACT measurements of left eye (first measurement and after 10 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
NON-CONTACT First Measurement Left	10	16.20	3.293	-.108	.914
NON-CONTACT After 10 min Left	10	16.60	3.565		

Table 12: NON-CONTACT measurements of left eye (first measurement and after 20 minutes)

	Number	*Average*	*Standard deviation*	*Z*	*p*
NON-CONTACT First Measurement Left	10	16.20	3.293	-1.119	.263
NON-CONTACT After 20 min Left	10	17.10	3.479		

group (10%) of participants in their study, intraocular pressure values were measured over 5mmHg at 1 and 5 minutes of wearing goggles.

Wakely et al. (2004) first reported the potential glaucoma risk depending on using swimming goggles and they determined extremely tightened goggles for strong leak proof use result in negative pressure, which could lengthen the person's bulla drainage in the course of trabeculectomy. Wakely et al. brought out that glaucoma pathogens and its progression may be related to use of tight goggles with small diameters. Morgan et al. (2008) found that intraocular pressure increased by a mean pressure of 4.5mmHg while goggles with smaller face area were used by Wakely et al. (2004). Kang et al. (2010) notified a 36-year-old unexplained glaucoma case who was using goggles with small frame during his swim exercises 4 hours a week.

In their intraocular pressure study, Ozmerdivenli et al. (2006) determined that there was no significant difference on sportsmen between aerobic exercises causing a decrease in intraocular pressure and anaerobic exercises such as swimming.

The relationship between the usage of swimming goggles and elevated IOP was also determined in other studies and it is suggested that when some types of swimming goggles are worn for long times, they can cause a decrease in the blood flow of the optical nerve head, which is a risk factor of glaucoma pathogen and progression (Kyoung et al. 2007; Starr and Radcliffe 2009).

CONCLUSION

At the end of this statistical analysis, the researchers have determined that there was no meaningful relationship between the duration of wearing goggles and intraocular pressure. The researchers applied the tono-meter to measure intraocular pressure because subjects participating in the study were children. After the duration of their stay in the pool was completed, the children took off the goggles and the researchers performed the measurements with two different appliances at the poolside. However, as stated in the previous studies, this study also made the researchers think that tightened side straps holding goggles in place apply pressure on the episcleral and orbital other veins and after removal of the goggles, the intraocular pressure values turn to normal immediately with auto regulation.

RECOMMENDATIONS

In conclusion, the researchers considered that patients with glaucoma and suspect glaucoma should use well fitting swimming goggles, which are not small, and their straps are not overly tightened. Examining patients with glaucoma and suspected glaucoma regularly will allow the researchers to inform them about the potential risks of raised IOP.

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