The effect of temperature on refractive and geometrical parameters of daily disposable soft multifocal contact lenses

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Introduction

Soft contact lens parameters are conventionally labelled and measured considering a temperature of 20°C as intended by DIN EN ISO 18369-3[1]. However, during wear their temperature increase to eye temperature (~35°C) and this increase can be associated to changes in typical contact lens parameters[2-5]. The aim of the study was to investigate the effects of temperature on daily disposable soft multifocal contact lens parameters and if temperature changes can modify dimensions as well as the power of this kind of lenses.

Methods

A pre-study was performed to define samples and measurement procedure. Following this, four different daily disposable center near soft multifocal CLs, three of them made of hydrogel material and one of silicone hydrogel, were selected each with two different powers and high addition (trial lenses which were not for sale). At least one night before the measurements the CLs were taken from their blisters into glass vials, filled with standard 0.9% saline solution for acclimatization whereas each vial was covered with a cap. The glass vials were stored during the study in the measurement room at 24±1°C. In parallel one glass meniscus lens (DIA: 14.2mm; BC: 10mm; CT: 0.55mm; Power: -3.00D) was measured as a cross-check. To obtain the measurement of mean total diameter, external sagittal depth and multifocal power a fully integrated workstation for the complete quality control of soft contact lenses (SHSOphthalmic omniSpect SCL, Optocraft) was used. The procedure for each lens was always the same: The sample was placed lens rim down into an open-top cuvette which was filled with standard saline solution. The cuvette was connected to a pump (model: omniPump III) which controlled the saline temperature to 20±0.2°C. Afterwards the test lens rested for roughly 1 hour in the cuvette for acclimatization. After stabilization 30 repeated measurements over a short period of time were performed and stored automatically. Thereafter, the lenses in the glass vials were preheated over night to 35°C on a heating plate. In the morning the cuvette was cleaned and filled with fresh standard saline solution and the pump was set to a target temperature of 35°C (controlled within ±0.3°C) and the measurement procedure was repeated. Each lens was measured two times at each temperature.

ID	Manufacturer	Lens name	Material	Parameters labelled			
				PWR (D)	BC (mm)	ADD (D)	DIA (mm)
1	*Johnson&Johnson*	*1-DAY ACUVUE MOIST multifocal*	Etafilcon A	-1.25	8.4	+2.50	14.3
2	*Johnson&Johnson*	*1-DAY ACUVUE MOIST multifocal*	Etafilcon A	-0.25	8.4	+2.50	14.3
3	*Alcon*	*DAILIES AquaComfortPLUS multi.*	Nelfilcon A	-0.00	8.7	+2.50	14.0
4	*Alcon*	*DAILIES AquaComfortPLUS multi.*	Nelfilcon A	-1.5	8.7	+2.50	14.0
5	*Bausch + Lomb*	*Biotrue ONEday For Presbyopia*	Nesofilcon A	-1.25	8.6	HI	14.2
6	*Bausch + Lomb*	*Biotrue ONEday For Presbyopia*	Nesofilcon A	-2.00	8.6	HI	14.2
7	*Cooper Vision*	*Clariti 1 day multifocal*	Somofilcon A	-0.50	8.6	HI	14.1
8	*Cooper Vision*	*Clariti 1 day multifocal*	Somofilcon A	-1.75	8.6	HI	14.1

Results

At first from all measurements outliers were eliminated according to Grubbs' test for outliers. The measured differences between both 20°C and both 35°C runs were quite small. Hence, the mean of both measurement runs was calculated and used for further evaluation. The results of the 35°C power measurements were corrected regarding the temperature dependence of the refractive index of the saline. The "labelled" internal sag. depth of all CLs was calculated considering the BC and diameter labelled using the SAG equation[6] assuming the CLs monocurve and with BC spherical. The internal sag. depth was also calculated removing the nominal central thickness for a -3,00D power, from anterior sagittal depth measured at 20° C and 35° C. The central sphere value was measured in the central lens area typically at around 2mm in diameter. The zone power value was measured in an peripheral ring zone with a typically width of around 2mm. Initially, the glass lens runs were compared: The differences between both temperatures were very small: -1µm for DIA, <0.001D for PWR and <1µm for anterior sag. The results for the CLs showed obvious changes in diameter, sag and power when temperature is raised. The rim diameter decreased for example with a Clariti lens by 0.25mm or decreased by 0.45mm with an Biotrue lens (Fig.1). The Acuvue presented the highest difference in respect to labelled diameter. Calculated internal sagittal depth decreased (e.g. 70µm for Clariti and by a maximum of 180µm for Biotrue) (Fig.2). The increase of temperature introduce also changes on central power values of the CLs although lower than 0,25D (Fig.3); Indicatively, all CLs presented an increased addition with lower change for DAILIES plano. Zonal power presented an increase in negative direction in all lenses except 1-DAY -0,25D. Power profile presented indicatively an increase of negative power towards the periphery and a reduction toward the center (Fig. 4/5). Indentations in difference plot (Fig. 5) are mainly caused by lens shrinkage.

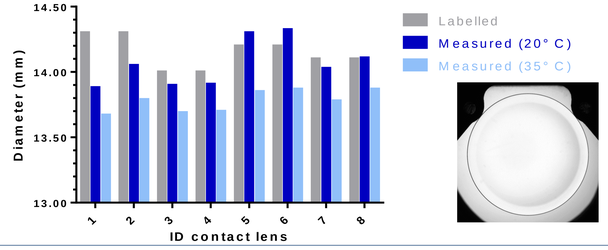

Figure 1. Effect of temperature on lens diameter.

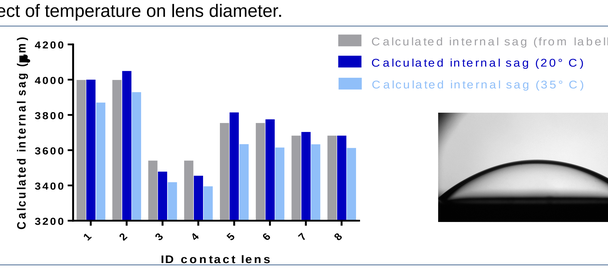

Figure 2. Effect of temperature on calculated internal sag. depth (Measured anterior sag – nominal CT)

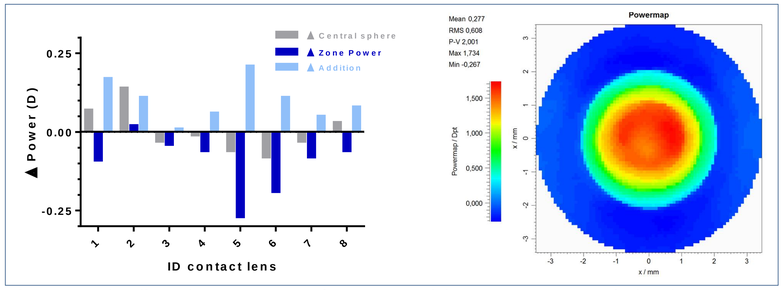

Figure 3. Left: Effect of temperature on lens power. Right: Powermap example (ID 7)

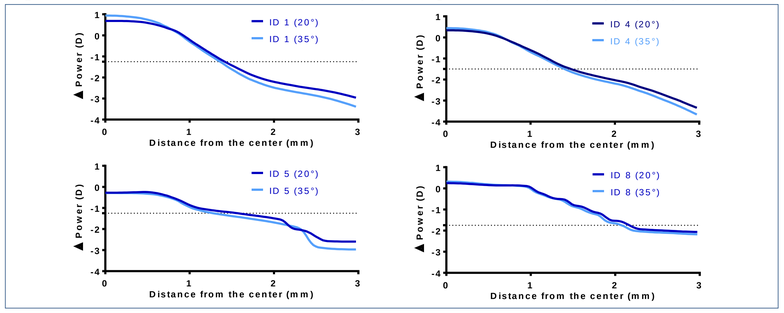

Figure 4. Effect of temperature on power profile, dotted line represent the nominal power.

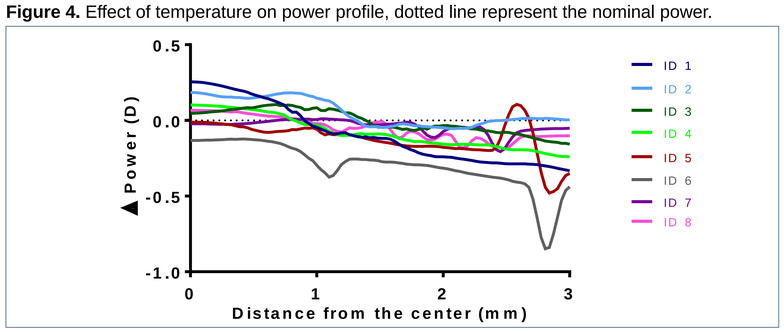

Figure 5. Change of power profile from 20°C to 35°C

Conclusions

Temperature increase from 20°C to 35°C induced parameter modifications in the tested daily disposable multifocal CLs with obvious changes and effects on their power. In general, CLs made from hydrogel materials with higher water content have more water to lose, and thus shrink more as temperature is increased[7,8]. Even if some of the changes are due to the shrinkage of the material itself[9,10]. The changes found suggest that labelled parameters of soft CLs are unhelpful to do comparison between products or for predicting their behavior on the eye. In particular way considering multifocal contact lenses where correct centration and precise determination of power values are essential for a successful fitting[11]. Considering our results, small changes of power as sometimes requested by over-refraction of some CLs could be related to changes of their optical profile which are induced by the increase of temperature.

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References

1. ISO 18369-3: 2017 Ophthalmic optics—Contact lenses—Part 3: Measurement methods.
2. Young G, Potts M, Sulley A. The Effect of Temperature on Soft Contact Lens Diameter. Eye Contact Lens. 2016; 42:298-302.
3. Montani G, Van der Worp E. BCE vs SAG vs DIAM. Global Contact. 02/2016: 34-39.
4. Ozkan J, Ehrmann K, Meadows D, et al. Lens parameter changes under in vitro and ex vivo conditions and their effect on the conjunctiva. Cont Lens Anterior Eye 2013;36:171–175.
5. Young G, Garafalo R, Peters S, et al. The effect of temperature on soft contact lens modulus and diameter. Eye Cont Lens 2011;37:337–341
6. Douthwaite WA, Contact lens optics and lens design 3th Ed. Elsevier. 2006; 57-58
7. McCarey BE, Wilson LA. pH, osmolarity and temperature effects on the water content of hydrogel contact lenses. Contact & Intraocular Lens 1982;8:158–67.
8. Tranoudis I, Efron N. In-eye performance of soft contact lenses made from different materials. Contact Lens & Anterior Eye 2004;27:133–48
9. Maldonado-Codina C, Efron N. Hydrogel lenses—Materials and manufacture: A review. Optom Pract 2003;4:101–115.
10. Jones L, May C, Nazar L, et al. In vitro evaluation of the dehydration characteristics of silicone hydrogel and conventional hydrogel contact lens materials. Cont Lens Anterior Eye 2002; 25:147–156.
11. Pérez-Prados R, Piñero DP, Pérez-Cambrodí RJ, Madrid-Costa D. Soft multifocal simultaneous image contact lenses: a review. Clin Exp Optom. 2017; 100:107-127