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End-of-day dryness, corneal sensitivity and blink rate in contact lens wearers

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ABSTRACT

Purpose: To study the relationship among the variables intensity of the end-of-day (EOD) dryness, corneal sensitivity and blink rate in soft contact lens (CL) wearers.
Methods: Thirty-eight soft CL wearers (25 women and 13 men; mean age 27.1 ± 7.2 years) were enrolled. EOD dryness was assessed using a scale of 0–5 (0, none to 5, very intense). Mechanical and thermal (heat and cold) sensitivity were measured using a Belmonte's gas esthesiometer. The blink rate was recorded using a video camera while subjects were wearing a hydrogel CL and watching a film for 90 min in a controlled environmental chamber.
Results: A significant inverse correlation was found between EOD dryness and mechanical sensitivity (r: −0.39; $p = 0.02$); however, there were no significant correlations between EOD dryness and thermal sensitivity. A significant (r: 0.56; $p < 0.001$) correlation also was observed between EOD dryness and blink rate, but no correlations were found between blink rate and mechanical or thermal sensitivity.
Conclusions: CL wearers with higher corneal sensitivity to mechanical stimulation reported more EOD dryness with habitual CL wear. Moreover, subjects reporting more EOD dryness had an increased blink rates during wear of a standard CL type. The increased blink rate could act to improve the ocular surface environment and relieve symptoms.

1. Introduction

Despite the large number of contact lens (CL) wearers worldwide [1], discontinuation of wear is still a major problem that limits the amount of successful wearers [2,3], with discomfort and dryness frequently being reported as the main causes [3–5]. The prevalence rates of dryness symptoms among soft CL wearers range between 28% and 77% [2,4,6–8]. Similar to patients with dry eye disease [9], a substantial number of CL wearers experience symptoms of dryness with CLs and show no clinical signs [10]. This lack of an association between symptoms reported and signs observed is often related to the variability of the clinical tests used to evaluate the signs [11]. However, it also may be due partly to the tests used to evaluate symptoms [12]. Some studies [4,13] have reported dryness changes during the CL wearing period with increased symptoms during the afternoon and evening. Hence, symptoms should be assessed at the end of the wearing period to best identify those who may have associated clinical signs, as Begley et al. [13] suggested. In fact, end-of-day (EOD) comfort in CL wearers was evaluated recently and smaller values were reported with silicone hydrogel than with conventional hydrogel CLs [14].

CLs alter the tear film distribution and interact with several parts of the lacrimal functional unit, i.e., the cornea, conjunctiva and eyelids. The sensory nerve terminals of the trigeminal nerve are dense in these tissues, with the cornea the most innervated tissue of all the ocular structures [15] by polymodal nociceptors, mechano-nociceptors, and cold sensitive thermoreceptors. Polymodal-nociceptors are activated by mechanical, heat and chemical stimuli. Mechano-nociceptors (activated by mechanical stimuli) show a relatively higher threshold (lower sensitivity) than the mechanical polymodal nociceptors. Finally, cold thermoreceptors are stimulated when the corneal temperature decreases. Several studies have reported evidence of reduced corneal sensitivity induced by CL wear (soft and rigid CL) [12,16–19]; however, corneal sensitivity seems to be restored after cessation of lens wear

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Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Age between 18 and 45 years Spherical refraction between −0.75 and −5.00 D and astigmatism ≤ −1.00 D Best-corrected distance VA ≤ 0.0 LogMAR. Soft CL wear for at least 6 months prior the study
Exclusion criteria	Any active ocular disease Systemic disease that contraindicates CL wear Anterior ocular surgery Use of any topical medication

D: diopters; VA: visual acuity; CL: contact lens.

[20]. Nonetheless, little is known about the difference in corneal sensitivity between asymptomatic and symptomatic CL wearers. In fact, one study reported higher corneal responses to suprathreshold stimuli in symptomatic compared to asymptomatic subjects but showed no differences between the two groups in mechanical sensitivity [21].

The blink rate seems to be associated with corneal sensitivity and dryness symptoms; however, the mechanism is unclear. Collins et al. [22] reported a link between corneal sensitivity and blink rate and that the blink rate decreased significantly after administration of topical anesthesia. Other authors [23,24] suggest that the activation of the blink is mediated by tear film disruption sensed by the corneal nerve fibers, while York et al. [25] propose that increased blinking acts to refresh the tear film more frequently and therefore, relieve dryness symptoms.

With these factors in mind, we hypothesized that CL wearers reporting higher ratings of EOD dryness have higher corneal sensitivity and hence, an increased blink rate. The aim of the current study was to evaluate the relationship between EOD dryness levels reported by soft CL wearers during habitual CL wear, basal corneal sensitivity and blink rate. To do this, experiments were conducted while participants wore one single type of hydrogel CL and experienced in the same indoor environment created in a controlled chamber.

2. Methods

The nature of the research was explained to the subjects before they provided written informed consent. The study complied with the tenets of the Declaration of Helsinki, and the study protocol was approved by the Institutional Review Board of the University of Valladolid.

Subjects who met the inclusion and exclusion criteria (Table 1) were enrolled. The study was carried out in two visits a minimum of 2 days and a maximum of 15 days apart. Subjects were instructed to not wear CL for at least 24 h before each visit. During the first visit, the EOD dryness was assessed and the corneal sensitivity was measured. During the second visit, the overall blink rate was measured with the subjects wearing a hydrogel CL (Omafilcon A; CooperVision, Pleasanton, CA) for 90 min while they were in a controlled standard indoor environment (50% relative humidity – RH, 23 °C temperature) in an environmental chamber [26,27].

2.1. Procedures

End-of-day dryness. Subjects were asked to indicate the intensity of the EOD dryness with habitual CL wear using a scale ranging from 0 to 5, where 0 meant “none” and 5 meant “very intense.” This question was based on the last item of the dryness section of the Contact Lens Dry Eye Questionnaire (CLDEQ) [28], which each participant completed.

Table 2
Descriptive data of tests performed.

	Mean ± SD
EOD dryness	3.32 ± 1.36
Corneal sensitivity	
Mechanical (ml/min)	127.89 ± 41.50
Thermal – heat (°C)	+1.40 ± 0.87
Thermal – cold (°C)	−2.41 ± 0.95
Blink rate	
10 blinks/min	28.25 ± 15.34
30 blinks/min	27.86 ± 14.83
60 blinks/min	29.56 ± 16.36
90 blinks/min	31.38 ± 16.73
Overall value (blinks/min)	29.38 ± 15.23

EOD: end of day; SD: standard deviation; ml: milliliter; min: minute.

Corneal sensitivity. A Belmonte’s gas esthesiometer was used as previously described [29–31]. Mechanical and thermal (heat and cold) sensitivity thresholds were measured on the right eye of subjects by the method of levels [29,31]. The mechanical threshold was determined using a controlled airflow ranging between 0 and 200 ml/min with an airflow temperature reaching the cornea at 34 °C (the basal corneal temperature) [31]. Then, the thermal thresholds were evaluated using airflow at different temperatures at 10 ml/min below mechanical threshold to avoid mechanical stimulation. The order of the heat and cold threshold measurements was randomized.

Blink rate. Individuals were fitted with Omafilcon A CL and exposed in an environmental chamber for 90 min under a standard indoor environment [27]. During exposure, the blink rate was recorded using a Live! Cam Socialize HD camera (Creative Technology LTD, Singapore) in primary gaze while subjects were seated watching a film on a 55-inch television (LG Electronics Inc., Gumi, South Korea) 130 cm above floor level. The blink rate was assessed at four time intervals of 5 min (5–10, 25–30, 55–60 and 85–90 min), and the average blink rate for 1 min during each interval was obtained [32]. The mean value of the overall exposure was computed for analysis.

2.2. Statistical analysis

Statistical analyses were carried out using Statistical Package for the Social Sciences software (SPSS 21.0 for Windows; SPSS Inc., Chicago, IL). EOD dryness, mechanical and thermal corneal sensitivity thresholds, and blink rate values were expressed as the means ± standard deviations. The normality of the data was assessed with the Shapiro–Wilk test. Analysis of variance was performed to evaluate whether the blink rate differed among the four time intervals. The correlations between variables were calculated using two-tailed Spearman’s rho test analysis (r) for nonparametric correlations. A p value < 0.05 was considered significant.

3. Results

Thirty-eight soft CL wearers (25 women and 13 men; mean age 27.1 ± 7.2 years; range, 18, 45 years) were enrolled. The mean spherical refractive error was −2.97 ± 1.12 diopters (D) (range −1.25, −4.75), mean cylinder error −0.27 ± 0.33 D (range 0.00, −1.00), and mean LogMAR best corrected visual acuity −0.06 ± 0.05 (range 0, −0.19). Subjects had worn CLs for a mean of 7.4 ± 5.5 years (range 1, 22) and wore the CLs for a mean of 9.3 ± 2.3 h daily (range 4, 18).

The descriptive data from the tests of EOD dryness, mechanical and thermal sensitivity, and blink rates are shown in Table 2. There were no significant (p = 0.78) differences in blink rate among the