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Short-Term Effects of Swimming Goggle Use on Corneal Tomographic Parameters in Patients with Keratoconus

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Introduction

- Keratoconus (KC) is a progressive ectatic corneal disorder characterized by thinning and irregular curvature.
- Biomechanical weakening makes the cornea susceptible to external mechanical forces.
- Periocular pressure (e.g., eye rubbing, goggles) may influence corneal shape and intraocular pressure (IOP).
- Swimming goggles create negative periocular pressure and transiently alter anterior segment parameters.
- Their effect on keratoconic corneas remains unclear.

Purpose

This study aimed to investigate the short-term impact of swimming goggle-induced periorbital pressure on anterior segment parameters in eyes affected by keratoconus.

Methods

- Forty-four eyes from 44 patients (mean age: 26.1 ± 5.1 years) with Stage 1–4 keratoconus, classified according to the Amsler–Krumeich system, were evaluated.
- Anterior segment measurements were obtained using a Pentacam® Scheimpflug imaging device immediately before and directly after 20 minutes of swimming goggle (Figure 1) wear.
- The assessed parameters included keratometric values (K1, K2, Km, Kmax), central and thinnest corneal thicknesses, corneal volume within a 10 mm diameter (CV10), anterior chamber volume (ACV), anterior chamber depth (ACD), iridocorneal angle (ICA), and pupil diameter (PD).

Figure 1. Swimming goggles utilized in the study.

Analysis

- Statistical analyses were performed using R software (version 4.4.1; R Core Team, 2024).
- To assess the clinical relevance of the observed changes, mean differences (Δ = T2 – T1) were reported along with 95% confidence intervals (CIs).
- Since multiple anterior segment parameters were evaluated and no single primary outcome was prespecified prior to study initiation, we applied multiplecomparison correction to control for the increased risk of type I error. To account for this, p-values were adjusted using the false discovery rate (FDR) method.

Results

- Demographic characteristics of the patients and baseline clinical features of the eyes are summarized in Table 1.
- Comparisons of the parameters before and after swimming goggle wear are presented in Table 2.
- There were no significant differences observed in keratometry, central and thinnest corneal thickness, ACV, ACD, ICA, PD, or intraocular pressure following goggle use (all $p > 0.05$).
- However, CV10 demonstrated a modest reduction ($\Delta = -0.18$ mm³, equating to a 0.3% decrease), which reached statistical significance prior to multiple testing correction ($p = 0.008$), but did not remain significant after applying the false discovery rate adjustment (FDR-adjusted $p = 0.10$).

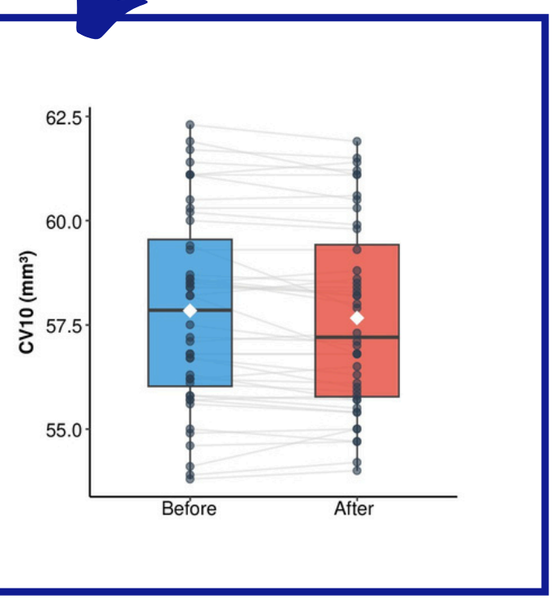

Figure 2. The change in corneal volume in 10 mm zone (CV10) before and after swimming goggle wear. Black dots represent the individual CV10 measurement at the corresponding time points connected by paired grey lines.

Discussion

- Previous studies in healthy subjects reported transient IOP elevation and anterior segment changes with goggle use.
- In contrast, our findings suggest limited biomechanical impact in keratoconic corneas under short-term exposure.
- Eye rubbing is known to induce significant mechanical and inflammatory effects, but goggle-induced stress appears considerably milder.
- Subtle, non-significant trends (e.g., CV reduction) may reflect early biomechanical sensitivity in KC.
- Overall, findings support cautious but generally safe use of swimming goggles in KC patients.

Conclusions

- Although short-term use of swimming goggles did not significantly alter most anterior segment parameters, a slight decrease in CV10 was observed.
- This finding may indicate a mild biomechanical response to transient external pressure in eyes with keratoconus.
- While the statistical significance diminished after correction, the physiological implication warrants further exploration.
- CV10 may have potential as an exploratory marker of corneal mechanical sensitivity in keratoconus and should be investigated in future studies with larger sample sizes.

RELATED LITERATURE

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Table 1. Demographic features of patients and clinical characteristics of eyes (n = 44).

Parameters	Value (Mean ± SD or n, %)
Age (years)	26.1 ± 5.1
Sex (female/male)	24 (54.55%)/20 (45.45%)
Best-corrected visual acuity (logMAR)	0.12 ± 0.11
Keratoconus staging (Amsler–Krumeich)	
Stage 1	15 (34.1%)
Stage 2	23 (52.3%)
Stage 3	3 (6.8%)
Stage 4	3 (6.8%)

SD = standard deviation; logMAR = logarithm of the minimum angle of resolution.

Table 2. Comparison of parameters before and after swimming goggle wear.

Parameters	Time	Mean (SD)/Median (IQR)	Change (Δ)/%95 CI	Effect Size	*p*	*p* (FDR)
K1 (D)	T1 T2	46.78 ± 4.25/46 [44.6–48.37] 47.17 ± 4.21/46.2 [45–48.52]	0.38 ± 2.71/0 [−0.2–0.2] [−0.1, 0.1]	0.01 [b]	0.916	0.916
K2 (D)	T1 T2	50.34 ± 4.32/49.7 [47.98–52.08] 50.45 ± 4.46/49.8 [47.85–52.02]	0.11 ± 1.65/0 [−0.3–0.1] [−0.25, 0.1]	0.17 [b]	0.236	0.413
Km (D)	T1 T2	48.48 ± 4.19/47.8 [46.18–49.8] 48.75 ± 4.28/47.9 [46.53–50.6]	0.28 ± 2.26/0 [−0.12–0.1] [−0.15, 0.05]	0.164 [b]	0.286	0.413
Kmax (D)	T1 T2	56.31 ± 6.48/55.55 [53.22–59.85] 56.35 ± 6.49/55.7 [53.32–59.95]	0.04 ± 1.81/−0.05 [−0.43–0.23] [−0.35, 0.15]	0.137 [b]	0.35	0.413
CCT (µm)	T1 T2	471.91 ± 40.51/477.5 [445.5–500] 470.89 ± 41.94/478 [439.75–496]	−1.02 ± 13.04/1 [−2–3.25] [−1, 2.5]	0.173 [b]	0.327	0.413
TCT (µm)	T1 T2	452.09 ± 45.49/455.5 [416.25–478] 452.98 ± 45.76/453.5 [422.75–480]	0.89 ± 6.71/3 [−1.25–5] [0, 3.5]	0.291 [b]	0.065	0.388
CV10 (mm^3)	T1 T2	57.84 ± 2.36/57.85 [56.03–59.55] 57.66 ± 2.27/57.2 [55.77–59.42]	−0.18 ± 0.43/−0.15 [−0.33–0.1] [−0.3, −0.05]	0.399 [b]	0.008	0.1
ACV (mm^3)	T1 T2	181.11 ± 33.57/178 [158–208] 180.34 ± 33.8/175.5 [156.75–205.5]	−0.77 ± 4.39/−1 [−3–2] [−2.11, 0.56]	0.176 [a]	0.249	0.413
ACD (mm)	T1 T2	3.23 ± 0.31/3.3 [2.96–3.48] 3.23 ± 0.33/3.33 [2.96–3.48]	0 ± 0.07/0 [−0.03–0.01] [−0.02, 0.01]	0.171 [a]	0.31	0.413
ICA (°)	T1 T2	40.1 ± 5.32/40.1 [36.98–42.9] 40.88 ± 5.42/41.4 [37.85–44.37]	0.78 ± 2.98/0.6 [−0.65–1.8] [−0.13, 1.68]	0.262 [a]	0.09	0.388
PD (mm)	T1 T2	3.43 ± 0.63/3.42 [2.87–3.79] 3.34 ± 0.48/3.33 [2.95–3.67]	−0.08 ± 0.42/−0.06 [−0.18–0.08] [−0.15, 0.02]	0.223 [b]	0.149	0.413
IOP (mmHg)	T1 T2	13.27 ± 2.72/13 [11–15] 13.34 ± 2.58/13 [11.75–14.25]	0.07 ± 1.15/0 [−1–1] [−0.5, 1]	0.052 [b]	0.775	0.839
AL (mm)	T1 T2	24.14 ± 1.06/24.2 [23.4–24.98] 24.15 ± 1.04/24.22 [23.51–24.98]	0.01 ± 0.17/0.02 [−0.09–0.11] [−0.02, 0.07]	0.145 [b]	0.342	0.413

SD = standard deviation; IQR = interquartile range; CI = confidence interval; FDR = false discovery rate; D = diopter; T1 = before swimming goggle wear; T2 = after swimming goggle wear; CCT = central corneal thickness; TCT = thinnest corneal thickness; CV10 = corneal volume within the 10 mm zone; ACV = anterior chamber volume; ACD = anterior chamber depth; ICA = iridocorneal angle; PD = pupil diameter; IOP = intraocular pressure; AL = axial length. [a]: Paired-sample *t*-test (Cohen's d). [b]: Wilcoxon signed-rank test (Wilcoxon r). *p* (FDR) < 0.05 was considered statistically significant.